WP2 KEY EUROPEAN TECHNOLOGY TRAJECTORIES

D2.1 FIRST REPORT ON KEY EUROPEAN TECHNOLOGY TRAJECTORIES

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The FISTERA network is supported by the European Community under the FP5 specific program for research, technological development and demonstration on a user-friendly information society (1998-2002).

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WHAT IS FISTERA?

FISTERA is a Thematic Network on Foresight on Information Society Technologies in the European Research Area.

The FISTERA network is supported by the European Community under the FP5 specific program for research, technological development and demonstration on a user-friendly information society (1998-2002).

The aim of the FISTERA Thematic Network is bring together on a systematic and extended basis, actors and insights in national foresight exercises on IST in the Enlarged Europe.

Main objectives:
- Compare results of national foresight exercises and exchange visions on the future of IST
- Provide a new forum for interactive consensus building on future visions for IST
- Contribute to the European Research Area through benchmarking and community building, by providing a dynamic pan European platform on foresight on IST

In order to meet these three key objectives, FISTERA will:
- Review and analyse the national foresight exercise outcomes (a country synthesis report)
- Build aggregate pan European Technology trajectories (a roadmap of potential developments of key emerging technologies)
- Map the European IST actor space (a SWOT analysis of the EU IST actor space)
- Provide an IST Futures Forum (strategically selected scenario exercises that will look at wider aspects of applications of IST)
- Disseminate the results to a targeted audience by various means (a dynamic website at the address http://fistera.jrc.es, an e-mail alert service, publications, conference presentations, a “road-show” of workshops and a final conference)

Network Membership:

Core partners (coordinators, work package leaders):
- JRC-IPTS (Institute for Prospective Technological Studies), part of the European Commission's Joint Research Centre, Scientific Coordinator of the network.
- FZK - ITAS (Forschungszentrum Karlsruhe GmbH in der Helmholtz-Gemeinschaft, Institut für Technikfolgenabschätzung und Systemanalyse), Germany.
- TILAB (Telecom Italia Lab – Scenarios of the Future), Italy and IDATE, France, as subcontractor.
- ARC/sr (ARC Seibersdorf research GmbH, Division Systems Research Technology-Economy-Environment, Seibersdorf), Austria.
- PREST (Policy Research in Engineering, Science and Technology) of the University of Manchester, United Kingdom.
- GCI (GOPA - Cartermill International), Belgium, Administrative and Financial Co-ordinator.

The group of Members, which is expected to grow over the duration of the contract, currently includes the following organisations: TNO-STB (The Netherlands), Danish Teknologisk Institut (Denmark), TecnocampusMataró (Spain), Observatório de Prospectiva da Engenharia e da Tecnologia-OPET (Portugal), ARC Fund (Bulgaria), IQSOFT (Hungary), Tubitak (Turkey), The Researchers’ Association of Slovenia (Slovenia), NMRC, University College Cork (Ireland) and BRIE-Berkeley University (USA). In addition, McCaughan Associates (McCA) runs a group of High-level Experts to the Network Management Committee.
This document results from the work developed within WP2 of the FISTERA project, www.fistera.es under the responsibility of TiLab, Telecom Italia, with the contribution of the Fistera partners. Its content reflects also the contributions of many actors such as researchers from TiLAB and from many European Universities, Emerging Technologies groups Technical Committees and members belonging to COMSOC (Communication Society), people working within other FISTERA WPs. They all provided insight, comment, guidelines by submitting their view, commenting on the web site and the information presented, through discussion at various occasions. There are many people who contributed to the content that it would not be possible to list all of them singularly but all their effort and dedication are gratefully acknowledged. Wherever the contributions received addressed a specific topic, this is acknowledge in the item description contained in the web site through a link to the person providing the material. One may refer directly to that person for more in depth discussion.
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Executive Summary

The European Community has budgeted investment for research in the 2003-2006 periods 16.27 GE (billion of Euros). Of these 3.6 are for the Information Society Technologies (IST) and 1.3 for Nanotechnologies.

This amount of money should be doubled when considering the actual research investment effort since the EU is financing most of the research project up to a maximum of 50%, the remaining part being financed directly by participants.

More research, and money, is obviously involved beyond 2006.

The basic questions the European Community has to answer are:

- where does it make sense to invest research money,
- where is it going to be more productive?

To help finding an answer to this question the approach of WP2 work has been that of developing technology trajectories from today to 2020 and identify disruption points.

Evolution happens, obviously, at different pace in different areas. For a given technology 3 years may lead to a significant change, for others 10 years will be negligible. A decision had to be taken on the timeframe to consider. A 2008 horizon meets the need to show how the current research efforts are likely to change the present scenario (which is used as a starting point). Five years gap (2003-2008) is a sufficient time (in most cases) to let researches produce result (or prove that such a direction is a dead end) and affect the world around us.

As the horizon is pushed further down into the future the vision blurs and the possibility something completely new happens to change radically the evolution becomes more concrete. It gets more important to understand what characteristics of an innovation can lead to a disruption rather then trying to pinpoint a specific innovation. Setting the horizon to 2020 let us create radically different scenarios by taking for granted that some of hurdles blocking today the evolution will be overcome.

This may actually never come to pass, and signposts need to be placed to indicate that the evolution foreseen is based on a certain assumption for which we do not have any certainty that it will be proven correct. As an example by 2020 wireless will dominate the access to networks for both people and equipment. In order for this to become a reality at a certain point in the future the powering of mobile devices need to be solved. It is not clear if this will be so because of the success of fuel cells, because of lesser demand from hardware (unlikely), because new portable powering sources will become available. Whatever it will be, there is a strong consensus that something will happen to make it possible.

The identification of the hurdles to be addressed let decision makers evaluate investment strategies on “basic research” to create enabling factors benefiting wide areas.

Technological evolution “per se” does not say much. As an example, we foresee a staggering evolution of the processing capacity, but what is the meaning of saying that, from a market-usage point of view? PC in the year 2020 is likely to run at over 2 THz delivering a processing power that compares to the fastest supercomputer we have today, do we need such a processing power? Is it going to change our life? How many people will benefit from it? Will a potentially infinite bandwidth make processing power a second order requirement?

The methodology to approach the identification and representation of the trajectories responds the need to put technological evolution into a context.

From the very beginning of the work it was clear that many technologies have no clear cut boundaries and any attempt to study its evolution will call in other technologies. As an example the chip evolution depends on the evolution of the lithographic process (that in turns touches a variety of issues), the evolution of the manufacturing and the one of design systems. But that is not enough. One can experience the effects of the evolution of the chip only if there is a parallel evolution of the packaging and of assembling. Therefore assuming that there is a consensus on the importance to invest in chip technology what would that actually mean? Investing in all related technologies, just in a few of them?

This discussion outlines the difficulties in identifying the technologies to consider. A subjective choice was taken in the selection of a first set of technologies. Then as work progressed it became

1 http://www.cordis.lu/fp6/budget.htm
clear that others were needed in order to outline the evolution of the first set and therefore were added. Now there are close to 100 technologies that have been considered, although at different levels of detail.

Money is invested to further research on a technology. But to understand if such an investment makes sense, particularly over long periods of time it is important to look at a technology from an upper layer, the one of functionalities. **Functionalities** are a crucial step in the decision process to determine where and when to invest. Given the expected evolution of the (alternative) technologies, the strength of the various actors involved and the policy at country level it is possible to take informed decisions. Looking at functionalities provides data to answer the question “where should research investment be focused?” but it does not answer the other questions “where the European Community investment is most effective?”

Responding to this question requires a closer look at market forces, rising up one more layer. This is why a **Service** layer has been considered. At this layer information (and speculation) is provided on who is interested in offering certain services (and to what market segment). The offering of a service bundles, in general, a number of functionalities in an attractive package. The “attractive” has two faces: the supply and the demand side. At the service layer the focus is mostly on the supply side, although the estimate of the market size involves an understanding of the demand side as well. The various aspects related to the supply side cannot be addressed into details, nor it would be possible to do that for a 2008/2020 scenario. The qualitative factors that influence those aspects are however important because they provide more ground on the evolution assumptions being made.

The demand side of the equation can be better understood in terms of what the end users need. There are, obviously, various kinds of needs, some more fundamental (safety, health care, education,....) other more ancillary (entertainment, ego’s satisfaction,...). The interplay of technology with the satisfaction of needs is quite complex and it is usually hidden in terms of services (products) and the functionalities these are providing. The variety of services available, their accessibility, their effective use and the way these reshape an ambient is a possible way to gauge the effect of a technology on our life. Hence it is also a way to gauge, from a social perspective, the opportunity of investing on a technology. All these reasons have led to the inclusion of a fourth level to be placed over the service one: the **Ambient**.

At the ambient layer, ethical issues as well as side effects are becoming manifest. A technology “per se” is neither good nor bad. It can get a specific “ethical” flavour only when it is seen “in action” in a given ambient. In the investment decision these aspects have to be taken into account. Links connect ambient with services, these with functionalities and on to technologies. Links represent relations between layers and are possibly the most valuable information resulting from the work.

Technologies in the area of behaviour, coding, communications, devices, powering, processing, storage and terminal points have been considered and evaluated within **three time frames**: **today**, 2008 and 2020. In each timeframe a forecast has been given in terms of the stage of the technology in the life cycle.

From an investment decision point of view to estimate the phase in the life cycle is important since it provides a gauge to measure the potential windows for the investment return. This window has to be compared with other alternative technologies providing the same functionality. Furthermore a crucial element of the analyses has been the understanding (and forecasting) of the value of the performances of any given technology. As an example the CRT and LCD performances have been measured in terms of brightness, contrast, angle of view. These performances, although important are no longer the ones valued by the customers when choosing one over the other. The main differentiator is the form factor and LCDs (flat screens) are now winning the market even though they are “less” performing (with respect to those parameters) and more expensive.

Understanding the value of performance on the market is a key issue in dimensioning the market window and, therefore, the potential for return of the investment.

Another important parameter assessed is the one related to the evolution of cost. Cost (decrease) may depend on production volumes, on the efficiency of production processes or on the type of the production process, on integration scale,....

Cost is clearly a main factor (although not necessarily “the main” one) and understanding how to diminish cost (where to invest in research in order to diminish cost) is very important.
Based on the above described parameters a number of technology trajectories have been identified on the basis of their capability to guarantee a functionality. More will be considered in the second part of the work in 2004.

For each of these trajectories the interplay of the various technologies and their relationship with the 3 upper layers has been considered, although an in depth analysis has been carried out only between the technology layer and the functionality layer. The ongoing work in the other parts of the Fistera project will provide information to complete the analyses. As an example the surveys on the national forecasting exercises and on the various national research initiatives, the strength of individual countries in certain areas will help clarifying the relationship with the 3rd and 4th layers (services and ambient).

Technological evolution, the availability of novel (or just significantly enhanced) functionalities and the widespread adoption of new services over a long time span is likely to create new ways of living and novel perception of values driving to the evolution of the culture. On a shorter term some mix of technology, production, distribution and adoption may disrupt some market segments as we know them today opening up opportunities to new players and changing the competitive advantage of whole countries. Although it is almost impossible to predict the when and what will cause a disruption, it is possible to outline the “why” a disruption in a given area may occur. Understanding the “why” is important from an investment point of view since it can provide further parameters to evaluate investment strategies.

In the past, disruptions happened when a new technology was able to deliver better performances at a lower price. Quartz watches were more accurate and came to cost less than the mechanical ones. Cogs were put out of the market.

The situation is still similar today: however what creates the disruption changes from case to case. CRT are not put out of business by a technology providing better images but by one providing thinner screens. The computer market has been disrupted by PCs not because they were more performing than mainframe but because their global volume shifted the market focus on them. Market volume is what matters. Because of this, PDAs and tablet PCs are not going to create a disruption. This may come from the smart appliances.

In evaluating technological trajectories WP2 has tried to understand the macro phenomena that would, if met, enable a disruption. In some cases a timeframe can also be provided but again not in the sense of predicting the time it will occur, rather the time frame when it may occur. Disruptions are a threat to established business actors but are a big opportunity for newcomers (and for that part of the established business wishing to reinvent itself); furthermore, they create a new market thus transforming mature business in new ones. It makes the evolution spin over and over. Because of this, disruption should not be considered as “bad” by established businesses. The fixed line telephone market has been disrupted by the advent of wireless: this created a completely new business with new rules. The key was the enabling of personal communications versus the place to place communication.

This is valid at country level as well. Potential disruptions are an essential ingredient to guide strategic investment in research and in innovation.

The results so far obtained by WP2, and contained in this report and in the web site, will be of benefit to:

- Governments and institutions in the EU countries wishing to get a third party overview of potential technology evolution, challenges laying ahead, and potential areas where research investment may be more productive, given the local situation;
- Ongoing projects in the VI Framework program that may gauge the evolution of the context versus the timeline of their own research and expected results;
- Planners of the VII Framework programme have a wealth of information presented that can be considered when drafting main directions and hurdles to be solved by research funding;
- The scientific community wishing to get a concise overview of technological evolution and technology interplay;
- Politicians and lay people wishing to understand some of the potential outcome of technological evolution. The plain language used throughout the material to explain technology and its evolution should facilitate the understanding.
1 Introduction

This part is intended to provide a brief overview of the results achieved by WP2, that is

- the definition and analysis of technology trajectories that help in identifying strategic investment in research and in innovation.
- the definition of a methodology and the creation of a tool providing a representation framework to forecasted evolution and useful to draw attention to some major trends (technology trajectories) and disruptions identified.

1.1 WP2 Goal and Approach

The work of WP2 has the goal of providing a “living” timeline of technology trajectories that can be used by Fistera and also by others to understand what is happening and what the implication of such an evolution might be. Additionally, there is the intention to create a backstage aiming at helping a variety of actors in the European Community to take decisions on where to invest, how to prepare for the future, how to stimulate the evolution towards sensible objectives. There are many organisations, some working in a very specific field, such as AgentLink which focuses on the evolution of Agent technology or the SIA, Semiconductor Industry Association, other addressing broader spectrum of technologies that provide very interesting roadmaps of evolution.

FISTERA, and WP2, did not want to duplicate efforts nor redesigning additional roadmaps. The focus here is to provide intelligence to understand current and future road mapping exercises by identifying the relations among the variety of current and future technologies so that it may be easier to steer the investment process at the European Community level. This steering is obviously a response to strategic objectives, like:

- the achievement of a competitive edge as Europe and as European Enterprises,
- the increased well being of its citizens,
- the leverage on the values, culture and diversity present in our Union,
- the role of Europe in the global context.

The technology trajectories developed (chapter 5) are basically projections based on the current situation as perceived by the FISTERA team and result from intensive discussion with many field experts. The selection of any set of technologies is ultimately bound to a subjective judgment.

Technology Trajectories for each Functionality

In this document a significant number of technologies are briefly presented (chapter 3) and for each, along with its definition, comes a set of information on its expected evolution, who is currently investing in the evolution and who are the stakeholders who will ultimately benefit from such an evolution. The depth of information presented varies from one to the other. In general only that information that is deemed necessary to understand the trajectory is provided linking to other places for more in depth discussion. The second part of the work of WP2 (to be provided next year, see chapter 9) will further expand in breath and in depth the result presented in this document.

For some technologies there is no consensus on the evolution. There is an understanding of the potential, of what may be needed but no real grasp on if that is going to be feasible. An example is quantum computing. In spite of the progress made so far there is no consensus if it will be possible to implement a quantum computer (that is usable...). In these areas investment decision cannot stand on firm ground, however the value of a success is (may be) worth an investment strategy.

Forecasting Value

The value of the forecasting should not be measured in the accuracy of the predictions made, as will be verified over the years, rather on the impact that such forecasted trajectories are having on the decision of investment at European and National level.

Saying that Europe is running late in screen display technology is a fact, saying that the current forecasting for 2020 is of a Europe “out of the game” is not a fact, nor a high probability forecast. It aims at saying that if nothing changes in the investment policies then Europe will be out of the game. It is up to decision maker to decide if being a third class player in this technological area is appropriate or not, and, if it is not, it would be up to them to take appropriate action to change the path to the future.
Disruptions

Some technological evolutions may lead to a disruption (see chapter 6): this is a significant change in the scenario involving actors and the rules of the game.

A disruption may:

- terminate the evolution of other technologies (such as the case for CRT vs LCD),
- lead to a complete reassessment of the regulatory framework (such it would be the case for a thousand fold increase of wireless bandwidth resulting from the resolution of interference),
- open the gate to new players (as it happened in telecommunication network equipment with the flattening of the hierarchy and the entrance of Cisco-like in the market),
- change the value chain and the relationship among established actors (such could have happened in the e-commerce vs the distribution chain),
- open new issues (such as the advent of quantum computing vs the public key cryptography).

Potential disruptions are an essential ingredient to guide strategic investment in research and innovation.

1.2 The Methodology

Technological evolution needs to be considered in a context if we want the evolution analysis not to remain an interesting intellectual exercise. For this reason, a methodology has been defined to be sure that the approach to the identification and representation of the trajectories would have been put into the right context. Four layers have been defined:

- **Technology layer** (see chapter 3), containing the set of technologies that have been identified as relevant to the IST; it is an open set so that more technologies may be added in the future. In order to provide a tool to assess technological trajectories in the overall context for each technology the relationships with other technologies is highlighted (i.e.: the evolution of the processing power depends on the evolution of the lithographic process needed to produce the wafer), also relations between a technology and selected functionalities it can support is highlighted (i.e.: the evolution of processing power increases the capacity of coding information, enables 3D imaging…).

- **Functionality layer** (see chapter 4): it contains a set of functionalities. Functionalities are a crucial step in the decision process to determine where and when to invest. A given functionality can be provided by a various mix of technologies: as an example displaying information can be achieved through CRT (Cathode Ray Tube), through flat screen LCD (Liquid Crystal Display), through OLED (Organic Light Emitting Display)… and so on. Given the expected evolution of the (alternative) technologies and the strength of the various actors involved, in the policy at country level it is possible to take informed decisions. Taking the case of information display the evolution timeline of CRT clearly shows a levelling out in production volume (in favour of LCD screens). Since volume, for this kind of technology is crucial to the evolution we can expect a significant decrease in the CRT evolution that will probably result in a “progressive” dismiss from the market. LCD on the other hand are likely to experience a significant evolution in the
production phase, with less waste and hence significant decrease in price. That would result in their taking the upper hand in the next 5 years over the CRT. Investing in this technology is therefore appropriate "time-wise". However, if we look at the reason for the expected evolution again we see that volume is crucial and there will be likely very few players on the world market. The current position of Korea and Japan (with a distant third being US) is likely to have locked in the market. Investment in this area – on a purely technology/market base - is not advisable. On a longer timeframe, alternative technologies, like OLED or quantum dot display, may become competitive because of some specific characteristics, like lower power consumption, thinner and flexible screen. Because of these aspects, we can expect a niche penetration in areas like cell phones and portable display. Eventually they may completely displace LCD. This is an area where Europe may still play the game but that means investing in basic research, aggregating major players that have interests in the niche areas (cell phone makers, as an example) and pushing into a focused direction. The "push", in this area taken as an example, is needed because the pure market forces are not sufficient to achieve leadership. European cell phone makers are well aware of the importance of brighter – low power display but they may find acceptable to buy them as components from Asia rather then investing on their own. A concerted action at European level may change this situation. This example clearly shows that the functionality view is important to consider alternative investment paths but at the same time it is not sufficient. Market forces have to be considered as well. This is why a Service layer has to be considered.

Service layer: Two main pieces of information are considered at this layer: the actors (and their potential evolution over the time frame considered) and the market segment (size – quality in terms of expenditure capacity) as it is now and how it is likely to evolve. The focus is here on all it’s related to the provision of that particular service: that is understanding the cost of the components, of the packaging, of the delivery and of the operation (customer care, upkeeping, maintenance). As an example the evolution towards disposable objects has significant implication on the service offering throughout the whole production – delivery – exploitation chain. Disposable objects are likely to become more and more common, in at least two different flavours. One is the availability of a product that is connected to a specific use within a specific time frame (e.g. a disposable camera that once has been used – all pictures taken - will be disposed; recycling issues…). The progress of production technologies towards low cost assembling is steering evolution in this area.

Another is the temporary property of a product (such as the sharing of a car...once used by a person is released and made available to another). The progress of the information society makes it easier the sharing of goods.

The trends towards disposable products will tend to fade the boundary between service and product with the former taking the upper hand on the latter. This is, in turn, going to have significant implications on a number of areas, from customer retention to product recycling, from the pace of innovation to the perception of value.

The functionality bundling into a service can be expressed into a set of relationship. Technology has been a strong enabler for bundling functionalities in a single product/service. A time piece (a clock) is bundled into most products simply because it has become cost free to provide it (in cell phones, in computers, in PDAs, in digital camera….). That did not cause the demise of wristwatches. The marketing drive may often push in the direction of bundling several functionalities to have a better market proposition. This is not necessarily what the users need (although it may be what they have the perception of "wanting"). The evolution of production may drive the evolution in an opposite direction, that of product and services with a much more limited set of functionalities. This can also be the drive of the market where producer will tend to differentiate their offering hence proposing specific products rather then omni-comprehensive ones. The interplay of functionality and service is expressed in terms of relations and the purpose of these is to connect what technology makes possible to what the market makes sensible (and pursuable in sustainable terms).

• Ambient layer: Ambient in this document means the physical as well as the virtual places where we see technology in action, through the services they are enabling. For this reason an ambient is better described
in term of a scenario, a storyboard, where the various characters (end users and services providers) are seen interacting with each other. This is not the purpose of Work Package 2 and therefore only pointers are provided to material on scenario presentation. In this document the ambient are qualified in terms of the set of services being used and the extension in terms of the population involved showing in the different time frame how these evolve. Links show the “dominant” relations connecting an ambient with services, these with functionalities and on to technologies.
2 The approach to the identification of Technology Trajectories

Technology is a word with a quite clear meaning but as one tries to apply it the definition blurs. A chip is a technology, no doubt: but is it a technology in itself or is it a composition of different technologies (for designing the logic, for etching the wafer, for doping the silicon). Is the chip a technology in the sense of the “packaging” technology that makes it possible to connect the silicon part to the board? If we accept the chip as being a technology, what about a PC? On a macro scale PC is quite similar to a chip, using basic components, requiring a sophisticated design, connection of components …packaging.

Technology and technology evolution “happen”. We may, through considerate investment, favour the evolution in one direction or in another but we cannot stop evolution nor we can force it. Investment decisions are more important in creating the favourable environment to take advantage of the evolution than to create the evolution “tout court”.

A massive investment in an area, say the NED – Nano Emission Display, may potentially leapfrog the competitive advantage of Korea in the area of LCD (and display production capabilities) but may be crushed by a new technology that today does not exist, or one that currently holds little promises in this specific field (like plastic transistors).

It is because of the intrinsic uncertainty of technological evolution as a whole and the limited value of focusing on a specific one that a decision has been taken by FISTERA to have WP2 focusing more on relationship and alternatives.

Functionalities can, to a certain extent, be considered as stable needs that are being satisfied by a set of clustering or alternative technologies. They serve the purpose to identify the various means technology can provide to satisfy them.

The evolution of a technology may progressively provide better value in meeting the needs of a functionality but the concurrent evolution of a different technology may disrupt the game resulting in the overtaking of the latter over the former.

CRT technology has been progressing over the years thus providing a better support to the display functionality. Today we are seeing the LCD technology, also targeting the same display functionality, displacing the CRT. Production of monitors up to 15 inches in CRT is being discontinued in favour of LCD, with 17” screens following suit.

Interestingly, the CRT technology is still much better than LCD in terms of resolution quality, viewing angle, colour hues. What makes a difference is…fashion. Sleek screens are so much nicer on our desk and in our living room. A technology is doomed by fashion.

The technology trajectories presented are as much as possible taken from studies or industry roadmap, whenever they are available. Alternatively projections have been developed based on the current situation as perceived by the FISTERA team and result from intensive discussion with many field experts. These projections cannot be considered as Roadmap (behind a roadmap there is usually a consensus of an industry and a plan to “implement” such a roadmap). They are provided to suggest how evolution may take place and to identify what are the hurdles ahead. This is important since:

- understanding the potential evolution out light the impact of a given technology on other competing one or the boost that such evolution may give to others’,
- it helps identifying research area, where to focus (if there is the intention to move along that path).

The selection of any set of technologies is ultimately bound to a subjective judgment. In this document a significant number of technologies are presented and for each, along with its definition, comes a set of information on:

- its expected evolution,
- what are the hurdles ahead,
- who is currently investing in the evolution,
- who are the stakeholders who will ultimately benefit from such an evolution.
The depth of information presented varies from one to the other. In general only that information that is deemed necessary to understand the trajectory is provided linking to other places for more in depth discussion. The second part of the work of WP2 will further expand in breadth and in depth the results presented in this document.

Over a hundred technologies have been selected as a starting point. The criteria has been looking into those that have a potentially strong impact on the Information Society. More technologies are “hidden” in the ones selected (such as the lithographic process which is not considered as self standing but it is mentioned in evolution challenges for silicon based storage and microprocessors...). Other technologies are considered at the edge of IST and therefore only mentioned in relation to the ones selected (such as the drug syntheses mentioned when dealing with molecular computing and the GRID).

Comments on this work and further discussion will surely lead to an extension of the present set in the second deliverable planned in Fall 2004. Here it follows a brief summary on the main evolution trajectories identified. In the main body of this document, specific report on each technology trajectory is provided.

1. Bandwidth trajectory
With bandwidth here it is meant the transmission capacity at the access level: the network capacity on trunks is not considered here. In the next 5 years there will likely be a heavy deployment of xDSL (now reaching up to 100 Mbps on 4 km loop length) and optical fibre. From a service offering perspective residential connections at speed close to 100 Mbps are likely to satisfy 99% needs well beyond 2020.
Bandwidth may remain at premium through this decade and part of the next one in a mobile environment (and not even in general since many high density areas will sport high bandwidth hot spots). If till the end of this decade bandwidth will remain the talk of the town by the beginning of the next decade the focus will shift onto bandwidth flexibility, bandwidth guarantee…the race for speed will be over. At a research level the search for bigger bandwidth is likely to continue to satisfy very specific needs (holographic projection, GRID support in scientific – medical – security environment) and that effort will create fall out onto general infrastructures and applications.

2. Communications trajectory
Communications technologies have evolved significantly in these last 30 years mostly making it simpler to connect points on the whole Earth. A significant step ahead in the next 10 years will be on one hand the connectivity among ambient and the personalization of connectivity. Beyond 2015 the emergence of wireless routers, ad hoc networks and possibly the resolution of the interference problem through inter-terminal communication may lead to a thousand fold increase in the wireless bandwidth leading to a radical change in the communication scenario (see 8.5 Infinite Bandwidth).
Obviously this is not “granted”: it needs a lot of research and investment. It also needs a vision to focus in that direction.

3. Data Capturing trajectory
Progress in data capturing has been growing constantly over the last decades but it is now on the brink of a strong discontinuity in terms of quantity and quality of data captured. Sensors as well as satellite survey, web cams, personal recording devices are become smaller, cheaper, simpler. Even 3D scans should become cheap and common in the next decade. There are several technologies converging to produce this effect: electronics, bioelectronics, nano technologies, MEMS, communication technologies, fabrication processes (letting analogue, digital and RF circuits mix together on a single chip). More recent concern on security threats is pushing to speed up this evolution.
Most objects in the next decade will embed “at production” sensors and sensors will be able to form autonomous networks to reach a communication gateway.
The availability of a variety of sensors will increase the availability of data and push towards effort to address the information retrieval issue.
4. Human Interfacing trajectory
Technologies like affective computing may customise the interaction to the mood of the person in the first half of the next decade. In the second part of the next decade sophisticated shadowing mechanism will take over part of the hidden communication interplays that is so important in human to human communication and that today lacks completely in human to machine communications.
As communication will become more and more based on “understanding” and less on formal commands new problems will come up. Issue like who is responsible for any misinterpretation are likely to delay progress.
Artificial intelligence, agents based dialogue, and many more will be both instrumental in the discontinuities and stumbling blocks. In several areas there are ideas of exciting possibilities but there is lack of firm ground to build upon.

5. Information display trajectory
The new forms of information display may prove crucial in several sectors (design, medicine, some form of entertainment) and may create new market opportunity significantly chowing on existing ones. The trend, therefore, may be summarised as: better displays in fixed and in mobile environment likely in the next 5 years. 2D imaging dominate for the next 15 years but will progressively become a commodity leaving very little margins. New display technology in the mobile area will boost services and provide greater margin to those companies controlling the advanced technologies. 3D display will be confined to niches for the next 5 to 8 years to become more common in the next decade enabling new services and eventually pushing 2D into the commodity realm (even though it will remain the dominant display mechanism). 3D display technologies will not be “per se” a disruptive technology; rather it will enable disruptions in communications mechanism if new communications paradigms can be created. Investment on these is more likely to produce wealth than investment on 3D technology as such.

6. Information Retrieval trajectory
The astounding production of information that in a way is characterising the Information Society (it is estimated that in the last 20 years human kind has produced more information than the one produced till the dawn of humankind and that in the next three years the amount of information will double) is likely to continue in the next 20 years at the same pace, a doubling every 2 to 3 years.
What really doubles, however it is not information but data.
The conversion of data into information and the information retrieval are going to be the real challenges in the coming decades.
Technological innovation is required in order to be able to retrieve information in whatever form it appears (it is stored).
Significant progress in this area is most needed but is not easy to predict. A signpost can be placed around 2008. At that time a number of basic technologies may have progressed to the point that a more precise forecast can be done.
Surely solving at the root the information retrieval problem will dramatically change the landscape allowing the “exploitation” of the Information Society. At the same time those same solutions are likely to generate an enormous concern onto privacy, information ownership and protection and generate enormous challenges. Criminality as well as the well being of citizen have similar stakes, and opportunity, in this area.

7. Pinpointing trajectory
Tagging, beacons and satellite constellation like the GPS and Galileo will become so widespread in services that by the end of the next decade people will rarely think about them. By 2008 most products will have a tag. In the following decade also soft product (like services and information/content) will also have a tag.
Security and privacy concern will be heightened till the end of this decade but as the next one comes by, it is likely that these concerns will move to the backstage as the advantages greatly overcome any potential inconvenience.
Several technologies are going to play a synergistic role taking us into the “tagged Society” the likely evolution of the Information Society.
Progresses in disciplines at the edge of the IST, like medicine and biology, are likely to provide even greater opportunities towards a tagged world. Today it is already possible to "tag" a protein (or a virus). By the end of the next decade tracking of this tagged protein will be much easier opening up the door to a revolution in healthcare in close synergy with communications and more generally with IST.

8. Printing trajectory
Although not often noticed, printing processes have evolved significantly from a technology point of view completely rewriting the business rules in the field, enabling new services and changing the way of working and communicating.
Disruption, on the longer term around 2015 and on, may derive from printers “embedded” in objects (as a standard alternative way of displaying information) and in the embedding of the printer in the printing material itself (e-ink).
Evolution may be expected in the capacity to print 3D objects as well as printing with different “inks” including biological ones for human tissue printing.
The printed object, starting 2010, is likely to show some dynamic behaviour, such as being able to interact with the user and to update itself autonomously. By 2020 printing objects rather than just putting micro drops of ink on paper is likely to become the standard meaning associated to “printing”.
DRM is likely to become part of the “printed” stuff rather than being a commitment on the user of the printed stuff. This can change the way we are looking at Digital Rights Management. Even a single page of printed text may be able to interact with the personal area of a user and negotiate reading rights before actually displaying whatever is negotiated.

9. Processing trajectory
Processing has been evolving at a surprisingly predictable pace, a doubling every 18 months over the last 30 years. This evolution made possible completely new services and new industries. The progressive decrease in cost has enlarged the market from a few computers per country to a computer (PC) per family and beyond.
The drive towards better processing power will continue, in spite of a decreasing demand, because of the need to decrease fixed cost (production plants) through higher and higher volume production and squeezing of size (which in turns lead to higher performance).
By 2020 every conceivable object is likely to have some sort of processing capability embedded. It remains an open question if such an embedding will be a commodity that any industry can acquire or if it will become part of the production process so that the dominance of processing technology will create a leading edge on the market. In other terms: processing can evolve in the direction of giving equal opportunity to everyone (and every country) to develop products and services or in the direction of locking in the market favouring those that can control processing capability.

10. Storage trajectory
Storage has been evolving in the last 10 years at a pace of doubling capacity at a 10% decreasing price every year for hard drive (current leading edge is 300 GB at a cost of 1 Euro per GB approximately), invention of new storage media every 5 years with a disruption every 10 years (floppy disk in the 70ies, diskette in the 80ies, CD ROM in the 90ies, DVD in the first decade of the 2000, holographic disk – thin film polymer based memory expected to take the upper hand in the next decade).
Each disruption cycle has had a profound impact on industry, from manufacturing to software application to content production, delivery, management and protection.
There is no sign of a slowing down of evolution both in capacity and in price decrease. Capacity is rapidly reaching a point to support local storage of huge quantity of information creating virtual local “internet”. At the same time everything will be potentially recordable enabling new services and creating completely new industry.
By 2020 one can expect to have as much storage capacity as needed on every appliance changing the usage of (data) communications infrastructure from access and download to update and synch.

Besides the objective of representing technologies and the context in which they are placed, this methodology provides the means of carry out what if scenarios; by manual modification of the
relevant information associated to layers and to relations it is possible to outline different possible evolution scenarios. An automatic tool might be part of the next year work.

This work is necessarily unfinished and partial and will remain so since forecasting, unlike history, is an ongoing activity. More information is expected from the interaction in the road show and this information will be used to reshape the trajectories so far identified and add a few others in the closing deliverable of WP2, September 2004.
3 Technologies considered

A broad set of technologies have been considered by WP2 for this first deliverable. More will be added in the second deliverable scheduled in September 2004.

The goal of WP2 was to outline a (limited) number of technology trajectories (presented in chapter 5) and specifically:

- Storage
- Processing
- Information Visual Display
- Printing
- Information Retrieval
- Communications
- Bandwidth
- Human Interfacing
- Data Capturing
- Pin-pointing

As explained in Ch. 2 and 3 a single technology trajectory may say very little from a strategic point of view since it is much more important to understand what such an evolution can bring to the overall fabric of Society (culture, thrift, well being…). Additionally, the understanding of the evolution of any technology calls for an understanding of its relations with other technologies and with the ways it will be applied and steered by the market forces.

The analyses of the chosen technology trajectories have therefore been made at the functionality layer. This has allowed the observation of several technologies that will likely evolve in the coming years as a whole.

Some of the technologies observed have been selected “up front”. Others have been included after analysing the evolution of the functionality and understanding that such an evolution will involve certain technologies.

In this chapter the technologies observed are discussed relating each of them to the technology trajectories that have been chosen as the focus of this first deliverable.

Since the technology observation is targeted to deriving those trajectories, the level of details varies from technology to technology. Only those aspects that are felt most relevant to understand the evolution are considered.

For more information on the single technologies one should refer to the web site or to the Annex B. There, links are also provided to get first hand information on the various aspects.

Any given technology may play a role in a number of (functionality) technology trajectories and therefore it would not be appropriate here to structure them according to the trajectories. In the following they have been clustered in:

- Behaviour Technologies
- Coding Technologies
- Communications Technologies
- Devices Technologies
- Power Technologies
- Processing Technologies
- Storage Technologies
- Terminal Points Technologies
3.1 Behaviour Technologies

This cluster of technologies is going to play an important role in the future since it provides tools to bridge the gap between the human way of doing and perceiving things and the way things are handled by machines.

3.1.1 Affective Computing

Affective computing is a name associated to a cluster of technologies enabling HMI communications where the human perceives the computer as emphatic. To mimic a human communications a computer interface needs to pick up, understand and react to “hints” that humans provide as they communicate verbally. Face recognition, in terms of detecting sadness, happiness, anger, boredom, anxiety..., is the object of several researches. Context understanding is another important area of research. Progress in storage capacity and processing will make it possible to have more sophistication in the analyses of the context. Gesture recognition is also going to play an important role.

The emergence of agents that can communicate at a meta level to disclose part of the experiences and expectations of a person engaged in a communication with a machine would also contribute to the progress.

Significant progress is expected to occur by the end of this decade with a flourishing of applications embedding affective computing in the next decade.

- Contributor to the Human Interfacing Trajectory
  2003: no contribution. Experiments in research labs
  2008: marginal contribution overall. Visible in few niche markets
  2020: medium contribution. Important feature in many products and services

3.1.2 Agents

A software component which is capable of acting in order to accomplish tasks on behalf of its “owner”.

Agent technology has been around for a number of years. It has been overestimated in terms of impact (autonomous negotiation for e-commerce was a much touted application for this technology). It may take an up-swing by the increasing demand to manage complexity and information “in the background” and on the move. Progress in artificial intelligence, processing, distributed processing, and storage is providing fuel for the evolution.

A market for autonomous agents is doubtful. More likely the embedding of agents in applications. In this sense they may remain a “pure” technology and never become a product. Agents' support environments, on the contrary, may become products of interest to companies providing services and also as ways to manage information within enterprises.

- Contributor to the Human Interfacing Trajectory
  2008: marginal contribution overall. Used to support profiling and customer retention.
  2020: medium contribution. Embedded in many interfaces to support customisation.

- Contributor to the Information Retrieval Trajectory
  2008: marginal contribution. Embedded in a few services.
  2020: high contribution in most personal information retrieval services.

3.1.3 Avatar

A software character impersonating a real or imaginary character.
Making an image alive on a screen requires a number of technologies in the area of information display (rendering, animation,...) plus a self characterizing behaviour. This latter requires the capacity to interact and manage the context adapting the interactions to it.

So far avatars have been a derivative of the movie industries (particularly the animation industry) and found some minor applications as artificial spokesman and in some games. Some psychologists feel that a dialogue with a machine that presents itself as an avatar may ease the communications.

It is yet an open bet if avatars will really play a significant role in the interaction with machine. At the same time the underlying technology for understanding the context and impersonating a character by “donning” an artificial or replicated behaviour and style need to make significant progress before it becomes “credible”. However, once that will be the case new issues are likely to surface, like distinguishing the real from a figment of the imagination, attribution of responsibility...

- Contributor to the Human Interfacing Trajectory
  2020: marginal contribution overall. It may have some significant role in few niches such as interactions with children, elderly, education...

### 3.2 Coding Technologies

This cluster of technologies is important for the evolution of ICT. On one hand, better coding would result in a more efficient implementation for a service point of view (i.e. it may involve high complexity in the design and implementation but it will make easier for the content provider to code information and, even more important, it makes easier, cheaper, the decoding of information by the end user). On the other hand better coding means the capability to include in the coded information as many characterisation as required. One of the most important one is the ownership of information to preserve property rights.

The importance of the “effectiveness” of coding will tend to diminish its importance, as processing power increases and gets cheaper and cheaper.

On the contrary, the capability to embed characteristics like ownership protection will become more and more important in the coming years.

Coding may evolve in the direction of entwining in the coded object both the information and the application required to manipulate the information.

#### 3.2.1 MPEG

A set of coding technologies particularly focussing on video and audio.

MPEG has been chosen as an icon to represent coding techniques. It is a suite of standards and as such it is not likely to “evolve”. New ones may be defined to substitute (slowly) the existing one. The appeal of standards to both producers and consumer is just that stability.

Hence when dealing with the evolution the interest is on the possible replacement of existing standard and in the understanding on what new features the new standards may provide.

The compression level provided by MPEG is going to increase (less bit needed to code information) although that is not going to be the main drive leading to the evolution of standards.

This will be driven by the need to code different kinds of information and to ensure property rights and security in a broad sense.

The coding-decoding algorithms are likely to become embedded in chips although part of the coding may be done by software and the overall architecture may become more and more distributed.

- Contributor to the Data Capturing Trajectory
  2020: high contribution. Most applications will assume coding and decoding availability in the (device) platform.

- Contributor to the Bandwidth Trajectory
  2003: medium contribution. Compression algorithm widely used.
2008: medium contribution. High compression code available fosters some video applications on mobile.
2020: marginal contribution overall. The increase in bandwidth capacity both in fixed and mobile greatly diminishes the importance of compression algorithms.

- Contributor to the Information Retrieval Trajectory
  2003: low contribution. Object oriented display used only in a few games.
  2008: medium contribution. Higher possibility to multiplex/demux image components through features in capturing devices and manipulation at the display end.
  2020: high contribution. Significant interplay between coding (information, structure and context) and the information retrieval. Possibility to retrieve images leveraging on intelligent coding at the source.

- Contributor to the Information Visual Display Trajectory
  2003: low contribution. Most of decoding happening in a separate processing unit
  2008: medium contribution. Growing decoding capabilities in displaying devices
  2020: medium contribution. Distributed decoding architecture involving the displaying devices

3.2.2 Public Key Cryptography

A technology allowing the cryptation of information in such a way that only those having the key can decode it.

Public key cryptography has been taken, like MPEG, as an icon of the issue of security in information protection. Actually there are several alternative technologies in use today to crypt information. The key characteristics is on the one hand the security (difficulty to decrypt the code by an unauthorised person) and the relative ease to decrypt by the authorised party. Additional requirements are the resilience to any tampering (detection of any attempt, successful and unsuccessful to intercept the information), the ease to manage the process....

Cryptographic technologies based on factorisation are widely used. An eventual success in the area of quantum computer may render these techniques useless since it will be practical to discover the factorisation and therefore get the key to decrypt the information.

Software and hardware technologies are used and will be used to enforce security in access to information. Biometric technologies will play a larger role in the future.

- Contributor to the Communications Trajectory
  2003: low contribution. It is not a main issue in communications in the large, however some leverage is already been made on the existence of a security guarantee in communications, like the claim of the higher security provided by GSM and the adverse publicity on WiFi that is lacking security protection measures.
  2008: medium contribution. Growing importance of security related technologies. Always -on connectivity will compound the security problem. As private information is progressively stored in digital form in devices and in the home, there is a growing access to information from everywhere; the sensitivity of information and its protection will grow significantly.
  2020: high contribution. Security will become a standard feature of a communication environment. The issue will become more challenging because of the higher interconnectivity and continuous connectivity, the greater number of machines connected. Security needs may become a factor driving the evolution of communications architectures.

- Contributor to the Printing Trajectory
  2003: no contribution.
  2008: marginal contribution. Ensuring copyright and protection of printed information starts to become an issue. Technologies for printing shadowed (invisible to the reader) ownership information will become available. Micro dispenser chips may, in the next decade, provide additional tools for watermarking information in the printing process.
  2020: medium contribution. Printers will be able to print a variety of "information" including biological tissue. The aspect of security in printing will become an important issue.
3.3 Communications Technologies

Communications technologies are at the core of the ICT evolution. For a while they have been one of the two main enablers of the evolution (the other being the processing). The environment has evolved “at the pace” of the communications technologies (and processing).

Now the situation is starting to reverse with communication technologies evolution dictated by the environment and its success depending on the capacity to evolve in synch and at the pace of the environment. An example is given by the telecommunications network whose evolution has commanded the terminal evolution. Now the terminals evolution is directing the evolution of the network and investment in the network.

Another significant shift is in the paradigm: the abundance of resources (capacity) makes the adoption of the IP (best effort) paradigm acceptable also in telecommunications. Telecommunications networks are moving towards IP. The core networks in certain countries, like Italy, are already all IP. In the coming years IP will enter also in the metropolitan area networks and in the longer term (2010) there should be a replacement of the SDH rings with Gigabit Ethernet.

Main players are from US and Europe. Japan manufacturers are also pretty strong and innovative although their impact in Europe is marginal. The shift towards IP favors US manufacturers over European for the time being. It is an area where investment is required to avoid European industry falling behind.

3.3.1 3G

It is a cellular system following the 2G and extending its capabilities through a new communication infrastructure. It has been named 3G to emphasise a new generation. However the gap between 2G and 3G is not as marked as it was between “1G” and “2G” with the shift from analogue to digital. This smaller gap is further diminished by the variety of 2.5…generations building up on the 2G infrastructures.

3G is a reality today and its evolution is not going to be significant in the next years from a technological point of view. What will increase is its capacity (through denser cells) and coverage. Services will gradually learn to take advantage of the 3G system. 3G is going to be there for quite a number of years, well into the next decade. As such it is a technology to consider for communications functionality and to a lesser extent for broadband communications. This is likely to be provided by alternative wireless technologies, particularly for data services. By 2020 3G may still exist but it is surely not going to be the system used by innovative services having faded into a pure commodity.

- Contributor to the Communications Trajectory
  2003: marginal contribution. It will grow significantly in the coming years, probably peaking soon after 2008.
  2008: medium contribution. In the wide context of communications 3G is going to play a minor role. However in the area of wireless voice communication it will play a significant role. Some services may prove to be particularly fit for 3G but as of 2003 they are yet to be identified. Service interoperability with alternative access networks, such as WiFi and UWB (starting in 2008), is going to be a major issue. It is doubtful, however, that EU driven research is needed. All involved actors are actively pursuing this kind of research.
  2020: marginal contribution. 3G is likely to be in the downturn by the middle of the next decade (may be sooner), under the pressure from alternative access networks.

- Contributor to the Bandwidth Trajectory
  2003: low contribution. It will grow in the next 23 years to peak before the end of this decade. In terms of global bandwidth provisioning it will remain a minor contributor.
  2008: low contribution.
  2020: no contribution. Too many alternative access technologies to remain a significant player in terms of bandwidth.
3.3.2 Antenna

A device transforming an electromagnetic signal over the air into an electric signal on wire and vice versa.

Antennas have seen a significant evolution and they will continue to evolve becoming active components. In this way they will be able to provide more accurate reception (focusing in the direction of the signal) and will allow the receiving device to require less power. These evolutions go under the name of intelligent antenna.

Recently (2001) research has made possible to include in the same chip the digital, analogue and RF part. That is opening up the gate to have every chip communicating in their environment wirelessly.

By 2008 a good portion of the antennas in the communication infrastructure covering the access network will be intelligent antennas (70% may be a reasonable estimate for base stations). Soon after, around 2010, we should see the appearance of fractal antennas. These are tri-dimensional antennas that promises to use less space than today’s antennas and therefore are likely to be used in portable terminals like cell phones.

By 2020 many portable devices will have some sort of intelligence tied to the antenna, possibly helping in resolving interference. Additionally there are studies to create micro antennas and associate them to molecules (proteins, DNA…) to be able to “steer” the molecules. That evolution promises interesting applications in the medical field.

- Contributor to the Communications Trajectory
  - 2003: medium contribution. Antennas are a fundamental component in the wireless infrastructure both on the network and the terminal side.
  - 2008: medium contribution. Evolution of antennas is a niche area, although an important one. Any increase in efficiency contributes to decrease the power emission (less EMC pollution) and at the same time decreases consumption (important aspect in mobile devices at least till a radical solution to powering will be available).
  - 2020: high contribution. Evolution of antennas will continue towards higher level of intelligence (being able to discriminate the signal and contribute to the resolution of interference). Research in the area can provide a fundamental advantage in the market. Antennas may become a basic component in a public infrastructure “leased on demand” to service providers. This concept needs some consideration for its various implications in the regulatory framework, in the feeder network(s) and for the ambient impact.

- Contributor to the Pin-pointing Trajectory
  - 2008: medium contribution. The antenna part is going to play an important role for tags (both active and passive), beacons, Galileo and GPS receivers increasing the functionalities of the devices, decreasing cost and making better use of the power. The dissemination of intelligent antennas is going to play a significant role in pin pointing for their capacity to determine the direction of the signal.
  - 2020: medium contribution. Antennas will continue to play an important role and breakthroughs may extend the fields of application.

3.3.3 Bluetooth

Bluetooth is a wireless way for electronic devices to communicate with one another. Bluetooth has been on the design bench for a number of years and only in the last ones it has become a market reality. This is important to notice to understand the time it takes for a new technology in this area to mainstream. Bluetooth has found a niche in the wireless communication world. In perspective this niche will be occupied by other technologies, UWB being a good candidate, based on today’s information.

- Contributor to the Communications Trajectory
  - 2003: low contribution. Bluetooth is a market reality but its impact is limited both by the area of application and the low penetration in terminals.
  - 2008: medium contribution. Bluetooth is likely to be embedded as standard in a variety of terminals. The area of application is not likely to change.
2020: marginal if any. By the next decade alternative technologies will take the upper hand.

- Contributor to the Human Interfacing Trajectory
  2003: low contribution. Bluetooth is a market reality but its impact is limited by the low penetration in terminals that does not permit the creation of ambient networks.
  2008: medium contribution. Bluetooth may play an interesting role in PAN, Personal Area Networks, thanks to its presence in a variety of personal devices. Software applications may take advantage of this communicating devices to improve the human interfacing.
  2020: marginal if any. By the next decade alternative technologies will take the upper hand.

### 3.3.4 Cable TV network

A cable TV (CATV) is a television distribution method in which signals from distant stations are received, amplified, and then transmitted by (coaxial or fiber) cable or microwave links to users. The penetration of this technology/infrastructure varies significantly across Europe (and in the world). Evolution is expected in the area of multiplexing on the CATV other information, such as internet, and in a parallel transformation from a mainly downstream traffic to a bi-directional one. There are obviously significant technical challenges but more important are the economic ones. Deploying a brand new CATV network just for TV may not make economic sense. If a new network is planned it is more likely to be a telecommunications one (fibre) providing also for television distribution.

- Contributor to the Communications Trajectory
  2003: low contribution. Most CATV is dedicated to television broadcast.
  2008: medium contribution. In certain European areas CATV will be upgraded to provide interactive communications services.
  2020: low contribution. By the next decade satellite digital television will take the upper hand in many countries thus diminishing the interest in the upgrading of the CATV. Its upgrade to provide only interactive services is doubtful to fly on economic terms.

- Contributor to the Bandwidth Trajectory
  2003: low contribution. Most CATV is dedicated to television broadcast. In those areas where CATV has been upgraded (or internet is provided in the downlink mode) it provides a valuable communications infrastructure.
  2008: medium contribution. In certain European areas CATV will be upgraded to provide interactive communications services and there a significant portion of users will connect to it for Internet based services. The situation in USA may be different with a bigger market share. The competition from xDSL is very strong and favours the latter, particularly in Europe.
  2020: low contribution. In those areas where CATV has been upgraded (or internet is provided in the downlink mode) it will continue to provide a valuable communications infrastructure. The dissemination of the satellite digital television, chewing the CATV market may lead to aggressive initiatives from CATV operators to redirect their infrastructures to interactive communications.

### 3.3.5 Digital Cellular Base Stations

The equipment connecting the network to the antennas (one or more) illuminating cells in the digital systems like GSM and UMTS.
This equipment is the gateway between the wireless access and the network (usually a fibre). The evolution is towards increased flexibility (including management of the software radio) and capacity to manage higher traffic.

- Contributor to the Communications Trajectory
  2003: medium contribution.
  2008: medium contribution. Software radio should become a reality approximately in this time frame.
2020: high contribution. As the network becomes increasingly “flat” its edges are likely to play a major role.

- Contributor to the Pin-pointing Trajectory
2003: minor contribution. Algorithms to calculate the position of a terminal based on the propagation parameters detected by the base station are starting to be use.
2008: medium contribution. Algorithms to calculate the position of a terminal based on the propagation parameters detected by the base station are likely to become common in spite of the availability of other pin-pointing mechanisms because of their ubiquitous availability (also inside buildings).
2020: medium contribution. As base stations will become more and more intelligent they will be able to provide more information usable for pin-pointing any device with an antenna.

### 3.3.6 Galileo

A European satellite navigation system for civilian purpose.
Galileo will provide a highly accurate, guaranteed global positioning service under civilian control. It will also be inter-operable with GPS and GLONASS, the two other global satellite navigation systems (the first American, the second Russian) that are militarily controlled. Deployment is expected in the next few years and the system should be operational by 2008 providing pin-pointing capability within a few metres.

- Contributor to the Pin-pointing Trajectory
2003: no contribution.
2008: low contribution. The contribution will grow rapidly in the following years as more and more devices will be equipped with the Galileo positioning system receiver (whose price should be as low as the GPS one to win most applications; a premium price justified by the higher accuracy is unlikely to win the market).
2020: high contribution. Most devices will be equipped with a Galileo positioning system receiver.

### 3.3.7 GPS

The Global Positioning System (GPS) is a worldwide radio-navigation system formed from a constellation of 27 Earth-orbiting satellites.
There is no plan to evolve the GPS system although the military are likely to discontinue its use for their purposes opening up its full set of capabilities for public use. This will increase the performances available to the end users (and to service providers).

- Contributor to the Pin-pointing Trajectory
2003: medium contribution. GPS receivers are quite common and their price went down significantly in the last decade. This trend is likely to continue in the coming years.
2008: medium contribution. GPS chip receivers will be very common and available at a low price. For some years there may be a fight to hold the market from the Galileo. GPS will ubiquitous in many environments, like the car for navigation. The grading reflects the fact that by 2008, and more so in the following years, there will be competition from Galileo.
2020: marginal contribution. Most devices will be equipped with a Galileo positioning system receiver. Additionally, commercial disputes may result in new satellite position systems deployed by non-European countries.

### 3.3.8 Home Networking

Set of technologies used for the home networking to connect appliances.
There are a number of alternative technologies to “wire” the house. More will become available in the next years. Proposals (and push) are coming from the telecommunications industry, from the appliance industry, from the consumer electronics (entertainment) and from the home wiring
industry. Both wireless and wired solutions are available and will continue to be available in the coming years. From an evolution point of view, home networking will spread and more considerations will be given to security and connectivity aspects (bridge to the external world). Capacity is going to be an issue for few more years (although not a big issue) and will tend to fade away from the user consideration. Configuration management will be an increasingly important issue.

- **Contributor to the Communications Trajectory**
  
  **2003**: marginal contribution. In some areas, like Germany, there is a significant percentage of homes equipped with home networking used to provide access to the Internet. In this case the grading is more like low. In the next years home networking should spread significantly.
  
  **2008**: medium contribution. A significant percentage of homes will be wired (both through wireline and wireless connections).
  
  **2020**: high contribution. Most homes will be wired.

- **Contributor to the Storage Trajectory**
  
  **2003**: no contribution.
  
  **2008**: low contribution. The dissemination of home networking along with appliances offering/using storage will contribute to the evolution of the distributed storage paradigm.
  
  **2020**: medium contribution. Home networking will be used as a storage network (also from the outside of the home) as well as a communications network.

### 3.3.9 Modems

Devices used to code digital signals into analogue tones that can be sent over a standard telephone line. Widely used for connecting to the internet they are likely to become embedded in many devices. At the same time the growing presence of digital information and a full digital network up to the terminal points is likely to decrease the importance of modems in the coming years. By 2020 most connections will be via routers rather than modems.

- **Contributor to the Communications Trajectory**
  
  **2003**: high contribution.
  
  **2008**: low contribution. The growth of full digital communications will favour adoption of routers. The growth will be very low but the market share will still be significant due to the large installed base.
  
  **2020**: no contribution. Most communications will be digital all the way through.

### 3.3.10 Optical Fibre

Optical fibres are light guides, which can be used to conduct electromagnetic energy at optical wavelengths. The basic principle upon which they are based is reflection. In the last 20 years optical fibres have been massively deployed (particularly around year 2000 with the Internet boom) and they have evolved significantly in terms of capacity (more wavelength usable for transmitting information). A parallel evolution in the optoelectronics terminations has driven the capacity to the 10 Tbps range. This will keep increasing in the coming years possibly reaching 100Tbps by the end of the next decade. Increased capacity, however, is no longer the main drive of research. The current networks provide overcapacity in the fibre infrastructure. Most evolution is expected from the extension of the optical infrastructure to the curb (or the home) and in the change in the network architecture towards a full optical network.

- **Contributor to the Bandwidth Trajectory**
  
  **2003**: medium contribution. Optical fibre in backbones and trunk network are enabling high bandwidth and traffic capacity. Same is occurring in metropolitan networks although the deployment is in various stages in different countries and within a single country in different areas. Deployment in the last mile is marginal in Europe (for residential customer), on going in Japan (although even there it is not significant in percentage, about 500,000 users). Business customers are using optical fibre on the last mile in many cases.
2008: medium contribution. Most of bandwidth is likely to be provided on the last mile by ADSL like technology plus cable modem (cable TV) satellite links...However in the years following 2010 significant deployment of optical fibre on the last mile will change the situation. In Japan and few other Asian market plus some municipalities in the USA the optical fibre in the local loop may have taken the upper hand.

2020: high contribution. The optical fibre in the loop will provide most of the bandwidth to the end user. Wireless gateway, UWB and WiFi like will un-tether the terminal equipment from the fixed network.

- Contributor to the Communications Trajectory

2003: high contribution. The bulk of communications is through optical fibre. The deployed capacity in the backbones should be sufficient for the next five years.

2008: high contribution. The optical fibre will remain the preferred media for communications. Its expansion from the backbones and metropolitan rings into the local loop continues and by the end of the decades it should become a significant infrastructure also at this level. At the backbone and metropolitan level new "windows" and faster electronics (and optoelectronics) will further expand the transmission capacity.

2020: high contribution. Optical fibre will be the main infrastructure for communications in the transport area. It will be complemented by wireless in the access area, both to support mobile access and for un-tethered access. Capacity provided by fibre should reach 100 Tbps in the backbones and rings. The architecture of the network will evolve to exploit this capacity reducing switching cost. A full optical network should already be a reality by 2020.

### 3.3.11 Passive Distribution Ntw

A (usually) optical network with no amplification component to distribute and collect telecommunications signals in the distribution network. Passive distribution networks have been devised in the 80ies as a replacement of the copper distribution infrastructure. Their success was limited due to the cost and to the open issue of powering the telephone (that is not possible with the fibre). Alternative architectures based on rings and add drop multiplexer terminating the copper have been preferred.

In the next years passive distribution networks may find some application to connect rings to the customer premises particularly if the requirement for powering the telephone will be superseded.

- Contributor to the Bandwidth Trajectory

2003: low contribution. Passive distribution networks constitutes a minority infrastructure today (although in Japan there are about 500,000 subscriber lines based on PON). Broadband connectivity in the loop is mostly provided through xDSL on copper connecting the customer premises to the switch or through VDSL connection to add drop multiplexer on a ring. Cable television constitutes a passive distribution network although it uses coaxial cable, not fibre and it is not normally considered in this category. Recent approval of recommendation G.984 may provide a new impulse to the deployment of this technology with capacity of up to 1.2 Gbps upstream and 1.5 Gbps downstream shareable with up to 64 optical terminations.

2008: medium contribution. Most of bandwidth is likely to be provided on the last mile by ADSL like technology plus cable modem (cable TV), satellite links...However in the years following 2010 significant deployment of optical fibre on the last mile will change the situation. The deployment of this kind of technology is likely to be steered by the need to replace the existing copper. From operation economics point of view it may be more convenient to replace the copper with fibre. The xDSL installed base is still having the lion’s share for the bandwidth provision.

2020: medium contribution. The passive optical networks, in various configurations are likely to replace the current copper infrastructure. The network is likely to have evolved towards a full optical network with massive presence of DWDM in the metropolitan rings. Bandwidth provisioning, however, is likely to occur also through alternative infrastructures, including satellite and wireless. This is the reason to grade the contribution of PON to medium with reference to bandwidth.
• Contributor to the Communications Trajectory
  2003: low contribution. Minimal deployment in Europe, only few trials. In Japan there are over 500,000 subscribers connected through PON, in the USA some hundred thousands.
  2008: medium contribution. The situation is unlikely to change in Europe by 2008 but the replacement of copper favours the deployment of passive optical networks. Hence we should be seeing a growing deployment after 2010 in Europe. In Japan the deployment is planned to continue and should reach a (almost) complete coverage by the middle of the next decade (Fibre to the home).
  2020: medium contribution. Optical fibre will be the main infrastructure for communications in the transport area. It will be complemented by wireless in the access area, both to support mobile access and for un-tethered access. Capacity provided by fibre should reach 100 Tbps in the backbones and rings. The architecture of the network will evolve to exploit this capacity reducing switching cost. A full optical network extending to the customer premises should already be a reality by 2020.

3.3.12 Power Line Transmission

A technology using the electrical line to transmit information.
There have been several attempts to use power lines for connecting customer premises to the internet. Technical hurdles have so far stopped any significant deployment. Some of the technical issues may be solved in the coming years however it is an open question if those solutions would not be too little too late, particularly in areas like Europe where telecommunications infrastructures are widespread and consolidated.
Use of power line as transmission within the home is technically feasible today and there are a variety of very affordable products for doing that (home PNA). In perspectives, however, it is likely that most of the home market will be based on wireless solutions. Power line solutions may still be used in old dwellings where the thickness of walls may create a barrier to wireless, and may be used for communications among electrical appliances.
Research interest is, anyhow, very limited. A different emphasis may be placed in developing countries where the telecommunications infrastructure may lag behind the electrical one.

• Contributor to the Bandwidth Trajectory
  2003: very low contribution. Only experiments are underway. No real deployment.
  2008: low contribution. Power line transmission is unlikely to play a significant role in provisioning of bandwidth to the residential customers (no role to the business customers).
  2020: low contribution. The situation is unlikely to change. In perspective the uptake of optical fibres is hampering even more the adoption of solutions on power lines.

• Contributor to the Communications Trajectory.
  2003: low contribution. Minimal deployment in Europe, only few trials. In Japan there are over 500,000 subscribers connected through PON, in the USA some hundred thousands.
  2008: medium contribution. The situation is unlikely to change in Europe by 2008 but the replacement of copper favours the deployment of passive optical networks. Hence we should be seeing a growing deployment after 2010 in Europe. In Japan the deployment is planned to continue and should reach a (almost) complete coverage by the middle of the next decade (Fibre to the home).
  2020: medium contribution. Optical fibre will be the main infrastructure for communications in the transport area. It will be complemented by wireless in the access area, both to support mobile access and for un-tethered access. Capacity provided by fibre should reach 100 Tbps in the backbones and rings. The architecture of the network will evolve to exploit this capacity reducing switching cost. A full optical network extending to the customer premises should already be a reality by 2020.

3.3.13 Radio Connectivity

Connectivity using electromagnetic signal over a radio link. There are a variety of ways to provide radio connectivity both as transport infrastructure and in the access network. Connectivity can be in a point to point or broadcasting mode. Both are used to exchange information.
Foresight on the evolution are given in the various technologies related to Radio Connectivity, 3G, UWB, Satellite, WiFi, WPAN.

### 3.3.14 Rings

Usually optical fibres in an architecture that provides high reliability. Widely used in metropolitan area networks. Ring topology is also adopted in the trunk network.

SDH rings (SONET rings in USA and Asia) is becoming the usual architecture in metropolitan area networks. In the future the evolution is likely to be versus Gigabit Ethernet and this will change the topology from rings to double stars and further down into mesh network.

- **Contributor to the Communications Trajectory**
  - **2003**: high contribution. Economic considerations are pushing towards this solution. Metropolitan networks are mostly based on SDH and the ring infrastructure is a good fit in this case. However Gigabit Ethernet is now being considered as a potential substitution of SDH and this would lead to a different architecture (double star network). Probably the Gigabit Ethernet will not substitute completely the SDH and the two may be used side to side and in some cases integrated. Resilient packet rings have just being standardised and this is compatible with both SDH and rings and it is based on Ethernet. So far it is not used in Europe.
  - **2008**: high contribution. The situation is unlikely to change in Europe by 2008 in metropolitan area network where there will still be a significant penetration of SDH. SDH is likely to integrate other protocols like Ethernet, fibre channel – ficon - escon (both used for storage area networks). In the backbone area, however, there is likely to be an evolution towards mesh networks because of the economic savings in resources used for restoration. This may disseminate in the metropolitan networks beyond 2010.
  - **2020**: medium contribution. Fibre will be available in many residential loops and the topology should evolve towards mesh networks rather than rings. Optical cross connect cost should have come down making it possible their widespread deployment. This is a prerequisite to move towards mesh networks and D-WDM in the metropolitan area and distribution networks.

A most significant evolution is the fading away of the distinction between the various segment of the transport network. The telecommunications network in the metropolitan area are likely to consist of nodes that have a distributed intelligence (IP routing in the periphery), storage and processing capacity. This is in line with the GRID paradigm with a strong integration between the processing and the transport.

### 3.3.15 Satellite

A device either stationary or orbiting providing observation and or communication capability from the space.

Innovation in this area (and research effort) has been decreasing mostly because of economic considerations. The satellite constellations that were planned have either failed or never lift off (like Teledesic).

The economics does not support peer-to-peer communications via satellite. A different story is the use of satellite for broadcasting. There the economics is working out. Economics is also in favour of satellite technology for provisioning of connectivity in isolated areas, like most of Africa. In Europe this is not the case (although some exceptions may exist).

Satellites have a lifetime that is related to the quantity of fuel they have available since to be operational (and not to fall off the sky) they need to remain in a limited space (an area of approximately 70 km). Satellite orbits drift due to gravitational pulls and to the accuracy of the launch. This drift needs to be compensated by readjustment each one using fuel reserve.

By 2020 most of the satellites orbiting today will have been replaced by new ones and therefore innovation is continuous.

- **Contributor to the Bandwidth Trajectory**
  - **2003**: very low contribution. The provisioning of a broadband channel for Internet is a fact in many country but it is marginal when compared to the number of alternative access in
place. It is of interest for those geographical areas where no alternative exists. The need to use (in general) an uplink via a terrestrial telecommunication infrastructure is limiting the kind of services that can be effectively provided, e.g. it is excluding broadband peer-to-peer services.

2008: low contribution. The contribution is likely to remain marginal in Europe. It may take up speed in other geographical areas and because of that we might see an increasing number of users also in European areas where no broadband service alternatives exist. The approval of the RCS (Return Channel Satellite) standard may stimulate the use of satellites for interactive broadband services although the competition from alternative infrastructures will remain too strong.

2020: low contribution. There is no indication whatsoever that satellite may play a role in Europe for interactive broadband communications. The advent of the DTT, Digital Terrestrial Television may further limit the interest of the satellite.

• Contributor to the Communications Trajectory

2003: medium contribution. Widespread use for broadcasting communications, limited and decreasing use for telecommunications.

2008: medium contribution. Situation is not likely to change in this time frame. New satellite working on the V band (50GHz) may start to be deployed in the next decade. On the one hand the higher frequency may make the receiving antenna much smaller (and therefore more convenient) but on the other hand it makes the signal more sensitive to atmospheric conditions.

2020: low contribution. The satellite is likely to continue play an important role but just in niche markets. The bulk of communications will not be using satellite infrastructure. Disruptive launch technology dramatically increasing the success rate and decreasing the cost would be needed to change this trend.

3.3.16 Software Radio

A technique to update the working of a device through software wireless download. Software radio promises to increase interoperability of systems by using a common universal channel to connect such systems to a wireless network to receive instruction (software) on how to use the connection protocols and frequency available in the area. A cell phone working in Europe can automatically negotiate a new set of protocols and frequency range when switched on in the US and download from the network, through a common channel, what is needed to update the DSP and radio part, hence becoming compatible with the new environment.

Software radio may lead to significant changes in the mobile business. Through SR potentially any mobile terminal may be dynamically reconfigured to operate on a given network with specific services provided by a specific service provider. The current fighting over the branding of terminals and shifting the control from the terminal to the SIM card may reach completely new heights.

• Contributor to the Communications Trajectory

2003: non existing.

2008: low contribution. Software radio is expected to appear within this time frame. Its real impact will be felt in the following years with a widespread use possibly in the 2012 timeframe.

2020: medium contribution. Increased portability of equipment enabled by widespread adoption of software radio will foster a better communications and the transparency of the infrastructure (but not of the service provider).

3.3.17 Trunk

A physical device (cable of some sort) used in long distance communications to transport information in a telecommunications network. It may be using a variety of technologies (fibre, copper, coax) although in Europe most of the trunk infrastructure is already fibre. In some cases microwave links can be used for trunking although this represents a marginal percentage with respect to the whole trunk infrastructure.
• Contributor to the Communications Trajectory
  2003: high contribution. Mostly based on optical fibre with speeds in Europe in the order of hundreds of Gbps in the main traffic relations and in the Gbps in smaller traffic relations.
  2008: high contribution. D-DWM massive adoption multiplying the capacity of the fibre, where needed.
  2020: high contribution. Capacity in the order of tens of Tbps (and more).

3.3.18 UWB
Ultra Wide Band technology for sending signals through low power pulse emission. Developed in the military world for communication across walls (used as a radar) has been recently open to public use and the FCC has approved it. Its low power signal is less likely to interfere with other communications carriers and it is suitable to cover very limited spaces, measured in meters. Its contribution to communications is mostly in easing the access, providing a tether less connectivity, and in its low power consumption making it suitable for mobile devices.

• Contributor to the Bandwidth Trajectory
  2003: no contribution. Only lab experiments
  2008: low contribution. It is likely to have a commercial debut around 2008 and it will take a few years before becoming a major player. It is likely to be targeted to the WPAN, wireless personal networks, and although it is much more performing than Bluetooth (even the upgraded version that will be in place at that time) it will have to fight a large installed base of Bluetooth and WiFi to win its market space. The bandwidth provided is close to 500 Mbps, a hundred times better than what Bluetooth can deliver, and better than WiFi. With respect to WiFi, however the main advantage lies in the lower power consumption expected.
  2020: medium contribution. UWB is going to play a significant role in Personal Area Networks acting as an infrastructure glueing for a variety of wearable devices. Its use as picocells substituting WiFi hot spots is not likely although some UWB beacon acting as gateway to the network may be deployed.

• Contributor to the Communications Trajectory
  2003: no contribution. Only lab experiments
  2008: low contribution. It is likely to have a commercial debut around 2008 and it will take a few years before becoming a major player. It is likely to be targeted to the WPAN, wireless personal networks, and although it is much more performing than Bluetooth (even the upgraded version that will be in place at that time) it will have to fight a large installed base of Bluetooth and WiFi to win its market space. With respect to WiFi, however the main advantage lies in the lower power consumption expected.
  2020: medium contribution. UWB is going to play a significant role in Personal Area Networks acting as an infrastructure glueing for a variety of wearable devices. Its use as picocells substituting WiFi hot spots is not likely although some UWB beacon acting as gateway to the network may be deployed.

3.3.19 WiFi
Transmission technology for wireless local area communications. It is currently in an intense widespread in many countries in the world. In Europe there were less than a 1000 hotspots at the beginning of the 2003 but by the year end there should be many more and by 2006 their number may reach 10,000.
The 802.11b is the one used in Europe (in the USA also 802.11a is allowed from a frequency viewpoint) and the 802.11g will follow suit.

• Contributor to the Bandwidth Trajectory
  2003: low contribution. Although rapidly spreading WiFi is marginal in its contribution to broadband. Contrary to the USA where there has been a significant uptake at the residential level thus creating a larger market for WiFi in Europe it has been mostly tied to business customers. The situation, however is starting to change in some countries in...
Europe as well with the piggy back of WiFi onto ADSL offer.

2008: medium contribution. Hot Spots are going to become ubiquitous in crowded spaces, like airports, railway stations, transportation systems…and houses as a way to connect wirelessly to the fixed network. Policies on who is providing hot spot services will vary from country to country but almost everywhere there will be a multi provider situation. The development of the market requires an ease of access and interoperability across the physical hot spots, independently on who owns the local infrastructure. Multi standard terminals will start to become common; however the issue of what they can be used for will be addressed differently in different countries (WiFi use only for data communications, support Voice over Ip…). The advent of 802.11g will increase the bandwidth.

2020: medium contribution. WiFi is likely to remain an important alternative to support broadband access both in the home and outdoor in selected places. It is unlikely to become the main access infrastructure. New standards will support increased bandwidth. New chips in terminals will provide a multimode access with WiFi being one of several.

- Contributor to the Communications Trajectory

2003: very low contribution. In communications terms the contribution of WiFi is negligible.

2008: low contribution. There are likely to be tens of thousands hot spots in Europe and a significant traffic will access the network through hot spot. It will remain clearly a minority with respect to the use of other access infrastructure.

2020: low contribution. Although the number of hot spot will have grown significantly it is unlikely that the overall contribution to the network access will change significantly in percentage terms. It is bound to remain marginal, although significant. In some areas the coverage and the traffic capacity provided may become significant and WiFi may become, within those areas a main access infrastructure. This will depend on local choices and on the wide availability of terminals (which is not likely to happen for wearable because of the high power consumption of WiFi).

### 3.3.20 WPAN

Wireless Personal Area Network. A set of wireless technologies (today the most viable one is Bluetooth) that can be used to establish a communication network in the limited physical space on a person and extending less than a meter around the person. Most of PANs are actually W (wireless) PANs for the convenience offered by not having “wires” around. In the future there seems to be opportunities to exploit conduction properties of the skin to connect devices “on the body” using high frequency signals. It is expected that the number of devices people carry with them will grow significantly (wearable computers, e-textiles) also because of a growing availability of sensors to proactively control health and fitness.

Medical sensors on the body may use the WPAN to send information to a “hub” on the person that can interpret data and transfer its aggregate via a gateway, such as a cell phone, to a service centre, incoming calls can be routed to a PDA if a picture or data is being received….

- Contributor to the Information Visual Display Trajectory

2003: no contribution.

2008: low contribution. Portable video display will appear in the next few years. Their impact is mostly tied to the evolution of screen technology (to have them bright enough to be seen in day light) and in battery (it is unlikely that a widespread use can happen unless significant progress, breakthrough, happens in the power storage/creation). In the following years retina projectors may substitute screens. Other devices are likely to become common, in addition to cell phones and PDA, and they will provide enhanced services by being always connected one another as we move around. Wearable computers and e-textiles are unlikely to become widespread before 2010, but once they will be the demand for WPAN will grow significantly. Before that date it is more likely to see a one to one communications, either via Bluetooth or via IRD. A good portion of these devices will provide visual information that will benefit from the variety of terminals available and from their interconnection. Particularly, local storage hooked on the WPAN may significantly enhance the visual display providing additional data and/or context.

2020: low contribution. The use will become more widespread with e-textile providing additional ways to display information.
• Contributor to the Human Interfacing Trajectory
  2003: no contribution.
  2008: low contribution. Same considerations made for the Display Trajectory.
  2020: high contribution. The availability and cooperation of a variety of devices will be exploited to significantly increase the interface both with machine and with other humans (e.g. real time translation through wearable). Making use of our own personal interface and profiling is likely to become the normal way to interface with the environment. The interface is on us and knows what we like and what we are used to. Communications with the environment is likely to be mediated by the devices and applications on the WPAN.

• Contributor to the Data Capturing Trajectory
  2003: no contribution.
  2008: very low contribution. Same considerations made for the Display Trajectory.
  2020: low contribution. Although the contribution to overall data capture will remain low this far into the future we may expect to have a variety of sensors on us, monitoring our function as well as our immediate environment. All these sensors will provide a lot of information for specific applications to work on.

• Contributor to the Communications Trajectory
  2003: no contribution.
  2008: very low contribution. Most communications will be through a gateway (likely the cell phone) that will direct in a peer-to-peer relation the communication to a particular device. Beyond year 2010, however, we should start to see real WPAN and WPAN manager taking responsibility for the communications and the configuration of the various devices and also to take care of directing incoming and outgoing communications through the most appropriate gateway.
  2020: low contribution. Devices will tend to have their own direct access to the communication infrastructure however some devices will rely completely on the WPAN to get access to the world. This will represent a significant market that is likely to develop significantly if the profiling applications and service will achieve a high level of sophistication.

3.3.21 xDSL

A set of technologies to provide high capacity over a copper subscriber loop. After several years of alternating interest in these technologies they have definitely won the market with massive deployment all around the world.

Currently ADSL is the most favoured one for its lower cost and higher span (it can be provided over lengthy local loops, several km long). Other forms of DSL provide higher speed. In Japan and Korea VDSL is now the leading one in deployment. Its speed may compare to the one provided by low cost optical fibre.

By 2020 it will be a standard feature for most of the remaining copper connection.
In addition to higher speed xDSL provides always on connectivity.

• Contributor to the Bandwidth Trajectory
  2003: high contribution. Massive deployment in many European countries (and world wide). Number one broadband access to information.
  2008: high contribution. We are likely to see evolution in two directions. One towards more bandwidth provided both on the downstream and on the upstream channel with a shift towards symmetrical or dynamically reconfigurable bandwidth technologies (like VDSL) as response to the increasing number of information created at home and sent to the network plus the drive from peer to peer broadband services, including video communication. The second towards the use of the “always on” characteristics to provide services like monitoring, security....Fibre in the loop will start to be deployed also in European countries as the copper infrastructure ages and needs to be replaced but its effect are not going to be felt before the end of this decade due to the large installed base of xDSL.
  2020: low contribution. This set of technologies is likely to become obsolete not because of their lower speed with respect to fibre (which they have indeed) but because it is more economical from an OPEX viewpoint to replace the copper with the fibre once the time
comes. Therefore we can expect that a significant portion of the distribution network will be in fibre within the next twenty years thus leading to the end of the xDSL.

3.4 Devices Technologies

Devices are changing the evolution scenario. This is the consequence of the high processing power that can economically be embedded in devices, along with local storage capacity and better screens. All together this is enabling the development of new applications on the device side. Evolution in the device is now steering evolution of the communications networks (for those devices, a growing number, which connects to the network) and is steering the market offering of applications. Up to now it was the reverse with devices evolving when the network was able to provide “something” more.

In the coming years this trend is going to reinforce and the evolution “control” will definitely move to devices (appliances, sensors, tags will be the areas to watch).

As a solution to powering mobile devices will be found there will be a further impetus in evolution of devices and that will have a significant impact on networks and applications offer. The single most important technology area for devices is packaging. The cost of packaging has not decreased anywhere near the cost of electronic components. However this set of technologies have not been considered here although it is noted that research in this area is very important. Most of effort is dedicated by manufacturing industry.

The second most important ones for the success of devices (particularly in the mass market) is the set of technologies and disciplines that ease the use and makes the devices appealing. This goes under the name of interaction design. It is probably more a discipline than a technology and has not been discussed here although its importance is noted.

By far the main players in this area are from Asia in the consumer electronics, from USA for processing related devices (PDA…) and from Europe and Asia for cellphones.

3.4.1 Scanner

Scanning technologies able to scan 3D objects digitalising the 3 dimensions. There are several approaches (and related technologies) for 3D scanning. Some are targeting the scanning of (relatively) small objects and are mostly based on structural light; others target the scanning of buildings and use methods based on the reflection of laser beams. Whilst the formers today can reach resolution in the mm range the latter has resolution in the cm range. There are furthermore other techniques used for 3D satellite imaging based on shifted photos with resolution in the m range.

All these systems are still quite expensive, both the hardware part and the software part (roughly accounting 50% each of the total cost), and may go well over 100,000 Euros (low cost settings can be slightly less than 100,000 Euros).

The fields of applications are varied but always in the institutional (museums…) or business area (modelling, production processes, medical…).

- Contributor to the Data Capturing Trajectory
  - 2003: low contribution. 3D is a specialised domain, involving high cost for the equipment and for the development of software that, to a significant extent, needs to be rewritten for any new application domain.
  - 2008: low contribution. No significant changes expected due to the basic stability of the technologies involved. Beyond 2010 a limited decrease in cost should become feasible although equipment and software is likely to remain in the realm of business, institutional use. The growth in storage capacity and a more intense interest in the preservation of cultural heritage may be a driver. Another is the gaming industry. As more processing capacity becomes available it is likely that gaming will move from artificial environment to real ones therefore increasing demand for 3D scanning and making also the software part more “standardised” by creating libraries.
  - 2020: medium contribution. 3D displays, gaming and entertainment are likely to open the market of 3D scanners thus leading to a drop in price that will further widen the market. New scanning technologies may also be available thus reducing some of the cost of today’s equipment and scanning process.
3.4.2 Printers

3D printers do what normal printers do but rather than creating a 2 dimensional representation on an object they create a 3 dimensional objects.

3D printers, in a way, are not new in that they are the offspring of Computer Aided Manufacturing and the Digital Lathe. They are, however, more compact units, cost less, and are more flexible.

Flexibility is not to the level of 2D printing where the only difference is whether they can print in color or just black and white. 3D printers are still specialized in the kind of materials they can print. 3D printers able to create plastic mock-up are a commercial reality (using either a layering of micro beads on a moving plane that will provide the depth for the 3\textsuperscript{rd} dimension or molding through laser beams a substance that becomes the object mock-up). There are even some companies providing this kind of service with listed pricing like making photocopies (http://www.ualberta.ca/CNS/3DPRINTER/).

3D printers able to assemble different materials (using as ink different kind of materials made available in micro beads) are at a lab stage, still quite expensive (in the hundred thousands Euro range).

- Contributor to the Printing Trajectory
  2003: low contribution. These devices are still in their infancy (not considering the CAM devices that are used in industrial production processes) and have a high price tag.
  2008: low contribution. The situation is unlikely to change although there will be more kind of 3D printers able to process different kinds of material and create a wider variety of objects. The use of 3D printers for mock up will spread but this activity is still confined in the business area. By the end of the next decade new technologies may become available to fragment materials in more (cost) effective ways. Furthermore nanotechnologies may become easier to operate extending at the same time the capabilities of these printers.
  2020: medium contribution. 3D printing will reach the consumer market, although 2020 may be too early to see this kind of printers substituting inkjet printers on people's desk. New approaches to the creation of objects may radically change the scenario by supporting self assembling. At the consumer level, however, this is not going to have an impact in this time frame.

3.4.3 Bio-printers

Printer like devices able to layer substances to create bio aggregates. They may print a 2 dimensional layer of cell (in the sense that there is no structure in the 3\textsuperscript{rd} dimension) or may be a special kind of 3D printers used to print human tissue and, in perspective, human organs. These printers usually print at the same time an inorganic scaffolding and inject on it cells with appropriate nutrients.

- Contributor to the Printing Trajectory
  2003: low contribution. These devices are still at an experimental stage. Most tissue development is today achieved through skin growth in vitro.
  2008: medium contribution. Skin printing is likely to become more common because of the greater speed that can be achieved. Other type of tissue printing is further down into the future.
  2020: medium contribution. 3D printing of bio tissue and organs should be commonplace although it may be feasible only for some tissues and for very few organs (like bones).

3.4.4 Cell phones

A cell phone is a telephone which is connected to the telephone cellular system by radio, rather than by a wire, and can therefore be used anywhere where its signals can be received. It is distinguishable from a cordless phone since this latter can operate only in the vicinity of its cradle and therefore it is normally used within a home.

Cellphones have been mostly associated to the voice communication as a personal tool. The main evolution in the future is on the direction of multi communication streams (video, images, text,
empathy..) and in its shrinking to become embedded in a variety of object as communication gateway. Furthermore it is likely to become a multi purpose tool for interaction (e.g. remote control, virtual wallet…).

- **Contributor to the Communications Trajectory**
  - **2003**: high contribution. The number of cellphones, worldwide, has exceeded the number of fixed lines. In Europe it is the same. The high contribution is not just because of the number involved but also because cell phones have a much shorter life time than a normal phone. Hence the innovation in telecommunications (and related) services can be more intense.
  - **2008**: high contribution. The number of cellphones will continue to increase worldwide although in Europe the growth will have reached a plateau for the human communications. However cellphones will start be embedded in many object thus leading to a further increase in communicating entities.
  - **2020**: high contribution. Most communications will be using a wireless device as terminal and cellphones will have a major role. Many objects will be connected through an embedded cell phone.

- **Contributor to the Bandwidth Trajectory**
  - **2003**: very low contribution. GPRS and first deployment of UMTS is providing more bandwidth to users. The most important aspect is not the bandwidth provision but the stimulation of the market getting people used to communicate via images and video.
  - **2008**: low contribution. The deployment of EDGE and UMTS will provide wider bandwidth to the user on the move. Most of broadband, however, is going through fixed lines and partly through WiFi hot spots. For the latter there may be a growing market for multi standard cellphones providing both GSM/UMTS and WiFi connectivity.
  - **2020**: medium contribution. Wireless broadband will be common but probably still at a premium price. Disruption in the area of wireless communications may have increased significantly the bandwidth capacity but probably this will happen somewhere beyond 2020. At that point the cell phone may be required to play a pivotal role in the resolution of the interference problem thus allowing enormous increases in the wireless bandwidth capacity. Research in this area may shorten the time needed.

- **Contributor to the Data Capturing Trajectory**
  - **2003**: no contribution. Basically the cell phone is used as a gateway connecting specialised equipment that do the data capturing.
  - **2008**: minor contribution. Some cellphones either directly or indirectly may start to be equipped with sensors and tag readers.
  - **2020**: medium contribution. Most cellphones will have tag reading capabilities plus other sensors to capture data from the environment. Also, sensors in the environment are likely to be equipped with cellular communications capability to transmit data (basically a cell phone without the voice part and without a keypad since there is no number to dial).

- **Contributor to the Information Retrieval Trajectory**
  - **2003**: minor contribution. Cellphones are being used to retrieve information. SMS and information push is quite widespread. GPRS is providing an always on channel that is particularly useful for retrieving information.
  - **2008**: medium contribution. Cellphones, also thanks to better screens and to Bluetooth connections with other devices, will be an important access device to information.
  - **2020**: high contribution. The trend will continue and the cell phone, thanks to more processing and storage capacity may become the ideal device to retrieve information in most cases. In fact it can contain the profiling information about the users and this will be used by applications, both resident in the cell phone and in the network/service provider to customise the information retrieval.
3.4.5 CRT

The Cathode Ray Tube has been the usual display technology for television and computer screens up to now. CRT comes in different flavours: interlaced and non-interlaced (for television and for PC respectively), raster and vectorial (for images and drawings respectively).

In the last few years it has been challenged by the LCD technology, first for computer screen and now for television screens as well. The cathode Ray tube is still a better technology in terms of brightness and contrast than LCD but the form factor (thinness) is winning the market to the LCD.

- Contributor to the Information Visual Display Trajectory
  
  2003: high contribution. CRT is by far the widest used technology in screens both in television and (to a lesser percentage) in computer.
  
  2008: minor contribution. CRT technology in computer screens will have faded away. Television screens of less than 20 inches diagonal will also no longer make use of CRT and many wider screens will use LCD or LCD like technologies.
  
  2020: no contribution. CRT will no longer be used.

- Contributor to the Human Interfacing Trajectory
  
  2003: high contribution. Television is one of the main interfaces today and it is based, by large, on CRT. The same goes, to a lesser extent, for computer screens.
  
  2008: minor contribution. Although many CRT screens will still be in use (in Europe the percentage may be lower than in other parts of the world) there are likely to be several other technologies available as alternative for human interfacing and this will significantly reduce the relevance of CRT.
  
  2020: no contribution. CRT will no longer be used.

3.4.6 Digital Video Recorder

A device storing video in a digital form. The storage in the digital form enables a number of ways to use the information that are usually exploited by the DVR, such as the recording and viewing of a different information previously recorded or viewing with a delay of the information being recorded (a few minutes gap would allow skipping the commercials)...

In perspective, the video information can be supplemented by others making it possible to tag specific parts and thus enabling more sophisticated information retrieval.

Progress in this technology is favoured by the increasing capacity of hard drives which makes it possible to store much more information. Today it is common to be able storing 40 hours of video (top of the line can store about 100 hours) and in a few years the number of hours should be several hundreds. By 2020 new storage devices would make it possible to store an almost unlimited number of hours changing radically the way we look at a DVR. No longer a "cashing" device where information is temporarily stored but a data base for permanent storage of information. This will create a whole new set of applications and services.

- Contributor to the Storage Trajectory
  
  2003: low contribution. DVR are quite widespread in the USA, much less in Europe. Price is coming down and the market is likely to grow.
  
  2008: medium contribution. Increased capacity and the piggy back of information will make DVR a more interesting proposition. Price will reach the level of a high performance VCR. Storage capacity will be in the 200 hours of video.
  
  2020: high contribution. DVR is likely to play a significant role in the home storage. It will provide a huge amount of storage capacity, in the TB range, and its connection to the home network, plus the variety of services plugged on it, will make it the central repository of the house, going further than the storage of movies and videos to include storage of personal information captured by the people living in the home.

Research in this field may prove essential in achieving competitive advantage not (as much) in the device itself which will likely sell as a commodity but in the services that will make it possible to have an easy exploitation of the information.
3.4.7 E-book reader

A device conveniently displaying digital information like a book.
E-book readers have been around for a number of years with limited success. The convenience of storing a significant amount of books has so far been out weighted by the more difficult reading of an e-book screen when compared to a paper book. Battery consumption has been a drawback as well. Large size displays are bulky to carry and PDA sized ones fit conveniently in the pocket but provide a very limited reading space.
Technology is progressing in various directions and better e-book readers are now on the market. Much better ones may be expected in the coming years.
The form factor and the readability will play a major role in the widespread acceptance. The amount of storage capacity will increase but it is not going to be a key success factor nor it will be the integration of communications capabilities (WiFi and cellular) although they can provide some motivation in choosing one model among others.
Other crucial aspects are the management of copyright issues and the convergence on a format.

- Contributor to the Information Visual Display Trajectory
  2003: marginal contribution. Products are available but there is a slow uptake in the market. New prototypes have been announced from some research lab, providing better readability and better user feeling. The aim is still towards mimicking the paper book. It may be a long road and possibly not a successful one.
  2008: marginal contribution. The evolution of technologies: screen, battery, font display, connectivity will improve the e-book. At the same time more titles will become available and the parallel evolution in the paper book distribution will make digital versions available at the same time of the printed ones. All these factors may not be sufficient for a success of the e-book but its uptake by the market may stimulate authors and editors to start producing books for the e-book, that is books that are not suitable for printing but only for an e-management. This may provide a much more compelling reason for people to buy e-book (and the needed reader).
  2020: medium contribution. Most people in Europe will have some sort of e-book reader handy. This will not signal the extinction of the paper version for quite a while. The availability of a wide installed base of e-book reader (in this time frame equipped with connection port) is likely to stimulate content production and services based on that content. Possibly, exploitation will come from the gaming industry, from education needs, tourisms...

3.4.8 Flat Screen

Flat screens make use of different technologies. The one that is mostly widely used is the LCD, Liquid Crystal Display. Other technologies are promising to provide bigger screen like the Plasma, and some even at lower prices, like SED (Surface-conduction Electron-emitter Display) and NED (Nano Emissive Display).
The trends are towards better characteristics (brightness, contrast, viewing angle, thinness, weight), larger screens and lower cost.
The main factor influencing cost for LCD is the production process that yields significant waste as the dimension grows.
SED promises to slash production cost and therefore to have bigger screen economically viable, NED provides higher resolution.

- Contributor to the Information Visual Display Trajectory
  2003: medium contribution. Flat screen display, mostly based on LCD technology, are winning the computer market where, as an example, Sony has discontinued production of CRT screen for sizes of 15 inches and lower. They are also making their way into the television market.
  2008: high contribution. Most screens are likely to be flat screens with the exception of wide screens (25 inches and above). However, flat screen technology will also be found in video projectors so also very large screen will be based on it. Beyond 2010 it is likely that all screens will be flat screen. By 2008 the main technology is likely to remain LCD but for the higher end of the market there will be a significant penetration of SED. Beyond 2010
SED and NED are likely to take the upper hand against LCD. In the small screen market (cell phones, PDA) OLED technology is likely to be the one more widespread although its (relatively) limited life time (5000 hours) makes it unsuitable to some devices where the screen is always on.

2020: high contribution. All screens will be based on some sort of flat screen technology. Plastic screens will be available. New technologies are also to be expected in this area providing better resolution and real big screen at low cost.

### 3.4.9 Information Appliances

Information appliances are everyday objects used mostly in the home that can interact with each other and with the dweller to create a more effective, or intelligent, environment. The main issue is that the benefits deriving from a single appliance are very limited and not sufficient to motivate customer to spend extra money for that. Over time it may be expected that all appliances will embed communicating computers and therefore will be bought. Once a sufficient density of appliances exists in a home new services and a new relation with the home environment becomes possible. One of the hampering factor can be the lack of standard and the lack of motivation of single industry to provide appliances whose better performance have a cost but whose experience has to be deferred till other appliances are in the same environment.

- Contributor to the Human Interfacing Trajectory
  - 2003: very low contribution. There are very few information appliances today and they are not connected one another.
  - 2008: low contribution. There will be many information appliances and the market should have reached a significant penetration in Europe. However it is unlikely that within any given home there will be a sufficient “density” of appliances to trigger a new way to interact with the environment. It will be more a peer to peer relationship with better interfacing between the person and that particular appliance but it will be difficult to exploit the potential of an intelligent ambient created by a multitude of appliances. Beyond 2010-2012, that is after the replacement cycle for appliances has turned around there will be a sufficient density in a significant number of dwellings to open the way to a new relation between the dweller and the home environment.
  - 2020: high contribution. Information appliances (and smart appliances) will be the standard inhabitants of every home and will provide a completely new way to interface with them and with the environment as a whole. Services will be both provided by the appliances themselves, by the platform made up by all the appliances together and possibly downloaded by third parties and by external providers able to access the appliances and the environment from the outside.

### 3.4.10 Notebooks

PC for people on the move. From the marketing view point there is usually a distinction, in terms of size and weight, into Laptop, notebook, and sub-notebook, this latter approaching the size of a PDA. From a technological viewpoint it is more convenient to group them all into one cluster, the notebook. Differently from the PDA they have a full operating system, Windows.

Notebooks are going to win over the PC in a few years for their smaller size that better fit in the home and also the office environment as constraints deriving from lower speed and the possibility of inserting specialised cards (graphic accelerators, video cards...) are fading away. It is likely to repeat the same pattern of the slow but sure uptake of the flat screen over CRT, even though CRT remains slightly better. First signs are already available with the offering of Mega-notebooks.

- Contributor to the Processing Trajectory
  - 2003: high contribution. Mostly used by business customers.
  - 2008: high contribution. Equally used by business and residential customers. Prices have decreased making them comparable to PC. The forma factor is winning the market. All notebooks embed wireless communications capabilities, most of them WiFi. All notebooks embed graphic accelerator.
  - 2020: medium contribution. The notebook, as we know it today, will have faded away.
There will still be many of them but people will be buying more specialised devices that will provide them with processing capabilities whilst ensuring a more function oriented interface, thus an easier interaction.

3.4.11 PDA

Personal Digital Assistant is any small mobile hand-held device that provides computing and information storage and retrieval capabilities for personal or business use, often for keeping schedule, calendars and address book information handy. There are a number of operating systems (Palm OS, Windows CE, …) still fighting one another. PDAs are on a collision route with cellphones and it is unclear what the outcome will be. For sure PDAs are going to become more and more connected and cellphones will embed more and more memory and processing power.

- **Contributor to the Processing Trajectory**
  - **2003**: very low contribution. PDAs are not used for processing data, their main use is for displaying and storing them.
  - **2008**: low contribution. More processing power and better batteries are pushing a more intensive use of PDA also for processing but more in terms of running applications on local data for presentation purposes. They are still not seen as processing devices.
  - **2020**: medium contribution. PDA are likely to have more processing power than today’s PC thanks to breakthrough in the batteries. Since the PC and the notebook will have faded away in most environment the PDA is likely to be considered as a device to do some processing as well. In this case it will plug in (wirelessly) into a screen for visual interaction. Interfacing with PDA will occur mostly via voice.

- **Contributor to the Data Capturing Trajectory**
  - **2003**: no contribution. Only specially equipped PDA are today used in some business environment for data capture (warehousing, distribution chain…) and in most cases are specially constructed.
  - **2008**: low contribution. A wider number of PDA will be equipped with some sensors. Tag readers are likely to become embedded around 2008 or soon afterward. In the next decade they are likely to become a standard feature.
  - **2020**: medium contribution. PDAs will be equipped with sensors and tag readers, plus other devices that can automatically pick up data from the environment.

- **Contributor to the Information Display Trajectory**
  - **2003**: medium contribution. PDAs are not as widespread as the cell phone but those using them do that to display information.
  - **2008**: medium contribution. No evolution expected in the use of PDA nor in their relative number in relation to cell phones.
  - **2020**: medium contribution. PDAs are much more powerful than today but they will be just one out of many devices people will be using to display information.

- **Contributor to the Communications Trajectory**
  - **2003**: no contribution. Most PDAs are not connected to the public network, only few exceptions.
  - **2008**: low contribution. Most PDAs will be connected to the network (wirelessly) and will also be used to retrieve and send information. It is unlikely that they can become communication-oriented terminals, they will just make use of communications.
  - **2020**: minor contribution. All PDAs will be connected to the network but the main use is not likely to change.

- **Contributor to the Storage Trajectory**
  - **2003**: low contribution. Personal data are stored on the PDA. This is, however, mostly a mirror of data stored somewhere else whose mirroring on the PDA enables consultation on the move with no need to establish a connection.
  - **2008**: medium contribution. The enhanced connectivity on most PDA is not decreasing their role as information storage. On the contrary. Leveraging on a bigger storage capacity the PDA are likely to become a main storage device for personal data and synchronisation will occur to keep other devices up to date.
  - **2020**: high contribution. Huge storage capacity and applications running on PDA help
make sense out of the data in accordance with the user profile. Data will be more and more carried around, in spite of the potential ubiquitous connectivity.

### 3.4.12 Personal Computers

A Personal Computer (PC) is a small, relatively inexpensive computer designed for an individual user. PC will keep growing their processing power and memory (both dynamic and storage). Processing power is likely to rapidly lose any appeal on consumers who are already starting to slow down the turn over being satisfied by their current processing power. For a few years the push towards upgrading the PC may continue, pushed by video applications but it will definitely exhausts its drive by the end of this decade.

Further down in the future it is unlikely PC will manage to remain part of the scenario since processing power will be gradually embedded everywhere and the economics that have pushed towards a multipurpose device, the PC, will no longer be valid. Every device needing processing power will have it. This will greatly simplify the interface making it function orientated.

- **Contributor to the Processing Trajectory**
  - **2003**: high contribution. The PC is “the processing” device both for business and residential customer. The continuous growth of its processing power has enabled more and more applications and motivated people to buy new models.
  - **2008**: high contribution. It remains the main processing device, both in the home and in the office. However the drive to change the PC because a new more powerful version is on the market is/has faded away. Applications are starting to be produced for specialised devices, gaming consoles being on the leading edge; these, in turns, are starting to offer processing power to other applications (e.g. entertainment). Digital cameras will have their own processing capacity that can be used for photo editing.
  - **2020**: marginal contribution. The PC, as we know it today, will have basically disappeared. There may be several around but the idea of buying a new PC is unlikely to come to a residential customer who would rather look for application specific devices.

- **Contributor to the Information Display Trajectory**
  - **2003**: medium contribution. Much information is being shown on a PC as result of its processing of the information.
  - **2008**: medium/high contribution. The same usage as today plus, potentially, the management of entertainment information, also the one coming from the television. It is this perspective that leads to the /high grading. However the scenario is still pretty unclear and its evolution may play out in a completely different way with the telecommunication, and entertainment system acquiring some of the PC information display functions. Already today, digital camera output is likely to be processed in a PC but the result is then displayed on a television set.
  - **2020**: marginal contribution. The fading away of the PC will obviously result in the fading away of its use as an information display device.

- **Contributor to the Communications Trajectory**
  - **2003**: medium contribution. Most of data communications, both business and residential, is generated and received by PC.
  - **2008**: medium contribution. The situation is unlikely to change in 2008 although there will be a growing number of devices that can generate and receive data hooking on the telecommunication network. This situation is bound to change in the first years of the next decade where on the one hand entertainment and gaming devices will produce massive data communications and sensors will produce huge number of transactions.
  - **2020**: no contribution. The fading away of the PC clearly leads to its demise also from the communications area.
• Contributor to the Storage Trajectory
  2003: high contribution. PC has become an important repository of data, both for business and residential customer due to the increasing storage capacity and to the applications on the PC to manipulate and display the information.
  2008: high contribution. The PC remains a main storage of information. It might even become a bigger one, not just in terms of storage capacity (which for certain it will do) but in terms of the quality of information. Much entertainment information is likely to end up on the PC. Progress in the entertainment devices will shift information from the PC to them and this may start to happen before year 2008 but it remains to be seen.
  2020: low contribution. The fading away of the PC will see its demise also as an information storage device.

3.4.13 Printers
Devices to print information on a variety of support materials.
Printers will continue to increase their resolution for the next few years but then the demand from the market is likely to stop requiring more resolution. New printing technologies may increase the printer speed and its flexibility. Demand for printed material is unlikely to diminish in spite of the possibility to use information directly in a soft form (through screens on various devices). Actually a lot of information is now used only in a soft form and never printed. However the amount of printed information has kept growing throughout all these years and this trend is likely to continue, just not at the same rate of the growth of information production.
In the longer term we might be seeing a levelling on the growth of printed information and possibly a decline.

• Contributor to the Printing Trajectory
  2003: high contribution. Widely used.
  2008: high contribution. Widely used. Better printers will provide all the resolution and colour definition needed. Wireless communications will favour the sharing of the printers with many objects.
  2020: high contribution. Still widely used. Smaller printers may find their way into many objects. Resolution is no longer an issue. Capability to print more than the eye can see will be a plus. Micro print will provide additional information that is invisible to the human eye but can be seen and processed by applications.

3.4.14 Projection Displays
Systems able to project a digital image on a screen.
Digital projectors are quite widespread, mostly in business and educational presentation. The other two markets are the digital entertainment (in theater) and in the home entertainment.
Cost has been the major stumbling block with a ratio of 10 up to 100 to one in favor of direct display technology.
Movie theaters are slowly going digital to slash distribution cost of the film. Additional services may become available in the next few years through multimode presentations (digital screen +WiFi connectivity to local personal screen...).
In the home market both price and noise have delayed the uptake of this technology. Cost is coming down but alternative technologies, like flat screen LCD are coming down as well. Noise has been reduced but it is still a factor.
Another drawback is the brightness of the projected light and the need to have a screen to get better performances and contrast. The big advantage of projection is the large image that can be obtained versus the still limited flat LCD screens.

• Contributor to the Information Display Trajectory
  2003: low contribution. Mostly used in business and institutional environment.
  2008: minor contribution. Technology keeps getting better but physical constraints, like the clear sight between the projector and the screen, make it unsuitable in many situations (like a living room where people moving around will stop the projected light). Rear projections require too much space to be practical in a home environment.
2020: marginal contribution. Competition from flat screens is making it a weak proposition in most situations. Projectors may find application niches in very large dimensions (like a theatre) and for mobile devices where projections is an interesting alternative to screen since it can provide large images without requiring a bulky screen. For these applications micro projectors will be used.

3.4.15 Robot

A machine or device that operates automatically or by remote control. Robots are independent entities having a place in the physical world. Sometimes they are human like although most of the time they just look like a machine. They can act purposefully to perform specific actions. Their evolution is towards goal orientated behavior. Most robots today are part of production environment although some are seen as extension of the human capacity, like in surgical operation. A very tiny minority is being used in entertainment (e.g. Aibo).

- Contributor to the Human Interfacing Trajectory
  2003: no contribution. Experiments in research labs
  2008: marginal contribution. Visible in few niche markets
  2020: medium contribution. Many human activities are going to be carried out by robots (or applications). Interfacing with them is going to become common although the path to get there is not easy at all. Possibly new communications paradigm will be needed as well as a new “culture”. The idea that robots will be good to interact with, once they will look like human, is ill founded.

3.4.16 Scanner

A Scanner is an input device that converts images or objects into digital information and transmits the data to a computer as digital code. There are a variety of technologies being used for scanning:

- Flatbed: also called desktop scanners, are the most versatile and commonly used scanners.
- Sheet-fed: are similar to flatbed scanners except the document is moved and the scan head is immobile. A sheet-fed scanner looks a lot like a small portable printer.
- Handheld: use the same basic technology as a flatbed scanner, but rely on the user to move them instead of a motorized belt. This type of scanner typically does not provide good image quality. However, it can be useful for quickly capturing text.
- Drum: scanners are used by the publishing industry to capture incredibly detailed images. They use a technology called a photo multiplier tube (PMT). In PMT, the document to be scanned is mounted on a glass cylinder. At the centre of the cylinder is a sensor that splits light bounced from the document into three beams. Each beam is sent through a colour filter into a photo multiplier tube where the light is changed into an electrical signal.
- Text: scanners: use optical character recognition software to read pages of text and produce editable text files
- Bar code: scanners, as used in stores, convert bar codes into digital information.
- Fingerprint: scanners: analyses and measures certain biological characteristics of an individual to create a unique identifier that can be electronically stored and retrieved for identification.

- Contributor to the Data Capturing Trajectory
  2003: high contribution. Scanners in various forms are widely used. Technology is progressing in terms of resolution and speed.
  2008: high contribution. Better (more resolution and faster) scanner available. Many are likely to become embedded in other objects as part of the data capturing capability of the object. New technology (particularly leveraging on software for image recognition and better image capturing chips) will enable new applications and also new types of scanners (e.g. through a video camera).
  2020: low contribution. As a single standing device scanners will no longer exist. However scanning functionality will be a common feature of many objects, glasses included.
3.5 Power Technologies

Power technologies are fundamental in the area of mobile devices and those that have to stay for long periods of time (months) without an external power supply. Many technological areas are being considered and progress is expected on many of them. In this first round of WP2 only those connected to the storage of electrical power (batteries) and to the creation of tiny spikes of current to support micro signalling and communications among objects have been considered. Most notably it was not considered the area of power generation (solar cells, turbines…).

Leading players are in Asia (Korea is investing significant sum in research and development) and partly in the USA, particularly in research in innovative technologies (like smart materials and nano technologies).

3.5.1 Batteries

Devices able to provide electrical power over extended periods of time. Batteries have a crucial impact on most portable devices and on stand alone systems needing to operate in places were no main is available.

For some of these devices new battery technologies, like fuel cells for lap tops and PDA may decrease, in the long term, the powering problem.

Advances in battery technologies have been significant but the parallel increase of demands from faster chips has nullified the advances; actually the gap between offer and demand is growing wider.

This has also resulted in an increase of chip complexity to be able to switch off those parts of the chip that do not need power at a certain time.

Batteries impact in a variety of ways the ITC scenario; as an example in the communications area huge battery racks are needed to provide continuity to the service. The spreading of optical fibres in the distribution network requires the availability (and maintenance) of batteries in various places (no longer confined in the exchange premises) with additional cost. Bringing the fibre to the home would require some batteries in the terminal to assure continuity of service.

Same goes for Information Display where the screen is using a significant amount of power and portable devices with large screen drain the battery resulting in short operation time.

In the end, however, batteries are connected to the processing since in all cases it is some sort of processing that requires the power (to display, transmit…). This is why focus is given to the impact on the processing trajectory.

- Contributor to the Processing Trajectory
  2003: medium contribution. All portable equipment are making use of batteries. Even equipment connected to the main usually requires a small battery to provide continuity of power to some chips even when the device has been switched off (e.g. to the clock).
  2008: high contribution. The growing use of mobile devices increases the importance of batteries. No new technology is likely to appear in this time frame, however a number of technologies that have been developing in the labs are likely to make it to the market. Among these the fuel cell technology, the piezoelectric technology (for low power demand) and flexible batteries. Beyond 2010 new technologies like the ones based on nano tech and porous materials are likely to provide even more capacity per cubic centimetre of battery.
  2020: very high contribution. Increased mobility of devices plus the huge number of sensors will keep putting pressure on batteries, including long lasting micro batteries. New technologies like converting bio-energy into electrical energy (micro turbine in the blood vessels, chemical conversion of glucose from the blood into electrical energy…) and micro nuclear batteries are likely to be available.
3.5.2 Micro piezoelectric

Capability to generate electrical current through a miniaturised device exploiting the piezoelectric effect.

The current produced is a short and tiny impulse sufficient to generate a radio signal with a reach of a few meters.

These micro devices may be of interest to provide signalling capabilities without the need for batteries.

An additional application can be in the charging of batteries such as the inclusion of these devices in shoes. The continuous generation of spikes created by walking can be used to accumulate energy. In perspective this may be a useful way to power WPAN as well as low power wearable devices.

The exploitation of the micro piezoelectric effect is becoming possible by the creation of very low energy consumption devices that can "live" out of the micro currents generated and the discovery of more effective ways to generate and harvest energy resulting from the piezoelectric effect.

Most of the impact is going to be felt on sensors attached to some moving devices that can provide the "force" activating the piezoelectric effect, and on tag reading or signal sending within limited spaces, like a room. For this reason the focus is on its exploitation in the field of data capturing.

- Contributor to the Data Capturing Trajectory
  2003: no contribution. Basically only experimental prototypes exist although some products are on the market, e.g. to send signals from a radio switch, activated by the piezoelectric effect, to a device.
  2008: low contribution. A growing number of piezoelectric generators will be inserted in everyday objects to provide signalling. In the next decade certain kinds of sensors and tag readers will start making use of this technology.
  2020: low contribution. Development in micro batteries technology is likely to keep the exploitation of the piezoelectric effect to some niches. It will remain important in those cases where the need for power is very low, it is demanded scarcely and over long period of time so that the use of batteries will be costly from an operation standpoint (need to periodically check and replace the battery).

3.6 Processing Technologies

Processing has been the other pillar contributing to the evolution of ICT. Progress is continuing towards more processing power and within 3-5 years the processing availability will reach the point where it exceeds demand for most uses.

One of the significant changes occurred in the 90ies was a shift from a demand driven by business to a demand driven by residential users. This trend is reinforcing now and in the next years evolution in processing is likely to come from the consumer electronics, rather then the business sector. A major role is going to be played by the gaming and entertainment business.

By far the main players in this area are in the USA. However new ones from Asia (Japan) are about to play a leading role given the shift towards consumer electronics.

Huge processing power will remain a goal in very specific sectors like scientific research (medicine, astronomy...), environmental forecast (earthquakes, weather...) and possibly in economy research (such as the study of chaotic systems).

Supercomputing technologies have not been considered in this first deliverable of WP2. It is worth mentioning, anyhow, that supercomputing today and in the future 15 years will depend heavily on three technological areas: the microprocessor evolution (the normal one, for normal microprocessors like those used in PC and game stations), the architecture evolution (this includes the interconnection of the chips and the way to partition the load) and the operating systems evolution. For the foreseeable future Linux seems to be the one playing the bigger role. The Blue Gene project (by IBM with DARPA funding) should provide multi Petaflops by 2010. http://www.research.ibm.com/bluegene/
3.6.1 Digital Signal Processing

The capability of manipulating a digital signal, usually to compress it. It is performed by a specialised processor on a chip able to manipulate the digital signal. Usually the raw digital signal is compressed and handed over for transmission. Modern DSPs have additional functionalities like pre-processing of the signal (conversion from analogue to digital) and the packeting of the compressed signal into a format suitable for transmission.

- Contributor to the Information Visual Display Trajectory
  - 2003: medium contribution. DSP chips process digital information. In many cases they are also taking care of the decoding (e.g. Mp3, MPEG-4...). Graphic processing cards in computer make use of DSPs.
  - 2008: high contribution. Digital television will start to be widespread and will make intensive use of DSPs. More and more objects will be processing and displaying information making use of DSP chips.
  - 2020: high contribution. With the decreased cost of screens DSP chips are likely to be as common as processing chips and, possibly, any processing chip will include the DSP function.

- Contributor to the Processing Trajectory
  - 2003: medium contribution. DSP is widely used to process graphical information.
  - 2008: medium contribution. DSP is widely used to process graphical information.
  - 2020: medium contribution. DSP function is likely to be embedded in most (if not all) processing chips.

- Contributor to the Communications Trajectory
  - 2003: high contribution. Most communication is digital in Europe (and in most parts of the world). DSP is a fundamental component in digitalising signals and in the processing of information for its transmission (coding and decoding).
  - 2008: high contribution. Most communication is digital in Europe (and in most parts of the world). DSP is a fundamental component in digitalising signals and in the processing of information for its transmission (coding and decoding). A significant portion of DSP will take place at the edge of the network and in access terminals. Part is taking place directly in the device (appliance) used by the person or machine communicating (e.g. video cameras).
  - 2020: high contribution. All communication is digital in Europe and in most parts of the world. DSP is a fundamental component in digitalising signals and in the processing of information for its transmission (coding and decoding). Most DSP is taking place directly in the device (appliance) used by the person or machine communicating. However DSP is also widespread in the network for various functionalities like protocol adaptation.

- Contributor to the Data Capturing Trajectory
  - 2003: low contribution. A growing number of appliances (in the entertainment sector) is making use of DSP (like digital video cameras).
  - 2008: Medium contribution. Many devices capturing data have DSP “on board”.
  - 2020: very high contribution. All devices capturing data have DSP embedded to code and pre-process data in digital form.

3.6.2 Distributed Processing

The cooperation of several processing units performing a single task. Distributed processing supports three requirements:
1 - the processing requires data that are located on different processors and that may not be shared as such but can be used to compute some functions;
2 - by splitting the task on several parts that can be computed in parallel one can harvest more computing power;
3 - the task is in reality a composition of several tasks occurring in parallel on their own. Telecommunications services and networks are usually in this situation. Here the problem is to avoid conflicts arising from parallel computation, also known as the “features interaction” problem.
In the first two cases clear definition of sub-tasking is very important. In 2) an effective multiplication of processing power occurs if the task can be performed in parallel computation. This is usually a very difficult problem to solve and in general the processing power harvested is a subset of the total power theoretically available.

Distributed processing technologies are partly hardware (supporting communications, synchronisation, data sharing at the architectural and chip(s) level) and partly software (managing applications, managing access to data, supporting the creation of applications...). Attempts in defining standardised software architectures for distributed software (like TINA and CORBA) have had limited success. Linux is today being used in processing clusters and more interest is now drawn by the GRID (see related item).

Significant evolution has taken place over the last 30 years and more is expected. Chips in PC are now supporting a certain flavour of distributed processing within the chip itself and within the PC (the use of graphical processors is an example).

Most of processing in a PC is done in a distributed way. The same goes for telecommunications networks. Distribution there occurs both within a single function (e.g. intelligent routing achieved through the coordination of several systems) and across different functions (e.g. service delivery where processing may occur in the service provider centre, in the network at various places and in the terminal).

Evolution towards GRID (see relevant bullet) is a further step towards distributed environment.

- Contributor to the Information Visual Display Trajectory
  2003: low contribution. Graphic processors are often used together with the main processing unit to present information. In some cases the terminal has sophisticated processing capabilities to take care of some processing function in the display. With few exceptions the architecture is more one of sequential cooperating systems rather than a real distributed processing.
  2008: medium contribution. Terminals are likely to become more and more powerful and able to perform tailored information display functions progressively using a distributed architecture involving other processing entities. The growing importance of profiling will also steer the evolution of distributed processing in the Information Display area. Most applications, anyhow, will work on a cooperation-based architecture rather than a real distributed one.
  2020: medium contribution. Distributed processing is likely to be a reality in information visual display. The complexity and variety of terminals and the applications available to manipulate information will have pushed towards this architecture. For business applications sophisticated information display is likely to make use of the GRID, a typical distributed architecture.

- Contributor to the Processing Trajectory
  2003: low contribution. Distributed processing is a reality in PC at the hardware level (within the chip and among chips in the PC). It is not at the application level.
  2008: low contribution. The situation is unlikely to change. Most of the distributed processing occurs at the hardware level with little involvement of applications. Gaming machines are likely to adopt as a standard a distributed processing architecture (beyond the splitting of core processing and graphic processing that is already a reality today), like the one proposed by Sony with “The Cell”. The increased importance of Massive Multiplayer Games will also contribute to increase the demand for distributed processing and distributed “applications”. At the telecommunications level the presence of many players will steer the interest towards distributed applications (and features interactions). The ever growing density of features on terminals (particularly cellphones) and the possibility to run applications on them will also stimulate work on distributed application processing. All these seeds are unlikely to spring by 2008 although significant research should be going on. They are more likely to bring results in the next decade. The GRID (see relative bullet) will be a widespread reality but mostly for scientific applications and some cooperative gaming networks.
  2020: high contribution. Most processing is likely to occur locally in objects. However the pervasive communication networks, both local (WPAN) and worldwide plus the presence of a variety of service providers will stimulate cooperative processing and the use of a variety of distributed applications. In a way by 2020 one is likely to see a reverse situation of what we have today where the dominant aspect of distributed processing is the...
hardware part. By 2020 the dominant part will be the software based distribution processing. This is not to say that hardware will not longer support or operate in a distributed way. Quite the contrary. But at the hardware level distribution will be a de facto situation with the real value laying in the software distribution. Progress is required in the creation environment for distributed applications, in testing and simulation. Environments will take advantage of distributed applications as long as privacy of data and ownership can be protected. Also negotiation and retribution for processing power is likely to play a significant role in its dissemination.

- Contributor to the Communications Trajectory

**2003**: medium contribution. The telecommunications environment is a distributed architecture with a lot of (hierarchical) rules in place to ensure everything works. Interoperability has, and is, a major concern. Till few years ago interoperability was mostly a network issue. Now, particularly with the growing interplay at the application level of networks and terminals (as seen in the UMTS) the main issue is shifting to the interoperability of terminals (given the wide variety and their rapid evolution). The distributed processing is a way of life, and because of that, it has a medium impact. Networks are already engineered to be distributed.

**2008**: medium to high contribution. By 2008 the situation is likely to be similar to the one of today. Networks are still based on a distributed architecture (physical, control, management, service provisioning) and the importance of terminal interoperability will be as high, or higher, than today. In the following years, however, dissemination of technologies like the software radio, the D-WDM in the metropolitan area networks, the greater presence of many content providers that are likely to become application providers will signal a much higher impact on the telecommunications networks. That is why the grading has been set to medium-high.

**2020**: high contribution. The distribution of applications will have a significant impact on the telecommunications environment, possibly resulting in an overlaid network (a virtual one) consisting of applications, content and application providers centres, terminals, users' applications. Complexity will skyrocket. Research in this area is still on the starting block. Results will be crucial and the outcome of this work may significantly change the telecommunications scenario in terms of actors. The balance may shift from current players to new ones or, with about the same probability, may reinforce some of the current players position.

The trend towards a separation between the network and the applications may happen, with main consequences on current actors, or may just be twisted around with an embedding in the network of key applications acting as the gluing of the distributed application architecture.

### 3.6.3 Graphic Processing

A special processing optimised for graphic manipulation and display. Graphic processing is widely used to enhance gaming on PC and console. Some games require the availability of a graphic processor to run.

Graphic processors have higher sophistication and have achieved higher performance than the normal processing chip. They are "power hungry" and therefore are usually inserted in devices with access to the main. In the coming years evolution of batteries is expected to make their use possible also for people on the move.

Some graphic processing, particularly for scientific and some business applications, make use of heavily distributed architectures (like the GRID, see relevant bullet). Typical is case of graphic processors usage for the rendering in the movie area. There, hundreds of processors are being used to render special effects and create video sequences.

- Contributor to the Information Visual Display Trajectory

**2003**: medium contribution. Visual display is making significant use of graphic processing. In PC, particularly those targeted at the residential and gaming market, there are graphic processing cards. Digital televisions have special graphic processing cards to support the
display of information and in some cases also top of the line analogue televisions have these processors. Their high power consumption makes it awkward their use in a mobile environment. Mobile devices, like digital cameras and video cameras usually have graphic capabilities embedded in DSP chips.

2008: high contribution. Graphic processing is widely used, also thanks to the digital television and the gaming console. The market preference for notebook (with a progressive decline of desktop PC) is pushing graphic processing in these computers. Battery remains a significant problem for devices on the move. In the next decade some radical solution to the powering problem (fuel cells...) is likely to further the adoption of graphic processing also in the mobile environment.

Scientific and business applications are likely to turn to highly distributed applications (and architectures) for graphic processing where each of the nodes is likely to embed the same graphic processing found in gaming consoles.

2020: high contribution. Graphic processing is likely to be everywhere. The widespread availability of screens will favour graphic presentation. Likely many of the features provided today by graphic processing will be embedded in the normal chip whose high clock speed makes it able to provide most graphic processing. However there will remain a significant market for graphic processing in the area of 3D in its various forms. This is likely to remain a specialised (more niche like) segment and separate graphic processing is likely to provide the required processing facility.

Scientific and business graphic processing needs are likely to be satisfied by distributed architectures.

• Contributor to the Human Interfacing Trajectory

2003: medium contribution. Usage of graphic display, and the support of graphic processing, is favoured by human beings in most interaction. There are obviously other interaction channels that have similar or higher importance, hence the rating of medium.

2008: medium contribution. The situation is unlikely to change, although there will be growing availability and use of screens requiring graphic processing support. In the next decade the number of screens, and particularly the way interactions will occur with objects is going to put even higher demand on graphic processing.

2020: medium contribution. Most graphic processing used in human interfacing is likely to be provided by graphic facilities embedded in normal processing chips. Some applications will make use of 3D representation (also hologram-like in the sense that images will appear dancing in the air in front of the persons) and these are likely to require specialised graphic processing facilities.

• Contributor to the Processing Trajectory

2003: low contribution. Most of processing does not need graphic processing. True graphic interfaces are widely used but they are basically at the end of the food chain.

2008: medium contribution. The relevance of graphic processing over the whole processing is going to increase. The wider availability of screens will contribute to it. Also graphics may become a way to represent entities in the intermediate steps of the food chain thus increasing the use of graphic processing. First examples are around today in labs and in some niches like bio-engineering, aircraft design. More will come in the next few years.

2020: medium contribution. Processing chips will embed today’s graphic function provided by specialised chips and cards. Graphic processing will be, to a significant extent, indistinguishable from the normal processing.

### 3.6.4 GRID Computing

The Grid is a type of parallel and distributed system that enables the sharing, selection, and aggregation of resources distributed across “multiple” administrative domains based on their (resources) availability, capability, performance, cost, and users’ quality-of-service requirements. Depending on the goal, the GRID can be classified into:

- Processing GRID (providing number crunching capacity by sheer processing power)
- Data GRID (providing huge and dispersed data analyses capabilities)
- Application GRID (providing access to and integration of distributed applications to create a higher level service).
Processing and data GRID are already a reality. The application GRID is still a research subject although some experiments have been conducted. This aspect of the GRID is not being discussed since it does not fall into the selected technology trajectories (it falls into services and service creation).

- **Contributor to the Storage Trajectory**
  - **2003**: low contribution. Data grids are applied in certain (limited) fields, like storage of astronomic and medical data.
  - **2008**: medium contribution. Huge amount of storage and the presence of distributed storage make the adoption of GRID technologies widespread in the industry and for scientific application. No mass market influence.
  - **2020**: high contribution. Distributed storage and massive local storage will be exploited through services likely based on the data GRID.

- **Contributor to the Processing Trajectory**
  - **2003**: low contribution. Only niches applications, like in movie special effect rendering, massive multi-user gaming and in some bio-engineering areas.
  - **2008**: low contribution overall. More niche markets, including environment protection, earthquake forecasting. Overall it remains a marginal contribution, although an important one for those niches where it is used. No processing “commoditization” through the GRID since processing is already a commodity through PC.
  - **2020**: low contribution overall. Processing will be available mostly everywhere in any object and there will be plenty of it locally. GRID will be used extensively but mostly in niches thus not contributing to the overall processing.

- **Contributor to the Bandwidth Trajectory**
  - **2003**: very low contribution. Experiments have taken place to increase significantly the real transmission speed over the network. In spite of the huge capacity of optical fibres the raw speed of data is limited by the protocols used and by the limitation of the electronic – optical conversion. By using GRID systems at the sending and receiving end it has been shown an increase of an order of magnitude in data transfer. This is of interest only for very specific areas.
  - **2008**: low contribution overall. GRID technology to increase bandwidth will be adopted in some niche market. It is irrelevant in most applications.
  - **2020**: low contribution. GRID technologies will be used to increase speed but it will relevant in selected niches only. The dissemination of the Storage GRID will provide alternative solution to the need of transfer data and hence it will decrease the speed requirement (but it will not diminish the capacity requirement).

### 3.6.5 Microprocessor

The core of the computer sporting processing capability. It has seen a continuous evolution in performances (Moore’s law) leading on the one hand to a tremendous processing power basically at a stable cost (slightly decreasing over the years) and to spectacular decrease in cost keeping performances stable. The cost decrease has reached such a level that today many microchips are embedded in disposable objects.

Within the next three-five years the performance level of microchips will have exceeded the thresholds of what is dreamed of by the end user and its price, as a consequence, will start spiralling down resulting in the embedding of significant computing power in everyday objects. Progress is depending on a shrinking of the basic component dimension, now in the 90 nm range with expectation to go down to 13 nm by the end of the next decade and a corresponding clock speed up to 30 GHz.

A project by the Austin University and IBM, TRIPS, aims at producing a 1 TFLOP chip by the end of this decade.

- **Contributor to the Processing Trajectory**
  - **2003**: very high contribution. It is at the core of the processing functionality. 1 billion chips have been produced in the last 30 years. It is expected the second billion will be reached within the next two years. Top speed around 3GHz with local cache memory, hyper threading...
2008: very high contribution. Higher clock-speed, probably higher than the need of most users.

- 2020: high contribution. Top speed may exceed 30 GHz with lot of local cache. Alternative microprocessor technologies may become available. Processing and communications will be bundled together.

### 3.6.6 Mobile Processing

Processing suitable for mobile devices where power consumption is a main concern. Progress in mobile computing is making desktop-like processing power available in laptop. However for devices like PDAs and cell phones processing power is lagging behind. This is putting some constraints on the human interfaces (both in the graphics and in the voice recognition). In the longer term low performance microprocessors (however with a much higher processing power than today’s desktop) are likely to be used for mobile processing. This is also due to the trend of embedding communications capabilities in the microprocessor so that it will be convenient to converge on a single architecture.

A different sort of mobile processing chip may play an important role in cellphones, the microprocessor embedded in the smart card (in the SIM). There is a strong interest from mobile operator to push towards multimegabyte SIMs with increased local processing power. The processor inside the SIMs is a mobile processor with some special characteristics that makes it likely it will have an independent evolution of the microchip for PC. Its characteristics are more similar to the ones used in active tags. Additionally the industry is starting to produce multiprocessors within a chip for the cell phone market. Each of the processors runs at low MHz thus consuming less energy and their sum provides high processing power at a fraction of the energy consumption that would be required by a single processor chip.

- Contributor to the Processing Trajectory
  2003: medium contribution. Although there is a lot of mobile processors their contribution on the whole market is still overwhelmed by the normal microprocessor.
  2008: high contribution. Most processing will be by 2008 or soon after through laptops and through network connections. That is why a high ranking is given to this technology. SIMs should have surpassed 1 MB of storage and its processor should have moved from 50 to a 100 MHz.
  2020: low contribution. Less need for specialised mobile processing. Standard chip is likely to be used. There may be a significant market for microprocessors deriving from the mobile ones for use in tags and SIMs like devices.

### 3.6.7 Molecular Computing

Rather than using silicon, molecular computing uses organic molecules (based on carbon). Molecular computing is attractive to perform some kind of processing like the ones requiring very dense parallel computation. It is unlikely to substitute, even marginally, the silicon based processing. Rather, in the longer term, it may complement it.

- Contributor to the Processing Trajectory
  2003: no contribution. The technology is on trial in several labs but no commercial application is on sight.
  2008: no contribution. Situation is unlikely to change, no breakthrough on sight. Some specialised molecular computing applications may be available in the bio-engineering field.
  2020: low contribution. Even in presence of some breakthrough the contribution of molecular computing to processing will remain low.

- Contributor to the Data Capturing
  2003: no contribution. Technology is on trial to be embedded in some sensors, particularly targeted to environmental monitoring
  2008: very low contribution. Embedding in some sensors both in the environmental monitoring and for health care (diagnoses, monitoring) is likely.
2020: medium contribution. The diffusion of sensors will give a boost to the use of molecular computing for its closeness to some component used to detect substances in the environment. The molecular computing provides a straightforward interface for local processing.

### 3.6.8 Quantum Computing

A processing capability based on elementary particle quantum status. Most of this technology is on paper. Only few experiments have been made with an approach that is not very different from the one used for molecular computing with similar problem in reaching stability of operation.

The unit of performance is the Qbit and so far top experiments have been able to reach 7 Qbits. To have some practical applications this number should double, at least, and this is beyond current technological possibility with no clear way on sight on how to solve the problems. Quantum computing would be capable of tackling problems that are really hard to solve with von Neumann architectures (the one on which the silicon microprocessor is based) like the factorization of large numbers. This would create havoc in the cryptography area making it possible to decrypt anything in a very short time.

At the same time the underlying technology needed in quantum computing can be applied to make communications tamper-free (any attempt to tampering will destroy the message). In this area research is getting real close to have commercial results available. This may occur as soon as 2004.

Speculation of the possibility to use quantum communications to increase the speed is still in the realm of theoretical talks. A sound mathematical bases is missing, since the one currently used assumes a statistically significant population for yieling correct results.

- **Contributor to the Processing Trajectory**
  - **2003**: no contribution. Only few experiments in the labs, still investigating a variety of approaches. No indication on where a breakthrough may come from.
  - **2008**: no contribution. Even if an unexpected breakthrough should materialise it is impossible that we can have a working quantum computer in this time frame. In the next decade some progresses may be expected. On the other hand a solution may never be found.
  - **2020**: marginal contribution. Assuming that a breakthrough is found and a quantum computer can be implemented the contribution to processing will be very focused to some niches and the impact on the overall processing scenario will be close to nothing. This does not underplay its importance since the impact on very specific areas like cryptography and information retrieval in huge data bases can be significant.

- **Contributor to the Communications Trajectory**
  - **2003**: no contribution. Only few experiments in the labs, still investigating a variety of approaches. No indication on where a breakthrough may come from. Open discussion on the possibility to establish and making use of a quantum based communication. Research on secure communications based on quantum coding is getting close to have applicable results.
  - **2008**: no contribution. Even if an unexpected breakthrough should materialise it is impossible that we can have a working quantum communication in this time frame. In the next decade some progress may be expected. On the other hand a solution may never be found.
  - **2020**: marginal contribution. Assuming that a breakthrough is found, and a quantum communication can be implemented, the contribution to communications will be very focused to some niches and the impact on the overall processing scenario will be close to nothing. Difficulties in establishing a working (usable) quantum communications are different from the one of establishing a quantum computer so one may materialise independently of the other.
Contributor to the Information Retrieval Trajectory

2003: no contribution. Only few experiments in the labs, still investigating a variety of approaches. No indication on where a breakthrough may come from. Before using quantum computing for Information retrieval a quantum computer has to exist. Alternative solutions to massive database search can be found in (yet to be implemented) holographic storage.

2008: no contribution. Even if an unexpected breakthrough should materialise it is impossible that we can have a working quantum communication in this time frame. Hence there is no reasonable hope to apply it to the searching of massive databases.

2020: low contribution. Assuming that quantum computing becomes feasible in this time frame (and there is no assurance to it) the most promising application is in the area of information retrieval. Its need will be substantial, given the huge amount of data available at that time. It would likely operate in a GRID architecture. It is not possible, however, to assign a probability to the happening of this scenario.

3.6.9 Software

The set of instructions, technologies and techniques to make use of a certain set of hardware capabilities.

Software has become a very large field but in general it is difficult to establish a metrics to determine how much the software has progressed and to forecast how much it will progress. Some metrics exists on the productivity (how much software can be implemented by a person in a given time) and on faults. In any given “software area” more focused metrics exist but still it is very difficult, even in a specific area, to measure and forecast progress. Usually one can see progress in terms of services provided but this is often a distorted view of reality. As an example voice syntheses has made tremendous progresses but most of these should be attributed to the evolution of processing capabilities and of storage capacity. At the same time it is undeniable that these progresses without a parallel progress in software able to leverage on them would have not resulted in progresses in the voice syntheses.

In another example some researchers are frustrated by the lack of progress in Artificial Intelligence. Is it because of the lack of progress in software or a lack of progress in the understanding of what intelligence is and the way to implement it?

For sure the number of software programs been written has kept growing and will keep growing in the future. Software is pervading any area, wherever there is processing power to harvest there is software to do it.

It may therefore be misleading to select one technology trajectory and not another one, since software is in anyone of them. As an example, today’s and tomorrow’s printers are loaded with software in the device and in the computer driving them and it is thanks to this software that increased performances are experienced.

Criticism on the analyses made in this report has been voiced and correctly so. If software is so pervasive and so crucial to any field why has it not been given much more of emphases? Are there research areas worth investing European money? The answer is not easy and it is felt more pragmatic to look at software in its many applications and in conjunction to the many technologies that are making use of it (e.g. 3D scanner technology evolution is crucially depending on both hardware and software so if investment is felt important to foster its evolution it should cover both hardware and software). Research on the evolution of the software productivity is also important but it is unlikely to be confined within one geographical area to serve that part of the world.

Contributor to the Processing Trajectory

2003: high contribution. Firmware and operating systems of various sort are making processing capacity available to applications. In addition to the three main operation systems for PC (Microsoft, Apple and Linux), on which research makes very little sense, there are a variety of small operating systems (for cellphones, for cars, for appliances…) that will prove crucial to make the best use of the processing power provided. Additionally there are operating systems harvesting processing power in distributed computing (many are based on Linux). There are operating systems for game stations (proprietary and unlikely to be worth investment at European level, although some thoughts should be given to the role of Europe in the gaming industry also given its potential fall out in the
education field).

2008: high contribution. Possibly some consolidation in areas like cellphones and appliances may restrict the number of operating systems. Operation systems supporting distributed environment and embedding communications features in a virtual communications environment are also needed. Among these the operation systems for the WPAN.

2020: high contribution. Software will continue to be a key element in exploiting processing power. Added complexity derives from the existence of processing power basically everywhere in the environment.

- Contributor to the Information Visual Display Trajectory
  2003: medium contribution. Software plays an important role in displaying information and in making it appear in the most suitable way for the specific viewer.
  2008: medium contribution. More information is available in visual form or can be transformed into a visual form thanks to the increased availability of displays. Software plays an important role also in the customisation of information to the specific display characteristics.

  2020: low contribution. Information visual display is likely to become standardised at the edges transferring part of the processing directly into the hardware. Today’s graphic cards are likely to evolve, in this time frame, no longer in the direction of more processing power (higher number of polygons) rather in terms of understanding what is needed to be displayed and work accordingly.

- Contributor to the Information Retrieval Trajectory
  2003: very high contribution. Software is already playing a crucial role in all information retrieval, the web browser being but one example.
  2008: very high contribution. Availability of more information makes the search, selection and adaptation of information to context ever more important.
  2020: very high contribution. In this timeframe the environment will be populated with information and this information will have many potential link to information in other context. Information retrieval will, almost always, involve the understanding of the context in order to pick up the best fit.

- Contributor to the Human Interfacing Trajectory
  2003: very high contribution. Graphical interfaces are progressing in providing better interaction with the users.
  2008: very high contribution. Haptic as well as voice and graphic interfaces cooperates in synch with the user profile to provide better interaction. Affective computing, a basically software issue, is starting to be applied to many interfaces.
  2020: very high contribution. Profiling, affective computing, understanding of the context, learning from experience, all software implemented features, are merged to provide much better user interfaces.

3.6.10 Voice syntheses - recognition

Voice synthesis and voice recognition technologies are mainly software systems for synthesizing and recognising human speech.

Progress in these areas have been possible by leveraging on greater processing power and storage capacity. The pre-processing of information (phonemes, sentences...) has resulted in much richer data bases that can be used to process voice and to create voice. Software has contributed to it in the sense of making it possible to exploit these advances.

In the future it is likely that the same path to evolution will hold. There is expectation that human language understanding, at least for the more commonly spoken languages is no more than a decade away. Once that is achieved the extension to other languages should not be a big issue. Services like language translation are becoming possible and voice recognition makes real time translation a possibility (by 2010 for continuous spoken natural language, thanks to processing speeds exceeding 5 GHz).

Voice recognition does not apply just to spoken language at the time it is voiced. A lot of applications will focus on the search of voice data bases, like news, meetings recordings...
• Contributor to the Human Interfacing Trajectory
  
  **2003:** marginal contribution. Only applied in niches. Extension to mass market (giving voice command to the PC, as an example) has not been successful.
  
  **2008:** low contribution. The diffusion of hand held devices and the increased processing power they can provide makes voice recognition feasible. First it is going to be used to intercept single sentences, then it will be able to recognise natural language spoken specifically at it. Several other forms of interaction remain in place and the voice interaction is unlikely to play a major role, outside, possibly, of some niches (like interface for the car driver, for people with hands disabilities,…). It is also unlikely that the emergence of natural language understanding, at this level, can change the situation for people who do not feel at ease interacting with the computer. Voice commands do little to change that.
  
  **2020:** medium contribution. More processing power in any device will make voice interaction more ubiquitous. Also, technology should have progressed to the point to understand a talk and discriminate one person among others. Interactions with machine at that point can become more natural and this may lead to a wider acceptance of interacting with machines. However by that time a new generation of users will be on the stage and they will not have the same trouble this generation has in the interaction with machines. In spite of a pretty good voice recognition and syntheses most interaction is likely to take place using other means than voice. Gesture capture and visual interaction is likely to have a bigger usage than voice interaction because of its higher effectiveness in presenting complicated patterns in an easy way.

• Contributor to the Information Retrieval Trajectory
  
  **2003:** marginal contribution. Only a tiny fraction of information is today retrieved by voice.
  
  **2008:** low contribution. More information, particularly the one stored in voice format (or deriving from a voice format, like voice messages left in an answering machine), is likely to be pulled out through voice command. This remains a tiny fraction of the whole.
  
  **2020:** medium contribution. As technology, to make sense out of voice information, progresses more interest is to be found in voice based information retrieval.

• Contributor to the Data Capturing Trajectory
  
  **2003:** no contribution. Voice activated recorders are already on the market but they are useful only when operated in a quiet environment. There is no voice recognition technology involved.
  
  **2008:** marginal contribution. An advance in the voice recognition technology and in the identification of a voice makes it possible to support voice specific activation of recording.
  
  **2020:** medium contribution. Sophisticated voice syntheses, always-on, can discriminate (through specific applications) when and what to capture. Captured voice is understood and therefore can also be stored in such a way that it will be easy to retrieve also in a textual format, if needed. Wearable devices may take care of the recording and of the decision on when and what to record. Project like MyLifeBits (Microsoft) and LifeLog (DARPA) will have made results available.
3.7 Storage Technologies

Storage technologies have seen a spectacular evolution, overall, faster than processing. Unlike processing, where the underlying technology has not changed (it just got better), in storage the evolution has been driven by the advent of new technologies leading to a more discontinuous progress (a continuous progress is seen, as in processing, within a specific technology). The trend is towards more storage capacity through higher density. Cost will keep decreasing and local storage will keep increasing, completely disrupting service architectures. Rather than turning to the network to connect to some service and content providers to make information available, the network is more likely to be used to get authorization since the required information is locally stored. By far the main players in this area are manufacturers from Asia (Korea, Japan, Taiwan).

3.7.1 Distributed Storage

Storage of data associated to a common purpose/ownership in separate locations or/and separate storage devices. Distributed storage is achieved through a set of technologies, partly hardware, most software.

As more and more applications will be available to link information the concept of distributed storage will extend from a business topic to a residential one as well. Information in the home will be partly stored in the PC, partly in the entertainment system, partly in laptops, partly in dedicated storage devices, like digital photo archive. This information may be pooled with other information at school, at the office…and so on.

All this makes up for a pervasive distributed storage. Indeed in the future distributed storage, by far, is going to be the way information is stored.

- Contributor to the Storage Trajectory
  
  2003: low contribution. Mostly focusing to support business needs. Correlation is not a major issue. Security, availability and capacity are the major drivers.
  
  2008: medium contribution. More information is being available in digital form, also in the home environment. More data storage devices exist and mirroring of information becomes a practical way to ensure availability. Applications (software) to support distributed storage proliferate.
  
  In the telecommunications network, distributed storage is widely used as a way to ensure fast access to information.
  
  2020: high contribution. Huge amount of information stored in a variety of devices. Links across information is a crucial part of the information value. Distributed storage is common and widely used. A variety of services are made available to exploit distributed storage platforms.

3.7.2 DRAM

Dynamic Random Access Memory is a volatile memory used in PC and most everywhere processing functions need fast local data storage. It is the smallest and most economical memory cell to construct.

- Contributor to the Storage Trajectory
  
  2003: very high contribution. Used in all PCs and everywhere there is need to temporarily store data and retrieve them at high speed.
  
  2008: very high contribution. Trend is towards increased density, with basic elements down to 60 nanometers. 1 Gb per chip should be the norm.
  
  2020: very high contribution. Higher density and basically same field of application.
3.7.3 Hard Disk

Devices for storing of data providing a fast read write cycle. Hard drives have evolved significantly in these 30 years both in terms of capacity and cost decrease. At the same time they have been able to increase the bit transfer rate and decrease the size of the device.

Evolution has not been smooth since periods of linear evolution have been followed by a breakthrough in (both) reading head and magnetic layer (covering the disk and storing the information).

Evolution is likely to continue at least for the next 5 years leading to the TB storage capacity.

- Contributor to the Storage Trajectory
  - 2003: very high contribution. Used in all PC, now also in digital video recorder. Micro drives are being used in digital cameras.
  - 2008: very high contribution. Expanded capacity, in the TB range makes it the preferred storage device in computers and big appliances. The evolution of the micro drive continues but has ever stronger competition from compact flash cards that in the same form factor are less energy consuming and provide higher capacity (cross over point in 2004 from a performance point of view, in 2005 from an economic point of view). Compact flash, in their various forms are taking the upper hand in mobile devices and wherever the main power comes from batteries. It is unlikely to see significant performance improvement beyond 2012.
  - 2020: low contribution. Competition from other kinds of storage technology is pushing the hard drive in the backstage.

3.7.4 Optical Disk

Plastic disk to store information that will be accessed through a laser. They are characterised by high capacity (depending both on the substrate of the disk and on the laser beam used to etch the substrate, with blue ray technology being the most performing for the time being). Because of their high capacity they have displaced the diskette.

They have high resilience although it is unclear for how long time information is kept before degrading. Anyhow the evolution in the disk driver is what poses the most severe risk to the preservation of information (capability to read it after a long time).

New technologies are increasing the capacity by using holographic techniques for storage. Currently the technology is a write once read many. The cost of the writing equipment makes it basically a read only memory from the consumer world point of view. This is bound to change in the coming years with the possibility to rewrite the substrate and the lower cost of the writer.

- Contributor to the Storage Trajectory
  - 2003: high contribution. Optical disk (CD ROM and CD RW) are widely diffused. DVD are mostly used as read only memory. Blue Ray disks are still in the lab phase. Holographic disks are on the market (with 100 GB capacity) but only for niche application (still pretty expensive). Most optical disks are in the 5 inches format. Smaller formats exist but are a rarity.
  - 2008: high contribution. Blue Ray disks should have become widely diffused with a capacity nearing the 20 GB. Holographic disks are available in 1 TB capacity but they are unlikely to be widespread in the consumer market. Smaller disk formats (for digital cameras, as an example) are more common than today but still the leading format is the 5 inches.
  - 2020: high contribution. 100GB + is the norm with widespread diffusion of holographic disks. Smaller form factor disk are the norm.

- Contributor to the Information Retrieval Trajectory
  - 2003: no contribution. Sequential access to information retrieval. The storage media is not suitable for accessing at high bit rates (although it is perfectly suitable for video services).
  - 2008: very low contribution. The use of holographic disks in some niche area stimulates the development of highly parallel data retrieval and information search.
  - 2020: low contribution. Holographic disks may become the preferred storing media for those areas where massive searches are required since they support parallel search. The search is performed without having to transfer the information in the processor. The
new reading head is positioned in such a way that it will just read the desired information. New technologies may be required to achieve this result. In addition new approaches may be devised to be able to retrieve information like voice or images through a direct search (no processing involved).

3.7.5 Read Only Memory

Digital memory that can be written only using special equipment and from then on can only be read.

There are several kinds of technologies for read only memory, including holographic memory, polymer based memory, and silicon based memory.

The trend is towards higher density and therefore more capacity. This is achieved through a shrinking of the elemental storage cell, a parallel increase in resolution by the reading heads (in those cases where there is a reading head like holographic memory) or a brand new technology, like micropede (IBM) where the information is stored on a plastic surface that becomes micro-dented through the etching produced by a laser warming the surface to 400 degrees and creating a micro hole.

New technologies, being tried in labs, make use of nano technology. This promises more than a 10 times increase in density and storage capacity.

Some of these technologies will evolve supporting also the writing. Read only memories are of interest to content providers since they are cheaper than read write and moreover they preserve the content, although they do not provide any ownership protection since the content can be copied. Attempts to block the content from being copied, or to require the original disk, so far have failed.

- Contributor to the Storage Trajectory
  2003: very high contribution. Widely used.
  2008: very high contribution. Widely used. The trend is toward higher density and therefore higher storage capacity and very low cost. Polymer memory should appear in this time frame providing for a few cents TB storage capacity. This kind of evolution have a disruptive effect on communications since it pushes towards the availability of large bulk of data in the periphery changing the requirements on the communications infrastructure. In the next decade nano technology may rapidly widespread leading to a ten fold capacity increase.
  2020: very high contribution. Widely used. Current technologies are likely to reach a limit in the increase of capacity but new technologies are likely to become available and push the capacity even further. As capacity exceeds a certain level searching becomes an issue.

3.7.6 Semantic Data Base

A database organised in such a way to relate entities by their meaning.

The increase in information gathering and the creation of huge data warehouses makes the problem of retrieval more and more complex. In addition current retrieval techniques, based on pattern matching, are not suitable in many instances where the person (or machine) searching for the information does not know the exact pattern.

Semantic data bases can support the retrieval of information based on their meaning. This can be derived by some specific applications at the time the information is stored and it can be stored in an appropriate way in the data base.

Research and innovation are required both in the data base architecture (how to store the semantic information to make retrieval effective) and in the technology to derive meanings from data. As an example data can be in a textual form and its content should be understood to answer queries like: “find me the meeting records where we had a hot debate on the use of broadband in the residential market”. Another example can be a visual content like images or video clip where a possible query could be: “find me a video where people get scared by a lion”. As shown by the examples the retrieval implies an understanding of the information meaning and it has to be able to answer a potentially unlimited number of questions phrased in hundreds of different ways although they can look at the same piece of information.
Semantic databases will become a very important business tool but more than that they will ease information retrieval to lay persons in everyday life.

- Contributor to the **Storage Trajectory**
  - **2003**: no contribution. Very little use beyond some experiments.
  - **2008**: very low contribution. Some use in niches.
  - **2020**: high contribution. Significant amount of information is stored in semantic databases. Hardware and software will make it possible to tag harvested information and associate meaning to it.

- Contributor to the **Information Retrieval Trajectory**
  - **2003**: no contribution. Basically no use of semantic databases. There are some services, like the AT&T one letting customers to look for e-mail or voice mail messages placing queries at the phone with question like: “has anybody left a message for the meeting in Geneva next week?”, but these services are not exactly using semantic data bases technology, rather they work more on a syntactical level searching for words and assessing probability, like a search engine on the internet. However they are making use of special applications to isolate keywords in the information, as it is stored.
  - **2008**: medium contribution. Technology is becoming available and a larger use of semantic database can be expected.
  - **2020**: high contribution. Significant interplay between coding (information, structure and context), storage and the information retrieval. Possibility to retrieve images leveraging on intelligent coding at the source and appropriate storage.

### 3.8 Terminal Points Technologies

“Terminal point” is “per se” a name projecting into the future. The assumption is that in the future everything will be connected to a network and therefore it will be a terminal point when seen from the network.

Terminal points for (telecommunications) networks used to be human beings (for a while a compromise was needed and a telephone was the termination point; with the dissemination of the cell phone it can now be said that humans are indeed terminal points). In the near future there will be many terminal points that have nothing to do with humans (unlike an ATM since it is just a special interface connecting a human to a specific network for a specific application). Machine to machine, sensors tags will dominate the scenario, at least in terms of numbers.

This is a major change from today.

The main players have yet to be identified and it is very important for Europe to be among them.

#### 3.8.1 Active Tag

An active tag is an identification element based on a powered chip that emits (continuously or on demand) its identity. A tag may also contain additional information, available upon request.

Price is one of the key issues for their success as it is the powering. Low power consumption is critical for their deployment in areas with no main available.

Active tags can be read and written through appropriate devices.

The line separating active tags from microcomputer and from sensors is a thin line. It is going to become even thinner as active tags will embed some processing capability and possibly some sensing capability at the same time that microchips and sensors will acquire communications capability. In the long term it is possible that the only differentiating factor, price, will become negligible and the active tag will disappear as a separate device.

- Contributor to the **Pin-pointing Trajectory**
  - **2003**: no contribution. Active tags exist but their use is more for experimentation than real. Price is still too high (in the hundred Euro range) to allow any significant dissemination.
  - **2008**: medium contribution. Price should have come down, in the 50 Euro range and less. In the following years lower price will be achieved contributing to their widespread use and therefore making them useful for pinpointing.
  - **2020**: medium contribution. Competition in pinpointing will come from several other...
technologies. Their use is surely not focusing on pinpointing but their wide dissemination may make it convenient to use them for pin-pointing as well.

- Contributor to the Data capturing Trajectory
  2003: no contribution. Marginal use in some experiments.
  2008: medium contribution. Growing dissemination with the potential to contain some KB of data that can be sent on demand to the tag reader.
  2020: high contribution. Wide dissemination supporting a variety of needs of information captures. The presence of some sensing and some processing capacity will increase the value of data.

3.8.2 Beacons

Reference points (mostly emitting a radio signal) usable by a variety of devices to determine their location.

The basic issue is the existence of a standard. Failing that, the application can only be local through locally provided devices (like in museums).

- Contributor to the Pin-pointing Trajectory
  2003: very low contribution. Only a few exist for everyday use. The ones used in aviation and maritime navigation are rapidly disappearing because of the availability of GPS.
  2008: low contribution. Indoor pinpointing may be achieved through beacons, as an example in museum to activate specific presentation.
  2020: low contribution. Mostly used indoor although there are likely to be several other competitors (outdoor, unless special cases like narrow streets in some municipalities, Galileo or the like will be used).

3.8.3 Bio-markers

A set of technologies used to identify a certain location within a tissue or a specific type of substance, e.g. a protein, within a body.

There will be a significant growth in the use of bio markers in the last part of the next decade as more personalised health care take the upper hand with respect to general drugs development. The contribution to pinpointing is obviously in very specific niches although very important ones like: scientific, environment, health care.

- Contributor to the Pin-pointing Trajectory
  2003: very low contribution. Only few applications in bioengineering and medical screening.
  2008: low contribution. Wider use, particularly in medical screening and in environment.
  2020: high contribution. Important applications related to personalised drug monitoring.

3.8.4 Bio-electronics

A technology bridging living cells (and beings, animals and humans) that aims at making it possible to interchange information between them.

Basic progress in establishing electrical interaction between living cells and electronics have been made and more are expected in the area of interacting with cells in living tissue. So far there is only a very rough interaction with tissue with little or no selectivity at all (the electrical signal cannot be directed to just one specific cell in the tissue nor it is possible to determine from which specific cell a given signal is generated). Micro needles are likely to be substituted by nanotechnology and further down in the future antennas may be bound to specific proteins in specific cells. Other technologies are providing means to have living cells operating in a symbiotic organism including electronic components.

- Contributor to the Human Interfacing Trajectory
  2003: no contribution. Only experiment in the area of the “electronic eye”.
  2008: low contribution. Much better results in the area of electronic vision both through
micro spikes at the brain cortex and through implant of a chip on the retina. Hearing implants are still in the research phase. **2020**: high contribution. Significant progress in using bio-electronics for supporting human interfacing both to assist disable people and to enhance experience. Acceleration sensation, tactile, augmented vision will be available for professional use and also in games and virtual reality situations. Hearing aids implant will be available but used only in very specific situations.

- **Contributor to the Data Capturing Trajectory**
  - **2003**: no contribution. Only few experiments in the labs and few medical applications.
  - **2008**: very low contribution. Increasing number of applications both for medical control of body activities and in a symbiotic relationship in sensors to capture certain data on the environment.
  - **2020**: medium contribution. Higher presence of bio-electronics in health care and in the environment for monitoring purposes.

- **Contributor to the Information Visual Display Trajectory**
  - **2003**: no contribution. Only few experiments to restore sight to the blind.
  - **2008**: very low contribution. Better implants also providing higher resolution for restoring sight to the blind.
  - **2020**: low contribution. Implants will become common to restore vision in blind people.

### 3.8.5 Biometrics

Technologies that allow identifying and/or authenticating people. Security concerns will stimulate research in biometrics making systems more accurate and easy to use in everyday life.

- **Contributor to the Human Interfacing Trajectory**
  - **2003**: very low contribution. Few labs experiments to recognise emotional status based on facial observation.
  - **2008**: low contribution. Diffusion of video cameras and evolution of image capture and recognition will make it easier to understand facial mimics leading to an improved human interface able to adapt to the specific situation.
  - **2020**: high contribution. Observation of various aspects in the human interaction (beyond face displayed emotions) will be a norm in human interfacing.

- **Contributor to the Data Capturing Trajectory**
  - **2003**: low contribution. Several products, marginally used except in some niche environment, to discriminate identity based on iris scan and fingerprinting.
  - **2008**: medium contribution. Biometrics embedded in chips will significantly reduce the cost and contribute to its dissemination.
  - **2020**: high contribution. Biometric data normally used for identification.

### 3.8.6 Digital Camera Sensors

Camera image sensors are silicon chips that have numerous photosensitive areas (photosites) constructed with photodiodes and arranged in arrays within the CCD or CMOS chip structures. Both CCD and CMOS image sensors' job is to convert light into electrons. New architectures of the image sensors will provide better definition and accuracy in colour nuances. The current top resolution in prosumer products is high enough to cover most photographic needs. Within 2-3 years sensor resolution will no longer be an interesting characteristic since it will have exceeded requirements. Other factors, like white balancing and transfer speed may keep distinguishing products targeted to professionals from the ones targeted to amateurs. By the end of the decade this component will be a commodity in many objects available at very low cost. A further evolution is happening on the usability of the same image sensor for both taking still images and video. Today’s chips targeted to digital camera make a poor job in taking video clip and the same is true for the reverse. By the end of the decade one image sensor will be able to perform both tasks perfectly.
Contributor to the Data Capturing Trajectory

2003: medium contribution. Digital cameras have already reached the number of conventional cameras sold in the US and Europe is following suit. In Japan they have already overtaken the sale of conventional cameras.

2008: high contribution. Most cameras being sold will be digital cameras. The sensor resolution and quality, even for low price model, would meet amateur’s requirements.

2020: high contribution. No more film based cameras. Some digital camera sensors will be available to take stereoscopic images.

3.8.7 e-ink

Electronic ink, it can transform a sheet of paper into a display. This name denotes a number of technologies that have already led to products on the market. The resolution is still low but it is going to increase in the next 3-5 years. Its advantage over LCD display is the lower price.

Contributor to the Printing Trajectory

2003: marginal contribution. Used, marginally, in supermarkets labels since it eases price updating from a central PC.

2008: low contribution. Better resolution and colour drive its adoption in a number of fields. Mostly used in situations where there is a cost associated to the updating. This cost should offset the lower cost of papers to which the e-ink has to be compared. It is not a competitor to displays.

2020: high contribution. A significant amount of paper will be produced in form to support display through electronics. E-ink, in one of its form, is likely to have widespread application. The paper feel of the page makes it a good candidate in substituting paper.

Contributor to the Information Visual Display Trajectory

2003: very low contribution. Used, marginally, in supermarkets labels since it eases price updating from a central PC and in some large advertisement billboards.

2008: low contribution. Better resolution and colour drive its adoption in a number of fields. However it is not a competitor to displays.

2020: low contribution. Competition from usual displays technologies is likely to remain too high. Its major advantage over these should remain the low cost. The paper feeling may make it successful in certain niches, like e-books.

3.8.8 Gesture capturing

Interaction with a machine achieved through recognition of human gestures. Although it makes use of video cameras (one or, more often, several) and in some cases of tags the technologies are basically software based. Image recognition plays a significant role.

Contributor to the Human Interfacing Trajectory

2003: very low contribution. Few applications, like in the gaming industry, are starting to appear. The capturing is quite limited, assumes the person to be in a specific position and it is only able to capture certain gestures. In research labs, more sophisticated software (and sometimes the specific setting of video cameras) provides better results. This software is finding some niche applications in the rendering of movies.

2008: low contribution. Gesture capturing will still be in a prototyping phase with more applications but either limited in performances or too costly (or bulky) to attract the mass market.

2020: high contribution. A common feature in several human interfaces. Together with affective computing is going to significantly change the interaction paradigm with machines.

3.8.9 Haptic Interfaces

Communication, or interface, with a computer involving a device that senses and/or recreate tactile sensation, such as a data glove or special force feedback joysticks.
Sensations are recreated (or detected) with a number of motors (or sensors). One of the key parts in haptic interfaces is the software application that has to render the sensation adapting the response of the device to the particular “hand” using it. Software is also used to model the object surface in order to create the sensation. Already used in a crude form in several games (force feedback) more sophisticated models are used in the medical and design fields. These latter have a very high cost (in the tens of thousands of Euro).

- **Contributor to the Human Interfacing Trajectory**
  - **2003**: very low contribution. Force feedback joystick, mouse and game pads are available in the gaming market at relatively low cost. More sophisticated devices are used in scientific and professional area.
  - **2008**: medium contribution. Wider use of haptic interfaces in gaming but also in other devices to ease the interaction. The car steering wheel may vibrate to alert the driver of a dangerous situation… Significant progress, although without significant price decrease can be expected in the haptic interfaces applied to professional activity.
  - **2020**: high contribution. Most interfaces will embed some sort of haptic interaction. In some cases, sophisticated sensations may be recreated through bio-electronics.

- **Contributor to the Data Capturing Trajectory**
  - **2003**: very low contribution. Only few applications in the design field and in movies to support the re-inaction of movements.
  - **2008**: low contribution. More applications using haptic to capture movements and model them digitally.
  - **2020**: medium contribution. A significant number of applications, also in the education area, will make use of haptic interfaces to capture movements.

### 3.8.10 Holography

Visualization in 3D of objects through interference of laser beams (pulsed laser). 3D images may be recreated using a number of technologies. Holography is one of these. Applications are in the area of design, non-destructive testing, credit card security… New interest to holography is coming from its possible application to high-density storage and fast information searching.

- **Contributor to the Information Visual Display Trajectory**
  - **2003**: marginal contribution. The process of creating a holographic display is quite complex and cannot be done in “real time”. Information display is therefore of interest in certain applications where data can be processed before hand. Used in some engineering design, testing and also in production of images by artists.
  - **2008**: low contribution. Higher processing speeds are likely to make it possible the display of 3D models through holography in quasi-real time. Applications are still limited. Cost remains too high for mass market.
  - **2020**: low contribution. There is no indication of a breakthrough leading to a massive use of this technology. Besides, in this time frame it will have to compete with other 3D displaying technologies and it is unlikely it will take the upper hand.

- **Contributor to the Human Interfacing Trajectory**
  - **2003**: no contribution. Only used as interface in some engineering design and testing environment.
  - **2008**: very low contribution. More processing power is leading to a better feasibility of human interfaces making use of holographic display. This remains anyhow a niche application.
  - **2020**: very low contribution. No breakthrough is foreseen leading to the normal use of holography in human interface.

- **Contributor to the Storage Trajectory**
  - **2003**: no contribution. Only lab experiments. First products may be expected in 2004.
  - **2008**: very low contribution. Holographic storage promises a high storage density providing enough capacity to store 40 hours of movies on a single DVD. This is an order of magnitude more than the density achievable by Blue Ray DVD (likely to be on the market in this time frame). Even taking an optimistic attitude holographic storage by 2008 will be...
in its infancy. In the next decade it should develop significantly.

**2020**: high contribution. Providing the technology is successful it may become the substitution of current DVD. This will also require progress in the reading technology to deliver a sufficient high bit transfer rate.

### 3.8.11 MEMS

Micro-Electro-Mechanical Systems (MEMS) is the integration of mechanical elements, sensors, actuators, and electronics on a common silicon substrate through micro fabrication technology.

- **Contributor to the Data Capturing Trajectory**
  - **2003**: very low contribution. Only few sensors are available that make use of MEMS.
  - **2008**: low contribution. The evolution of sensors will increase the adoption of MEMS in this field.
  - **2020**: high contribution. MEMS, and nanotechnologies, are likely to be part of many data capturing devices, particularly sensors. Applications in the environment monitoring and healthcare will use MEMS based devices.

- **Contributor to the Printing Trajectory**
  - **2003**: medium contribution. Several printers use MEMS.
  - **2008**: high contribution. Most printers will be using MEMS.
  - **2020**: high contribution. Most printers will be using MEMS.

- **Contributor to the Communications Trajectory**
  - **2003**: low contribution. Only few applications in optical add-drop multiplexer.
  - **2008**: medium contribution. The growth of the optical network and add drop multiplexer will increase the use of MEMS in telecommunications.
  - **2020**: medium contribution. Used in the optical network, both in optical switching, routing, add-drop and in the local loop.

- **Contributor to the Bandwidth Trajectory**
  - **2003**: very low contribution. Only few experiments in research labs.
  - **2008**: low contribution. Devices in the optical local loop will start to make use of MEMS providing broadband exceeding 100 Mbps.
  - **2020**: medium contribution. Gbps in the local loop making use of MEMS on the optical fibre.

### 3.8.12 Micro delivery chip

Chip like device with the capability of delivering small doses of substances on command. The surface of the chip is covered with micro reservoir that can contain any type of substance. This can be delivered to the surface of the chip on command. The further transportation from the chip surface to the target area is normally achieved by placing the chip in an appropriate position. Among the potential use is the delivery of drugs. The chip is injected under the skin and gets commands via radio link.

- **Contributor to the Printing Trajectory**
  - **2003**: low contribution. Only few printers dedicated to special purposes are using this technology (although ink jet printers are using micro injectors that share some of the technological aspects with these chips).
  - **2008**: low contribution. No significant change expected.
  - **2020**: medium contribution. The development of the micro delivery chip technology will stimulate its adoption in some printers, particularly for trade-marking applications.

- **Contributor to the Human Interfacing Trajectory**
  - **2003**: no contribution. Still in a development phase in research labs. USA have the leading role in this area.
  - **2008**: very low contribution. Some applications in the medical field.
  - **2020**: medium contribution. Wider use of micro delivery chips in the medical field.
3.8.13 Nanotechnologies

A manufacturing technology able to inexpensively fabricate most structures consistent with natural law, and do so with molecular precision.

Nano dimensions are already a reality in the production of most chips (where the smallest elements are measured in nano meters).

Tools for manipulating nano particle and assembling them are under construction as well as research on auto or self-fabrication. Whilst the first approach is being successful for MEMS the latter is the one that holds most promises for nanotechnologies.

Research has given the capability to assemble 2 dimensional objects from nano particles. Now effort is focusing on assembling 3 dimensional objects and aggregates of nano particles.

Nano technologies are coming under scrutiny for their initial success that on the one hand promises their rapid application and diffusion in a variety of fields and on the other hand rises concern on the visibility of the product and its effects on living cells (and living beings). The nano particles have a smaller size than viruses and can enter the cell membrane with no effort.

According to the 2003 Nanotech report http://www.luxcapital.com/nanotechreport.pdf more than 700 companies worldwide are working on nanotechnologies with 3 billion $ invested in research. No clear leadership at the moment from the USA, as in micro processing. Asian is becoming very competitive in this area funding a lot of research. There is the estimate that by 2010 90% of nanotechnologies scientists will be from Asia (50% working in Asia).

Japan has invested 750 million US in 2002, Europe is investing 1 billion from 2002 to 2006. USA has committed 2 billion between 2000 and 2003. 386 million US $ have been invested by venture capital in nanotechnologies in the US in the 2002.

Top of the list for patent is IBM with Samsung a close second.

The estimate is for a 1 trillion industry by 2015 involving 2 million workers.

- Contributor to the Data Capturing Trajectory
  2003: no contribution. Few experiments in research labs.
  2008: very low contribution. Some data capturing devices make use of nanotechnologies.
  2020: high contribution. Nanotechnologies will be widely adopted in a variety of sensors.

- Contributor to the Processing Trajectory
  2003: no contribution. Not used, although one may claim that today’s chip are based on nanotechnologies.
  2008: low contribution. Some chips will start to be built by assembling atoms and nano particles. Additionally some applications of nano technology in batteries to increase their capacity can be expected around this time.
  2020: high contribution. The fabrication of most chips will be based on nanotechnologies.

- Contributor to the Storage Trajectory
  2003: no contribution.
  2008: medium contribution. Some storage devices will make use of nanotechnologies.
  2020: high contribution. Many storage devices will be based on nanotechnologies, also in the reading/writing part. The creation of the magnetic substance by assembling nano particles in a 3 dimensional shape allows the creation of substances with particular magnetic properties increasing the storage density.

- Contributor to the Information Visual Display Trajectory
  2003: no contribution. Only few experiments in research labs. Asia (Korea and Japan) are leading the way.
  2008: high contribution. NED (Nano Emission Display) displays will become a commercial reality leading to larger screens (over 50 inches).
  2020: high contribution. Many screens will be based on nanotechnologies as well as the processing part driving them.

- Contributor to the Human Interfacing Trajectory
  2003: no contribution.
  2008: very low contribution. Some interfaces will start to make use of nanotechnologies (including screens and bio-electronics devices).
  2020: medium contribution. Wider use, although, with the exception of screens, there are likely to be applications only in very specific fields, like healthcare.

- Contributor to the Communications Trajectory
  2003: no contribution.
2008: no contribution.
2020: low contribution. Nanotechnologies may find application in optical modulators. Nano laser may also be used to increase the effectiveness of D-WDM on fibre.

3.8.14 OLED

OLED (Organic Light Emitting Diode) it's an evolution of the LCD screen with the difference that OLED absorb much less energy.

It is most suitable to provide very high definition in small size screens. Through the adoption of lenses the screen images may appear much larger, as large as a those provided by a television screen thus easing the display of information on small devices, like cellphones. 1 cm OLED screen, may, as an example, be placed on the edge of a cell phone and through a set of lenses deliver the same perception of a 21 inches CRT.

- Contributor to the Information Visual Display Trajectory
  2003: low contribution. Used in several cellphones screens.
  2008: medium contribution. Most cellphones and some PDAs are using OLED screens.
  2020: medium contribution. In addition to Cellphones (integrated in PDA or the other way round) OLED screens can be found on a variety of devices like information appliances.

3.8.15 Optical Tags

Tags based on optical technology. They have the drawback of needing a line of sight with the reader (hence they are less practical than passive and active tags). Their strong point is in the capability to provide different codes to different readers thus effectively partitioning information. This is of interest in several business applications and supports higher security.

Their cost compares to the passive tags today however the decline in cost is expected to be slower than the one of the passive tags. The cost of the reader is and it is likely to remain higher for optical tags.

- Contributor to the Pin-pointing Trajectory
  2003: no contribution.
  2008: very low contribution. Very few applications.
  2020: low contribution. Few applications in those cases where pinpointing is associated to the retrieval of different kinds of information depending on the reader.

- Contributor to the Storage Trajectory
  2003: no contribution.
  2008: very low contribution. Used in special applications.
  2020: low contribution. More widespread but still providing very little contribution.

3.8.16 Passive Tags

Tags able to provide a unique identity, activated by an electromagnetic field. The identity is coded in a number of bits varying between 64 and 128. There is currently no unique standard and this may represent a problem in stimulating the general market. Absence of a unique standard is not a problem for niche applications.

- Contributor to the Storage Trajectory
  2003: no contribution. Only marginal use although several companies have expressed an interest and some have outlined massive usage plans. Main target is inventory and tracking in the distribution chain.
  2008: medium contribution. Beginning of a widespread diffusion in mass-market products. In the following years readers will be made available to the general public, possibly embedded in other devices like PDAs and cellphones. Services to provide information triggered by the reading of the tag are likely to be offered.
  2020: high contribution. In many cases access to information is mediated by tags that will
be basically attached to any product. Software tags will be attached to immaterial services and goods.

- Contributor to the Data Capture Trajectory

  *the contribution derives from the tag reader, obviously.*

  **2003**: no contribution. Only marginal use although several companies have expressed an interest and some have outlined massive usage plans. Main target is inventory and tracking in the distribution chain.

  **2008**: medium contribution. Beginning of a widespread diffusion in mass-market products. In the following years readers will be made available to the general public, possibly embedded in other devices like PDAs and cellphones. Services to provide information triggered by the reading of the tag are likely to be offered.

  **2020**: high contribution. In many cases access to information is mediated by tags that will be basically attached to any product. Software tags will be attached to immaterial services and goods. Readers will be embedded in many appliances.

### 3.8.17 Sensors

Devices able to detect specific parameters in their surrounding environment. The variety of parameters that can be and will be detected is constantly growing.

Sensors are also becoming able to communicate first with the environment. In the next decade in many cases sensors will form local networks communicating one another. These networks are likely to have processing power embedded so that communications will be between the network and the environment, rather than between a sensor and the environment.

The cost of sensors will rapidly decrease giving steam to their massive diffusion.

- Contributor to the Data Capturing Trajectory

  **2003**: medium contribution. Many sensors are already active. Their communications capability is usually limited as is their intelligence.

  **2008**: high contribution. Many more sensors will be spread in the environment, in homes, building and on people’s body providing timely information and continuous monitoring. Although the single sensors generate little traffic the whole sensors taken together are likely to generate an enormous amount of transactions.

  **2020**: very high contribution. Sensors will be everywhere. Sensors infrastructures are likely to emerge both in the physical sense, sensors talking to each other and collectively with the environment, and in the logical sense, sensors being considered an information-capturing platform usable on demand by many applications “owned” by different parties.

### 3.8.18 Wet-ware

The interaction of living cells, usually neurons, muscular, secretion cells, with Information Technology, and microelectronics in particular. Wet-ware applies both to devices and to sensors/actuators connecting electronics to the living cells (and beings). Bio electronic progress is at the core of the creation of wet-ware.

- Contributor to the Data Capturing Trajectory

  **2003**: no contribution. Only few experiments in the labs and few medical applications. These include wet-ware implant on mice and roaches but they are mostly finalised at studying the interaction and the way to interconnect nerves and nerve networks with the electronics.

  **2008**: marginal contribution. Increasing number of applications both for medical control of body activities and in a symbiotic relationship in sensors to capture certain data on the environment.

  **2020**: medium contribution. Higher presence of wet-ware in health care and in the environment for monitoring purposes.

- Contributor to the Human Interfacing Trajectory

  **2003**: no contribution. Only experiments in the area of the “electronic eye”. Chip implant prototypes are being tested.

  **2008**: very low contribution. Much better results in the area of electronic vision both through micro spikes at the brain cortex and through implant of a chip on the retina.
Control of muscles and arms – legs movement through implant on muscle and nerve termination is becoming feasible in many cases. Wet-ware implants are also used to control certain pathologies like epilepsy, tremor, instability for lack of position-nerve reaction.

2020: medium contribution. Significant progress in using bio-electronics for supporting human interfacing both to assist disabled people and to enhance experience.

- Contributor to the Information Visual Display Trajectory

2003: no contribution. Only few experiments to restore sight to the blind. 2008: very low contribution. Better implants also providing higher resolution for restoring sight to the blind. 2020: low contribution. Implants will become common to restore vision in blind people.
4 Functionalities

Functionality is a feature made available upon request in order to pursue a certain goal. They are characterized by what they provide to services and how they provide it, including the cost of using them.

Each functionality is enabled by one or more technology. This is visualized by the tool (at the Web site http://fistera.telecomitalialab.com) through links to the enabling technologies. Some of these technologies may be needed at the same time (hence links to these assume the forms of grouping), others may be alternative (and belong to separate or partly overlapping groupings).

The functionalities represented at the moment in the Web site are listed in the following. Ten of them are marked with a flag since they are the ones which contain a more in depth analysis of their expected progress (see chapter 4.2). The other ones will be focused on in the coming year, and will be included in the 2004 WP2 deliverable.

4.1 Functionalities represented in the Web site

4.1.1 3D imaging

Representation of digital objects in 3D

The representation is based on a digital model and the functionality provides on one hand the control of devices to display the 3D image and applications (software) to manipulate the displayed object.

Normally it supports commands for rotating the object on the 3 planes. In many cases it can handle hidden surfaces and support slicing to see the object inner parts.

In many fields of application 3D rendering is a crucial feature offered by the functionality. The rendering is based on modelling the surface according to a pattern (e.g. representation of plastic, skin, metal, ...) and creating the lighting effects. These are fundamental to create the feeling of real 3D since they introduce shadows and depth.

In most of the situations, today the functionality is required to simulate 3D imaging on a 2D since there is no real 3D display. In the future there will be a growing availability of terminals capable of 3D display but the capability to project 3D objects through 2D display will remain a crucial one.

In the future the functionality will provide walk in capability simulating the object in a way that it can be felt and manipulated in a 3D space. Virtual reality is going to make intensive use of this capability.

A further feature that will be offered is the understanding of the object being displayed in its 3D characteristics. Different feelings are rendered depending if the object is touched in one direction or in the opposite one, if the contact is in a downward direction or upward….

Research is required both in the hardware and in the software areas.

4.1.2 Broadband/Bandwidth

Communication able to carry information at high speed. The speed of the infrastructure used to relay information is obviously the main enabler. However also the architecture of the communication plays a crucial role. A 6.4 Tbps fibre carries potentially 6.4 Tbps: however this speed has very little to do with the real speed perceived by an end user. Information is coded and transmitted according to a set of rules (called protocol) and this limits significantly the real speed as perceived by the end user. Speed of 1 Gbps is at the leading edge today in information exchange. New architectures based on GRID technology are under study to increase this speed.

The broadband functionality provides speeds (capacity) that are related to the architectural aspect of communication not to the theoretical physical speed achievable by the used infrastructure.
Clearly the speed provided by the infrastructure used is the upper limit that can be achieved by the functionality (there are also limits in usable speed and this are specific of the technology used, as an example LAN speed is usually 40% less then the top speed declared). When the speed (capacity) offered by the functionalities is much greater than the required speed this value is the most significant parameter characterising the functionality. However when the demand for bandwidth approaches what the functionality can deliver the other characteristics became important, such as the continuity of the bandwidth provided, the delay in transmission...

Speed is also affected by the quality of the transmission, since any error generate the need to retransmit information thus effectively decreasing the speed perceived.

At what perceived speed there is the shift from narrowband to broadband? There is not such a speed because it depends on the context and on the experience of the user. In radio communications speeds higher then 50 kbps are considered as broadband. In communications based on fixed infrastructure speed should exceed at least 256 kbps to be qualified as broadband. As time goes by and the experience shift towards more powerful networks these speeds will be considered as narrowband. By 2008 speed lower than 1 Mbps on a fixed network are likely to be considered as broadband and in 2020 10 Mbps will definitely be narrowband.

From the user side it is important to note that speed of information transfer is perceived in a logarithmic way (as most of human perception). Doubling the speed does not increase the perception of speed in a significant way. Perception of doubling happen when the functionality delivered speed is ten times greater. At the infrastructure level this is likely to require an increase of at least 20 times.

The broadband functionality involves much more than the infrastructures being used to communicate. It involves the end points, terminals and applications to manipulate the information. Broadband perception derives from the evolution of architectures and the way information is stored. The increase of local storage is likely to provide a significant shift in the way the broadband functionality is perceived. The existence of huge local storage and appropriate applications enables different protocols and information distribution architectures. Information may be, by far, be transferred in batch and burst mode to the local storage and interaction with information will involve access to local storage plus some access to remote storage, through the broadband infrastructure, for that part that is likely to have been changed or that does not make sense to have stored locally. The demand on the infrastructure is clearly completely different in this situation. In the future the complexity of broadband functionality is going to increase involving many more actors and the software part of the functionality is going to achieve a bigger importance. This is already so for the request of very high broadband speed, in the order of Gbps. This cannot be achieved with normal approach to use infrastructure. Attempts to apply the GRID technologies at the edges are on the way as indicated.

### 4.1.3 → Communication

A functionality trajectory that groups:

**Digital broadcasting systems**

A system of transmission of radio and/or television based on a digital coding of information

The digital broadcasting system uses a digital coding to transport information. Although the simple transposition of the analogue signal into a digital one would require higher bandwidth the digital code can be compressed significantly. The compression ratio may affect the quality of the signal. Very good quality of the signal is however possible with compression of 1/50 video and 1/10 for image. Compression rates of 1/100 for video and 1/20 for images still provides quite faithful reproduction. It is the compression made possible by the digital coding that makes the digital broadcasting so interesting effectively augmenting spectrum capacity.

On an average 5 television channel may fit in the spectrum required by one analogue channel. The coding requires a lot of processing power. Depending on the coding technology there may be more processing required at the coding station or more at the decoding station. For digital broadcasting the algorithms used minimize the decoding at the receiving hand at the expense of the coding at the sending hand.

Digital coding has been made possible by the progress of computing processing power. The asymmetry between coding and decoding is the result of the high cost of processing power in the 90ies. In the future, with negligible processing power cost (also in terms of energy consumption) symmetrical coding decoding may become the norm.
**Internetting**

Communication transport via Internet infrastructure. Internet – frequently considered as the worldwide www - is bigger than the Web. It is a worldwide network of interconnected computers, "containing" protocols for accessing the Web, email, Telnet, newsgroups, etc. There are about 60,000 independent, interconnected networks that comprise the Internet. The Net is the set and the World Wide Web is just one of many subsets.

The Internet was first formed in the 1960s, and was originally called ARPAnet (Advanced Research Agency Project Network). It was developed to help the military communicate across a non-centralized computer network during a nuclear war. It launched in 1969 when four universities connected their mainframes. As of January 2000, there were approximately 3 million servers for the Web, according to a NEC/Inktomi audit, while nowadays both figures of servers and of users has increased dramatically.

The Internet is governed --to the degree it’s governed-- by the [World Wide Web Consortium](http://www.w3c.org) and the [Internet Society](http://www.isoc.org).

The internetting functionality is widely used both for private, company, institutional and public aims. Evolution paths of the internetting involve the enlargement and upgrade of the physical network, and the number and capability of the servers, to be increased consistently with the rise of the number of users and of the time of active presence in the net.

**Transport network**

A communication infrastructure to carry information over a long distance. Next generation IP over optical networks and network-based storage services are two of the main research directions for the near future.

**Untethered communications**

Communications that is performed without the need for a wire to connect the communicating parties. A host of new technologies are likely to appear in the next decade to transform any environment into a gateway to the communication network.

From the very tiny, like wireless communication within a single chip, up to wireless communications among equipment we wear, the Personal Area Networks, to let appliances talk one another within the house or between the car in the garage and the house. Other wireless area will support communications among cars and on the road.

Technologies in the area of radio waves but also optical wireless, for point to point connections, are going to increase in capacity and become more pervasive.

In the near term we can expect dissemination of today’s’ standards, like 802.11/a -b-g and Bluetooth, in the longer term UWB and others.

All wireless local access can benefit from lower investment and from the possibility to focus on those area where a demand exist. This is of particular value for developing countries that may have a grand plan for wiring and focused plan for local access.

Wireless is unlikely to become the infrastructure of choice for very dense communication. Optical fibre sports so much more capacity that there is really no competition.

One interesting twist in wireless access is that as it becomes more ubiquitous it can begin to work as an alternative backbone. The wireless router technology effectively let a network to be created out of pure access points. Wireless enabled cars, within a city, may provide an alternative telecommunication network; similarly densely populated area sporting WLAN in each home may create an overlaid network.

However we should note that these new technologies support access to the network, by themselves they do not support “communications”. The market will take advantage of this increased connectivity and many new services may become available. The telecommunications industry should be careful not to engage into a battle for the control of the infrastructure losing at the same time the view of the real business, providing communications capabilities. The risk is that by fighting a lost war against myriads of dwarfs they will end up handing them the communications business.

Regulators are inclined to regulate the Moguls and give the dwarfs a chance to grow. They may end up in distorting the business, as it happened with the 3G licensing.
The Communication functionalities, each in their own area, are serving the purpose to enable the exchange of data between two or more points.
In communication today we are well accustomed to four paradigms: broadcast, time sharing, client server and peer to peer.

**Broadcast**
Television is a well known service using a broadcast functionality (in the future a digital broadcasting one). Radio is also based on a broadcast paradigm as well as, although this might be less obvious, newspapers. In broadcast information is available in a single place and broadcasted around. Once information is broadcasted there is no longer control on who is receiving it. Note, however, that a broadcasting architecture may support different paradigms of communication. As an example information can be coded in such a way that even if a broadcasting medium like a satellite is used only that particular equipment that has the decryption code can access and use the information, as shown in the second picture where the broadcasting infrastructure is used to support a peer to peer communication paradigm. The way through which this is achieved may differ. It can be the node that knows if some of its end users have the privilege to access that information and based on that will forward it to the appropriate receiving party or it can be the terminal itself that decides if that information is relevant to it. Third generation cell systems typically use a broadcasting infrastructure in the cell, through an un-tethered functionality, but only that particular cell phone having the key to that communication can hook on it. In this case it is the cell phone itself that decodes the information stream of interest. Therefore this communication is not according to a broadcast paradigm. The broadcast paradigm, as a communication means, is useful to let many parties access simultaneously information, as it happens for television programs. Also Internet can be used to support broadcasting as shown in the third picture; indeed there are many “radio stations” (broadcasting stations) on the Internet. It is important to distinguish between network architecture and communication paradigm.
A broadcast architecture can be used to support any type of communication paradigm and reciprocally whatever network architecture can be used to support a broadcast paradigm. Clearly some network architecture are much better suited to support some communication paradigms and much less suited (i.e. it would be very costly and inefficient) in supporting other communication paradigms. In the future the core communications will tend to be more and more “broadcast”. This is the consequence of the way to handle spectrum (a typical broadcasting medium), a reality by 2008 and even more so in the 2020, and the huge bandwidth in the optical fibre which makes it possible to duplicate (many times) the information letting the receivers to select what it is for them, a reality in the last part of the next decade. D-WDM is going in this direction.
When designing a network (and calculating its related cost) engineers look at its architecture, when providers look at services (and estimating the related revenue potential) they look at the communication paradigm. Since there is a cost – efficiency relation among the two, if one is designing a network from scratch it makes sense to look at the kind of communication paradigms it will need to support. If on the other hand there already is a certain network the issue is how to make use at best of it to support a given communication paradigm. Incumbent are usually dealing with this latter issue, newcomers have the option of considering the first one as well.

**Time Sharing**
Making the most of a scarce resource has always been the first priority for any engineers. It has become so much entrenched in engineers’ mind that even when there is not a real need to save resources any engineer would still consider ugly a design that does not strive to save resources. Timesharing was invented to make the best use of a scarce resource. Although many people

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2 In some cases this is known as multicasting to indicate that several streams are active to take information to different parts of a network.
3 Efficiency is, actually, the keyword. If one doesn’t care about efficiency, one may pay less attention to the way use resources are used. In DWDM networks the bandwidth is so big that a broadcast transport paradigm can be used to support a peer-to-peer communication paradigm. The waste of transport resources is not an issue.
believe timesharing was invented in the computer trenches it was indeed invented in the telecommunications area. PCM, Pulse Code Multiplexing, was invented in the fifties as a way to make better use of transmission resources. The idea is to slice time into slots and assign each slot to a given communication stream. As shown in the picture the communication is chopped into pieces, the first piece is inserted in the communication channel and then it is followed by another piece from a different communication stream and so on till it comes its turn again and the second piece is inserted. If the communication channel has a greater capacity than that required by each single communication stream it will be possible to insert more streams onto a single channel as shown in the picture. At the end point the slots of a given communication stream are joined together and the receiver will experiment a continuous incoming flow, mirroring the one generated by the sender. This is a typical application of a time-sharing paradigm. In the computer world time-sharing has been used first as a way to share computing power. Hence a central processor would start processing an application then it would suspend it and start processing another one. That gave the impression to the various users to have the complete computer system available.

In the late 60ies the idea of packet communication started to be proposed in the computer world as a way to network computers. This idea also stems from the goal of sharing resources, however it cannot exactly be called “time-sharing”. In packet networks there is no predefined time slot associated to a communication stream. The sender waits until a slot is available and then inserts a packet. Then it waits for another slot and inserts the second packet. Packets are identified by a destination and by a sequence number and potentially can take different communication channels (paths) and arrive in different order at the destination. It is the receiver job to reorder correctly the packets and also to request resending of those packets that did not reach the destination within a certain time. At a system level one can still claim that packet networks abide to a time-sharing paradigm although at the single communication channel this is not so.

Time-sharing is good for a machine that can easily switch context without getting confused. It is normally not a good thing for human beings although some time some activities are organised according to a time-sharing paradigm. Communications among humans is not organised according to a time-sharing paradigm, nor do we do any packet network communication. The reason is that time-sharing requires some sort of central control that is not available in our brain. We process information concurrently. Multimedia communication is changing this situation a bit and interface designers are trying to understand how to make all communication streams to be effective at perception level. There is still a lot of research to be done in this area but it is unlikely that time-sharing paradigm can find significant application.

**Client server**

In the nineties the need to share information across a variety of applications led to the development of the Client Server paradigm. Here there is a (usually) centralised point having some information that can be accessed and manipulated by several computers connected to the central point. These latter are called “clients” and make use of the information through some applications that can interact with the “server”. The existence of such an application is the key point in the “client-server” paradigm. In the picture the server is represented in red and the clients in blue. An application on the client (in dark green) interacts with the application on the server (light green) to access specific information. **Internetting** function supports this paradigm (although its evolution has been towards the peer to peer and will continue...
in the next few years with more and more peer to peer and with the other two paradigms explained later). The World Wide Web is the most obvious example. Here we have an application, the browser, that is able to interact with the application managing the information access in the server. The client-server paradigm is good because it decouples the various interacting actors, solving the issue of compatibility. That issue was the crucial one in the implementation of the web. Today it is possible to access a multitude of information in millions of computers independently of how it is stored and whether it is text, picture, music, or video. The client server paradigm, however, implies someone owns the information contained in the server. The server, in spite of its name, becomes a master in the communication. If the server is blocked no one can access it. If that server contains information that is not legally owned the legal owner can take steps against the owner of the server. Client server is the dominant paradigm on the internet and although in the future the peer to peer will be the one likely to generate more communication traffic, client server is likely to remain very important, particularly from a business point of view. Any communication functionality is likely to support it.

Peer to Peer
The usual telephone conversation we have been engaged on for many years does not work on the client-server paradigm. Once the circuit is set up between the caller and called parties they can talk one another independently of whatever happens in other parts of the network. Whether they understand each other is not an issue for the network as long as it is providing a faithful reproduction of voice at both ends. This very normal way to communicate has become known lately as peer-to-peer. The novelty of the paradigm is not in human communication but in its application to machine communication. Napster has become the epitome of peer-to-peer. It works exactly as the intelligent network in telecommunications has been working for decades. One asks for something (a song in Napster, a certain telephone number in the intelligent network) and the system replies by providing the path to get where is the answer to the query (a computer having that particular song, the telephone addressed by that particular number). In this case there is no longer a server that controls the information. This latter can be anywhere and the system just acts as a pointer to get it. This is represented in the figure where the red element acts as the repository of addresses for getting to desired information (e.g. Napster). One can enquire that repository but to get the actual information one should go to the address that will be provided by the repository. The repository does not grant communication success. It may turn out that in order to understand that particular information there is a need to have a specific application. Peer to peer goes one step forward to ensure this. The sending party can download to the receiving party what is needed to ensure the success of the communication and also the usability of information. This latter is a tremendous leap forward with respect to the telephone communication. In the case of telephone, one does not need to have such a mechanism since the assurance is given by the standardisation enforced in the telecommunication network. When one sets up a call between Europe and the US the voice, and the one of the correspondent, goes through some adaptation to make up with the different speeds used and provide a compatible end-to-end communication. Although this is rarely perceived the telecommunication network has been doing this since its inception: peer-to-peer communication is made possible by the harmonisation ensured by the network.

In the case of computer network peer to peer, the network does not play a role with respect to compatibility. It is up to the end point to negotiate and activate whatever procedure might be required to ensure meaningful communication. This is likely to be the evolution for all communications in the long term. By 2020 most compatibility will be solved at the edges of the network and in the access terminals. New technologies, such as software radio that will be applied in 2008 onwards in the third generation cellular system, do just that. If the cell phone finds itself unable to communicate it will ask for software to be downloaded on the internal chip so that an appropriate coding and transmission can be used to fit the local environment. This moves the burden of compatibility from

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7 This mechanism is at the core of the business model for browsers. Companies, namely Netscape and Microsoft, distribute the client free of charge and make money by selling the applications on the servers.
the network to the terminal and even beyond, to the application. If you want to provide a new service it is no longer necessary to make that service compliant with the network or with the terminals as long as one can devise a way to transfer the control and interpretation capability to the user.

This was the idea behind Java and Java beans: enabling applications by sending them the appropriate code to retrieve and manipulate information. Since in peer-to-peer there’s no longer a need for an entity ensuring compatibility, and hence in a position to control information, it gets easier to do whatever you want, such as letting people to duplicate copyrighted material, as it happened with Napster\(^8\).

However Napster is just one way to implement a peer-to-peer paradigm, and not even a novel one as discussed. As network capacity increases one could imagine sending inquiry to millions of computers till one finds what is needed. There is no longer the need for a centralised directory. That, to a certain extent, has happened with the successors of Napster, such as Gnutella. This makes layers’ life more difficult since it gets almost impossible to sue millions of people although the music records giants are starting doing just that, prosecuting a few with the hope of stopping the haemorrhage of revenues. Some serious research work in this area is needed.

The higher network capacity along with the presence of communicating objects will lead to the emergence of two novel communications paradigms. This will happen in the next few years but it will somewhere in the next decade before a real impact is perceived.

Cluster to Cluster

In peer-to-peer there are two single entities communicating and establishing a direct relationship. They have to be smart enough to negotiate a way to communicate and to interpret each other information. What can be seen on the horizon is the emergence of a multitude of very simple communicating objects that will have very limited capability in communication terms. There will be so many of them and they will keep changing continuously at such a rate that it will be impossible to establish a uniform communication by a network in charge to harmonise differences and incompatibilities. At the same time the peer-to-peer requires individual entities to be sufficiently smart and this, by large, will not be the case. Hence, the need to have a sort of gateway to extend communication capabilities from one environment to the other. Creating this gateway will position companies to control specific environment, as creating a successful operating system leads to the control of the application environment, at least to a certain extent. Hence it is easier to foresee a strong battle from major players to set a foothold in the environment gateway business.

Research on this communication paradigm is central to the idea of ambient intelligence as proposed by the IST. At the same time gateways may absorb, over time, significant intelligence in terms of global networking and may challenge the Operators’ business. It would therefore be crucial for the Operators to pay very close attention to these gateways. The long honoured socket needs to evolve and become the intelligent outpost of Telecom Operators. This evolution is also going to have a major impact on research bringing different fields together. Consumer electronics as well as enterprise processes and their support need to be taken onboard by telecommunications research.

The future for effective research is to go much closer to application areas, to understand and somewhat steer the evolution in specific everyday environment. Fantastic innovations have been developed over the years having in mind just the inner workings of telecommunication. Many of these applications have been used also in other field, exploited by others. It is time to bring competence and expertise in other fields and use it to make telecom the real fabric of evolution rather than to try making telecom evolve in the hope everybody else will come along.

These environments, where a variety of devices and objects cooperate in a loose fashion, may and will also be conditioned by the people using them on a very personal way. In the near future technology and services will embed personal habits and wishes; more than that it will embed specific person’s context and make the environment one happens to be in to conform to the

\(^8\) And that explain the harsh fight on copyright infringements and the resulting legal action that basically put Napster out of business.
person and not the other way round. This will mean a lot in terms of usability and managing complexity.

**Sticker**

A somewhat “weird” novel paradigm may also complement the ones described so far. The name “sticker” is not an already recognised one in bibliography but it has been given by WP2 to represent the idea to have information floating around, around each person and in the environment a person happens to be, and then aggregate on that person, on her applications as well as on other people.

Actually it is not something really new, what is new is the way to do it and the implication it might have. Today as one moves in town advertisements are all around; as one is in a living room there might be a television throwing information at that person even if she was not the one who switched it on and she is not paying particular attention; newspapers at the newsstand beam their headlines to everyone passing by, even the car as the engine ignites tells the driver to check the safety belt. These are all example of non-requested communications, simply happening.

In New York a start up, Wireless Graffiti, has proposed a service to allow people to leave their messages in the air, just like graffiti drawn on walls. As soon as someone with a cell phone enters in the cell area his phone will receive a copy of the message. It is like, indeed, one could write up in the air.

**Un-tethered** functionality, not necessarily the cellular one, offers the capability to do just that. And technology can support also some very sophisticated services and communications capability. As shown in the figure one can imagine that in a certain area there may be a number of information floating around. Each of this information can potentially be duplicated and a copy delivered to any application happening to be within that area. The application has communication capability connecting it to the environment. Additionally, it can have some filtering criteria blocking undesired information, or actively enabling some kind of information, in this case asking the environment if any of that kind of information is available. Intelligent agent technology is quite ready to support this paradigm.

New terminals, PDA, 3rd generation cell phones, and down the line digital cameras and wearable computers will be ideal sticking boards for this information. Set top boxes, mall wireless LANs, local digital radio they all can be distributors for this information.

The advertisement market is surely one area very much interested in this kind of paradigm. One might have commercial information sticking on him when he is watching a television program and popping up in front of him when he comes close to a certain shop...

Personal services may also be envisaged exploiting this communication paradigm. One may drop messages connecting him to specific areas. The fridge might intercept the kid as he enters the house to let him know what mommy has set aside for his lunch...Stupid? Probably. Possible? Yes! The whole area of intelligent personal agents is available as technology, although it will be significantly refined in the future, but it has not been converted into services so far. A sticking communication paradigm is quite attractive.

Along the same line technologies are in the making for semantic databases and theory of complexity. The two are loosely related: as the availability of information keeps extending it becomes more and more difficult to get what one wants or what one needs. Studies in semantics database aim at packaging meaning with the information. Obviously information acquires specific meanings once inserted in specific context. The technology being studied allows a context to grab information and extract its relative meaning. Moreover meaning can be derived from the relationships among information, partly existing in the context and partly outside of it. Theory of complexity shows that given a sufficient number of entities and relationships some of these relationships tend to reinforce themselves transforming the landscape and thus letting some specific meaning emerge.

Work in these areas is still in its infancy but this communication paradigm is likely to stimulate several interesting applications. Someone will have to take charge of all this floating information and facilitate intelligent sticking. It might well be a playfield for Telecom Operators who can grow from distributors to up-keepers.
None of these paradigms is likely to take the upper hand killing all the others. They are likely to coexist. It is important, however, to understand their implication on the networks, in terms of technologies and architecture, and on the market in terms of services.

### 4.1.4 Data Capture

Acquisition of data from the environment and their conversion into a digital form.

Data capture is an important functionality. Data is present in the environment in various forms, sound, voices, images (still and moving), temperature, pressure, acceleration... and its coding in a digital form. Depending on the form of the data in the environment different devices are needed for its capturing. A different degree of fidelity in the transposition into bits is required depending on the purpose of the acquisition. In the last decades significant progresses have been made in data acquisition and the parallel growth in computing processing power and data storage capacity has made it possible to obtain faithful representation in a digital form.

In the current and coming decade this progress will continue and devices will be available to continuously acquire data from the environment creating digital copies of almost everything.

Significant progress has been made in the sensor area, both passive (tags) and active. We have technology to sense a variety of molecules; electronic noses are in use for specific tasks. In the next ten years capability growth will make sensors applicable in many areas and the dramatic cost reduction will make them applied.

Every conceivable object will have a tag within 10 to 15 years time. And many objects will be able to read these tags and connect with a database to retrieve information associated to those tags. Our cell phone, as an example, will be able to pick up tags and if required it will retrieve related information from a database. It may even be set in a “pick up mode” to pick up any tags we come nearby (and retain those that may be of interest to us for later use remembering the place it detected them).

Every single pill we swallow will have a tag and it will be easy for doctors to tell what we got in the last 24 hours and therefore to prescribe appropriate drugs.

Medical examinations are likely to result in the tagging of our organs, rather than checking their functionality at that particular time. Cell tagging helps in curing many diseases letting specific medicine or micro robots to home in at exactly the right spot.

Environment will be tagged as well so that, as an example, landslides may be easily predicted and avoidance measure undertaken.

The dissemination of sensors will obviously increase dramatically the use of telecommunications networks, although with a different sort of traffic than the one we are used to today: billions of tiny messages flowing on the network.

Disruption in this area is self-evident. Having a responsive environment opens up the gates to new way of interacting with it. Markets are based on the possibility to understand the environment and to create the better fit for the tuple product-user-environment.

Advanced studies are also inquiring the possibility to capture data related to emotion - see affective computing - avatars.

### 4.1.5 Encryption

The capability to encode digital information in such a way that only authorised parties can decode it.

It includes any procedure used in cryptography to convert plaintext into cipher text in order to prevent any but the intended recipient from reading that data. In this functionality it is also included the decryption part.

There are many technologies that can be used for data encryption. Common types include Data Encryption Standard and public-key encryption. Most of these are based on an algorithm used to scramble data which makes it unreadable to everyone except the recipient.

A data encryption functionality is characterised by its solidity (difficulty in decrypting data for a non authorised person) and by the speed data can be encrypted and decrypted.
4.1.6 Gaming Platforms

Platforms on which games are played on. They are a crucial enabler stimulating developers to create an offer. Today they are mostly proprietary platform (Microsoft, Sony, Nintendo, Nokia/Sega). In the future there might be an evolution towards open platforms although the probabilities are low. They may become very complex and latest studies are considering GRID structures to support millions of online players. Interesting evolution are also in the area of mobile gaming where Nokia as acquired Sega.com to bring on its gaming platform (N-Gage) the variety of games developed by Sega.com.

4.1.7 Gaming Storage

Mediums used as storage for games or gaming devices. Various memory devices are chosen for supporting the gaming platform use. They are not uniquely devoted to gaming applications. Two critical requirements for gaming are the size and the access speed. Their capability has to support a large quantity of “heavy” – large and high quality - images which require the use of a number on polygons. Different solutions are available and under study, both for PC and Playstation, and for mobile solutions such as the mobile phone, the PDA.

4.1.8 Human Interfacing

A functionality to interface a human being with its context (mediated for human to human interaction, direct for human to machine/network interaction)

Human interfacing is a set of capabilities letting a human being interacts with a machine (directly or via a network) for the purpose to get information or using services provided by the machine. The end goal may be to establish a communication with another human although mediated by a machine, as it is the case in real time translation systems.

Sometimes human interfacing has also the name of "anthropocentric interfaces" that, enabled by "cognition technologies", will "enhance or substitute for our senses". Context-aware and proactive systems will "hide overall system complexity, and preserve human attention, by delivering to us only information which is rich with meanings and contexts". Faced with a "tera-world" filled with "open, unbound, dynamic and intelligent systems", we will soon need to "provide them with learning, and gracefully evolving capabilities, as well as self-diagnosis, self-adaptation, and self-organisation capabilities".

(Last paragraph taken from Doors of Perception, desk@doorsofperception.com which are also warning that complexity of systems would be better resolved at design time rather than letting them be complex and trying to solve the resulting problems afterward).

4.1.9 Image Recognition

The capability of a machine to recognize a shape and attributing a meaning to it.

The image recognition is an everyday function of the human and animal brain. It is a key feature to relate us with the world.

Computers and machine have enormous problems in image recognition. Image recognition goes much further than comparing shapes and pattern. A face of a person and photography of that same face have completely different meaning in terms of recognition.

Image recognition makes use of a variety of technologies, some to acquire data (image sampling, pattern matching, hidden lines recognition...) some to understand the meaning (artificial intelligence, context understanding, history understanding...).

This functionality will prove crucial in the development of a variety of services in fields as diverse as health care, car safety, entertainment....
Progress is required both in graphical processing and in artificial intelligence. Better image capturing will also help as well as integration of multiple sources of information about the same image (e.g. visual and infrared).

Today image recognition is basically performed through pattern matching. Only a few research applications go a little further.

By 2008 some widespread niche applications, such as road security, driver assistance, medical analyses, security checkpoint, will become available. Some basic technologies usable in image recognition may become available in this time frame as result of the research program LifeLog funded by DARPA.

Further down the line evolution will be along better more accurate image recognition and its application to mass market use, e.g. entertainment for searching clips in movies...

### 4.1.10 Information coding

Ways of transforming information into a code suitable for a variety of technologies (e.g. transport over a telecommunication infrastructure) and a variety of services (e.g. television). It can be based both on hardware and software components. Although the software components are usually the first to arrive on the market once a given coding approach is consolidated a hardware component is likely to be developed. By 2008 in the radio environment the use of software radio will become a possibility. This will allow to dynamically select a coding based on the software uploaded on the chip.

### 4.1.11 Information Displaying

A functionality converting digital information into a form visible by a human being. Digital information can be accessed in a visual form through a component, such as a screen, converting them, usually by displaying a multitude of points (pixels) that all together give the viewer the impression of an image.

Displays can be achieved through a variety of technologies varying in complexity, cost, and capabilities. Information display is characterised by some parameters like the quantity of information that can be displayed, the refreshment speed (time required to update a displayed information), and the quality of the display that in turn is measured by considering the context of use. Outdoor display of information requires much brighter and higher contrast screens than indoor.

Visual communication can become common and natural as it used to be. The availability of screen does not steer towards a piggy back visual communications (as it was the case with the attempts of the video phone) nor would propose it as a value added (and at a price like the one through 3G phones).

A variety of technologies is now available and will continue to grow and boost display functionality, at a lower price.

### 4.1.12 Information Retrieval

The functionality facilitating the retrieval of information. The information society is growing its information base at neck breaking speed. Information is produced and consumed in a variety of forms. However the information retrieval tools available mostly focuses on the retrieval of textual information. All other forms of information today need to be tagged with a text to facilitate retrieval. This puts a strong limitation on the possibility to exploit the wealth of existing information.

There are basically three approaches to overcome this problem:

- to automatically tag any information in any form (in many cases translating it into a textual form, as it is done by an AT&T service that translate voice mail into text and let the user do searches in textual forms or by voice, in this latter case also converting the voice into a text to be used as query for text retrieval);
- to use a pattern matching technique to find similar pattern (as it is done in fingerprint matching);
- to discover new way to understand other forms of information and do searches based on that.
4.1.13 **Interactivity**

Ways of mediating two or multiple ways communications to condition one stream by the other. Usually it applies to two streams, one in a direction the other in the reverse direction. However more complex interactivities are possible among different streams.

When interactivity is among services it is often called “features interaction”. In the future more and more complex interaction schemes will become possible and the functionality will evolve to provide the physical means on one side and an easy interface on the other.

4.1.14 **Language understanding**

The capability to understand human (and in perspective non human) communications, in all its forms and in all its contexts.

If one has to pick a single technology area that has led to most illusion and delusion in these 40 years of ICT probably the area of voice synthesis and recognition will be chosen.

True we made incredible progress, but the “incredible” would be used only by computer scientists who have been working all these years in the field. Ask any layperson and you’ll get the answer that “well, it is better than it used to be, but it is still a machine talk”.

The problem is that we have hundreds of thousands of years wired in our brains helping us in understanding any subtlety of voice.

Reaching a complete dominance of language by a computer has proved to be an elusive goal and it may remain so for twenty years or more.

However by 2010 we should be able to have a reasonably good translation of natural language, applicable to many day-to-day chores. If that will prove to be true the world will shrink, commerce and culture will flow in an easier way from place to place.

Language understanding functionality is not based on a single technology, rather on a sophisticate mixture of technologies.

Clearly we need speech recognition and syntheses, but we also need software able to understand the context in which the speech takes place, the context of the listener.

Software agents tracking the speaker, the listener and the community they live in are crucial to provide a human like language understanding.

To make use of an artificial language understanding we need seamless, non intrusive equipment, probably wearable, that can interface with it.

4.1.15 **Micro Embedding – Encapsulation**

Micro embedding and encapsulation is the possibility to enclose or attach invisible parts to any object to augment its features or monitor its behaviour. Several technologies lend themselves to this embedding, both in living beings and inanimate objects.

Examples are tags, nanotechnologies, micro medicine vectors....

In 2001 it is estimated 150 millions CPU were produced for powering PCs. In that same year the estimate is of 7.5 billion microprocessors embedded in any objects but PCs.

The most important characteristics of the functionality are:

- Invisibility
- Accountability
- Privacy

Obviously the cost of packaging is a major factor for the functionality adoption.

4.1.16 **Multimode**

The capability to support a service using a variety of communications channels and information sources that are merged into a single one at the receiving end. Modern facilities use a variety of communications methods; email, one and two-way numeric and alphanumeric pagers, cell phones, voice mail, LAN/WAN, Internet and Intranets to communicate both inside and outside of the family and office areas. The old carriers-specific single-function paging terminal of the past does
not fit in this modern environment. At the terminal level, MultiMode Communications (MMT) provides all formats of paging plus voicemail, narrowband paging, E-Mail, web-paging, cell phone paging and DirectLink paging, showing a long list of features. Application areas of multimode functionality are several. As the individuals spend their day in a set of vary activities, getting in touch with different technology settings and communications channels, the integration and merge in a unique communications solution represents a desired simplification of the daily life. Another application of the multimode functionality is the Siemens HiPath 3000 Real-Time IP System that can be configured with up to 500 IP telephones, 384 digital phones, or in a mixed configuration up to 500 telephones and soft clients.

### 4.1.17 Personal Identification

A variety of means to identify a person. Personal identification will definitely move from paper to electronics using a variety of technologies like iris and fingerprint scan, face characteristics pattern matching, implanted tag, bio characteristics, DNA. The different technologies available will obviously evolve to provide better performances and ease of use and are likely to be used in different context. There is no technology in sight that can meet top of the line performances (e.g. absolute security, ease of use, speed, presence in any environment...).

Some of these technologies are also like to become part of everyday object, e.g. cellphones, and would then support everyday activity.

In general the functionality, from the user perspectives, may support identification independently of the user (potentially the user may be unaware of an identification process going on, like identification of people in a mass riot through police cameras) or identification through an explicit act from the person (like iris scan).

Personal identification will grow in importance in the coming years for many reasons: security, simplified and more effective human interface, personalization of services, ownership control...

### 4.1.18 Pin-pointing

A functionality trajectory that groups:

- **Localization**
  - The ability to identify a place one is in. Conversely the ability to identify where someone else is in is called tracking
- **Tagging**
  - The capability to associate a unique identifier to an object (physical or virtual)

This functionality is enabled both by tools which help identifying objects and locating them in the space and by usually small markers (tags, beacons, ...) which are embedded in the objects to be localised. Most markers contain also information that can be used and updated. Whilst people got used, with the mobile phone, to think they can be localised, it is still quite unusual to imagine that while walking in a city tagged monuments will "talk" to us.

### 4.1.19 Printing atoms

A way to convert digital information into objects (both organic and inorganic). These first 40 years of ICT have focused on technologies to transform atoms into bits. New technologies will become available in the coming two decades to transform bits into atoms. It will be possible to print almost anything, a computer, a cell phone, a bike, a chinaware. This will have significant effect on the distribution chain, not as much because it will reduce the amount of goods being physically transported, because it will let producers to export at very lower price their goods. Developing countries may benefit from this evolution since it will open them rich markets abroad. Besides, those are the first markets that will have these technologies available. A related set of technologies may lead to the packaging of hardware into services. Instead of selling a general hardware that can run a set of services and then sell each individual service we will be in a position to sell just the service providing along the required hardware to support it. The
cost of the hardware will be negligible and therefore the attention will focus on the price of the service. This will have a twofold impact. On the one hand, hardware customised to a specific service can have a service specific interface, thus greatly simplifying the interface and usability. On the other hand, service creation and delivery will no longer be restricted to existing hardware. This accelerates the deployment of new services and stimulates the market. Disruptions may happen in the distribution chain and percolate in many other areas. The drive towards disposable products makes the recycle of materials an even more important issue. A particular area of printing atoms is the printing of organic tissues and organs. This is a huge promise in the medical field, both for transplant and for tissue replacement (such as for burns).

4.1.20 → Processing

The capability to process data, as exemplified by a PC. The information society is characterised by the overwhelming presence of information, the capability of sending it almost instantly from any place to any place and the capability of manipulating it to create more information, better fit to a specific need. Processing is an almost constant requirement of any service; any ambient in the future will be using and making processing available. In turn processing is achieved through a number of technologies in rapid evolution. Electronic processing, such as the one provided by a computer, is possibly the most familiar one and it is the one that has made more progress in these last 50 years, thanks to the evolution of the micro electronics (microprocessor). Other technologies for processing are the optoelectronics processing and molecular processing. Further down is the quantum processing and photon based processing. Moore’s law is likely to keep its validity for the next 7-9 years (at least). What Moore’s law is telling us, a doubling of performance every 18 months basically at the same price, is that in the next 18 months we will experience the same growth we had in the past 35 years! However impressive this growth is, the real disruption results from the over processing capacity that will be reached by 2006, earlier in some areas, later in others. This will cause a dramatic drop in computing cost, the same drop that pushed the 8080 in hotels’ locks or in washing machines. Once computing of today is available for a few cents of a Euro we will see processing power in any objects. And this processing power can be harvested for providing some environmental awareness to objects. In other words objects around us will became smart, able to make sense of their environment and behave accordingly. Furthermore computer chips will embed communication capabilities, and this will transform the environment, as we know it today. We have been used in developed countries to take for granted electrical sockets and our life has been powered up. The pervasive presence of computing power everywhere is likely to have a similar effect. More than that. The fact that each object can be “computerised” decrease the need for general-purpose objects, such as a PC, thus simplifying enormously the interface. The object itself, by its shape and function, will seamlessly guide the user. This will create a real disruption in the way we live. Processing is likely to evolve in the coming 10 years on the same track it did in the last 50: smaller and smaller devices will incorporate processing capacity based on microchip. The increase of microchip performance will provide increased processing power at a lower cost. The interconnection of these devices as well as interconnected devices to provide more processing capacity will increasingly make distributed processing a reality. However most of the processing, by far, will be made locally. GRID technologies are likely to play a role in processing. However it is considered unlikely that they will be the solution to the idea of a processing grid, as we have an electrical grid. While the electricity have to be produced in one place and then have to be distributed processing can be easily “produced” locally and does not need a grid to be tapped. Very specific processing requirements, however, will be making use of GRID technologies in this decade. In the next decade many of these will be based either on local processing or will access massively parallel computing structure.
Beyond 2010 new technologies may start be applied to processing, in particular for parallel and fuzzy processing. Drug design, DNA mapping, weather forecast, image recognition and retrieval are a few areas where parallel processing based on non-electronic chip may emerge. Between 2015 and 2020 concrete application of DNA computing, molecular computing and optical computing should be available. Quantum computing may happen in that time frame or much down the line (or never).

4.1.21 Profiling

The capability to identify unique needs related to a specific person. End user profiling functionality can be used to filter required data by items and dimensions thereby speeding the time required for repeated searching by data users. Data profiling is an upfront process that digs out the issues early and allows intelligent decisions to be made. Data profiling is a critical process completed during every data migration or quality assessment project.

4.1.22 Security

A set of capabilities to ensure various kind of security to information, transaction, resources. As far as information security is concerned the security functionalities defines a few basic proprieties to refer to: privacy, that ensures only to authorized people to access protected data (that is simple data, documents, services and so on); integrity, which looks after consistency, accuracy and completeness of information and process methods; availability, which ensures that data are always accessible to those people authorized to access them.

The diffusion of wired and wireless broadband communication is going to generate personalized security solutions both for the residential customers and for business. People start feeling the need of accessing from everywhere the same information has at home or in the office.

The trend is that of creating services and devices with specific built in security features. The growing diffusion of multimedia content available on line also requires security mechanisms able to ensure Company’s Rights; Digital Right Management solutions are therefore needed. Technologies like biometric may be used to recognize and authenticate people. The growing diffusion of applications for the home environment and the use of IP protocols over dedicated systems such as vehicles, consumer electronic devices and personal objects places new problems to the security issues up to now used. The same is for security issues tied to people health: applications able to monitor vital functioning are going to be more and more popular so that security functionalities even have to grant people health.

The attention of the market on security is going to have alternating peaks. Total security is probably beyond achievement and one has to strike a balance between ease of use, efficiency, and security. In the next years, till 2008, security is likely to be in the eye of the consumer. Some applications may fail on the market because of security concerns (and problems). In the longer term security is likely to become an embedded feature of services, products and infrastructures and it will probably fade away from the forefront.

4.1.23 Shadowing

The capturing and storing of daily activities, in images and sounds taking place in an autonomous way. Shadowing is a general name for the capability of capturing some or all daily life activities of a person performed through a set of data capturing technologies.

The capturing is performed autonomously form the person (who can decide what need to be captured and what not but once decided he is no longer involved in its operation).

The images and sounds may be captured from the environment, i.e. resulting in the person been seen, or from the person perspective, hence images as that person would see from his eyes. Part of the shadowing is related to the rerun of the information captured. The shadowed person may want to reuse those shadows as memories in a number of occasions. Shadowing can also be invoked for business purposes, e.g. by a company that having shadowed one of its expert (with due permission) rerun the shadow to train other employee.

It can also be used by a circle of relatives and friends as remembrance.
There are a number of technical as well ethical challenges:

- integration of images and sounds detected through a number of sensors
- searching methods and ways to indicate what need to be searched
- recording versus reality. Reality may be faithfully recorded but the perception of the person in that moments might have been quite different. Hence the objective reality may differ from the subjective reality perceived thus leading to a “distorted”, although faithful representation
- ownership of data
- privacy of information

The increase in storage capacity, in sensors (particularly camera sensors) in WPAN, in environmental control, in AI, in information retrieval, in image recognition, in semantic data bases are all contributing to increasing the performances of shadowing.

From very limited, but sensible recording, and very broad but almost useless taping of whatever is going on with encumbering devices (around 2008) we will see progression towards broader but sensible recording and easy to wear devices. Eventually, beyond 2020, everything will be recorded and meaning will be attributed in back stage and through the searching mechanism plus embedded devices that disappear from perception.

Cost today would be in the order of tens of thousands Euros for a significant performance. By 2008 it should go below ten thousands and by 2020 it may stay within 1,000 Euros making it affordable by a wide market.

### 4.1.24 Storage

Storage is a fundamental functionality in the Information Society. Although there are storage technologies supporting storage for very brief period (usually for buffering purposes, even a ray of light can be used to store information for a few nanoseconds) in general with storage it is intended the functionality to support the keeping of data for extended periods of time.

Storage can use a variety of technology depending on the purpose. These technologies have evolved and are evolving at a very rapid pace leading to a breakneck capacity increase and cost reduction.

For an insight on specific technology see each of them in the relation area.

Storage keeps evolving at a spectacular pace and we are on the thresholds of a tremendous impact. By 2005 we may expect to have 500 GB of local storage available in many houses, exceeding 1 TB by 2010.

This growth of local storage leads to an architectural change in the telecommunication network: today’s drive to stream data will fade away. Burst communication will be the one used to download movies.

People may tend to create their own cocoon of information locally always ready to tap. Of course information in many environment will be ready available through download but in many areas for at least the next 10 years it will not be so. The availability of large storage repository may provide a wealth of information also in those areas.

Profiling will also thrive on the availability of storage. This is likely to be a drive to have local information also in areas where information would be easy to download from the network. Local information may be customised and aggregated to fit specific needs.

New technology will allow having billions of information at one’s fingertip. A Swedish company has shown a prototype of a polymer memory that in a credit card size may store a few TB of information. You go to a movie and as you pay the ticket you get, for free, a card with the 2000 movies of the year. Back home you plug it in a reader on the television and you can get some peek at them. Should you decide to see a movie you simply ask for the decrypting code to be sent to you (and you’ll pay for it). Movie download has shrunk from 2 GB to a few hundred of bytes, what it takes to ask and transfer the decrypting code.

Growth in the dynamic memory, the one on chip, will provide 52 MB in a cell phone by 2004 and much more in the following years. Today we are using few hundreds B. Couple this capacity with software radio and you have a host of applications that can run on your cell phone, and on whatever contains a cell phone.
The idea of Memex, articulated by Vannevar Bush back in 1945, is now on the way to become reality. The idea is to store all of our life, documents, images, sound and voices...Microsoft is working on it with the MyLifeBits project.

Now this abundance of “retrievable information” may prove to be disruptive on the market. The parallel with Gutenberg printing is not so far fetched. That allowed economic and fast reproduction of books thus letting many more people to touch knowledge. Blogs, that is one of the application of the availability of unlimited storage, let people to cluster and build on each other ideas. Ideas are no longer local; they can be dynamically tied together.

For a number of applications it will be crucial to ensure long lasting storage (current technologies are unlikely to preserve data for more than 100 years) and procedures should be in place to refresh data stored. As the digital bank grows this will become more and more difficult and new storage technology providing longer lifetime will be needed.

- Information retrieval
- Ownership and privacy of information
- Resilience of information, accountability

Performance: Storage can be gauged in terms of a number of characteristics:
- life span: how long data can be kept without undergoing any deterioration. Current best is less than a 100 year (optical storage)
- capacity per cubic millimetre: current value is around 100 MB
- speed in storing : current value is in the order of 100 Mbps
- speed in reading: current value is in the order of 10 Gbps
- cost per MB of storage : current value is around 1 thousandth of Euro per MB.

All of the above figures do not reflect the situation of a single technology but the best value provided by the best technology in that respect. Actually the challenge for equipment manufacturers and users is to find the technology that better fit their needs.

A general increase in capacity, speed (read and write) and a decrease in cost can be expected at a rate of about a doubling of performance (halving of price) every 12 months for the next 10 years. This will not apply to all storage technologies in about the same way (see each one for details) but from a functionality viewpoint it may be a quite accurate forecast.

The life span is not likely to improve with the current set of technologies. New breakthrough is required.

### 4.1.25 Virtual Presence

The possibility to participate from far away to an ambient. The perception is that of being together with other people (in time and space dimensions) while physically in a different place. A number of technologies enable the virtual presence functionality: for example telephone, personal computers, video conferencing, 3D displays, Internet, broadband availability, and growth in the use of portable devices. Virtual presence applications allow socialization activities (such as chat, email, avatar presence, entertainment) working activities (such as video conferencing, joint editing) marketing activities (such as e-commerce, banking, virtual traveling), medicine and surgery (the evolution of human machine interfaces towards haptic interfaces enable these kind of applications) and many other types of applications (autonomous spacecraft and robots to establish a virtual presence in space).

Web conferencing solutions enable remote workers to communicate with their colleagues on a more frequent basis, enabling a level of collaboration that would otherwise be impossible. As IP networks with high bandwidth and managed quality of service become readily available and solutions emerge to resolve security issues, IP conferencing offers enterprises an opportunity for increasing flexibility and productivity among individuals and dispersed work groups.

### 4.1.26 Wearable

Set of capabilities provided by specific devices to be wear by an individual.

“Wearable computing facilitates a new form of human-computer interaction comprising a small body-worn computer system that is always on and always ready and accessible. In this regard, the new computational framework differs from that of hand held devices, laptop computers and personal digital assistants (PDAs). The “always ready” capability leads to a new form of synergy
between human and computer, characterized by long-term adaptation through constancy of user-interface.\(^9\)

There are a number of key issues that make wearable attractive:

- They extend the range of information that can be exchanged, such as health parameter for continuous monitoring, environment information, security data,…
- They allow more appealing representation of information, through the use of various kind of displays, actuators recreating sensations…
- They are invisible to the external ambiance, if so is wished, thus supporting seamless communications
- They are mostly unperceived by the wearer thus allowing communications to take place even when the wearer is engaged in other activities thus extending the time available for communications to happen
- Their inner complexity is hidden to the user thus enabling a variety of easy to use services
- They easily connect to fashion and to everyday objects: technology is completely hidden below the surface of things we are already used to; this opens up the broad market of technophobe, that is to say about 80% of the whole market
- Because they are hidden they are perceived a services or features, not as products

Their capability can be greatly improved by a close cooperation with network-based applications. Application examples are healthcare, maintenance/logistics, sport, gaming, military and security, tourism, education, personal wearable pocket computing

These are some of the most important functions that are provided by a wearable device:

- **Photographic memory**: Perfect recall of previously collected information.
- **Shared memory**: In a collective sense, two or more individuals may share in their collective consciousness, so that one may have a recall of information that one need not have experienced personally.
- **Connected collective humanistic intelligence**: In a collective sense, two or more individuals may collaborate while one or more of them is doing another primary task.
- **Personal safety**: In contrast to a centralized surveillance network built into the architecture of the city, a personal safety system is built into the architecture (clothing) of the individual.
- **Tetherless operation**: Wearable computing affords and requires mobility, and the freedom from the need to be connected by wire to an electrical outlet, or communications line.
- **Synergy**: Rather than attempting to emulate human intelligence in the computer, as is a common goal of research in Artificial Intelligence (AI), the goal of wearable computing is to produce a synergistic combination of human and machine, in which the human performs tasks that it is better at, while the computer performs tasks that it is better at. Over an extended period of time, the wearable computer begins to function as a true extension of the mind and body, and no longer feels as if it is a separate entity. In fact, the user will often adapt to the apparatus to such a degree, that when taking it off, its absence will feel uncomfortable, in the same way that we adapt to shoes and clothing to such a degree that being without them most of us would feel extremely uncomfortable whether in a public setting, or in an environment in which we have come to be accustomed to the protection that shoes and clothing provide. This intimate and constant bonding is such that the combined capabilities of the resulting synergistic whole far exceeds the sum of either. Synergy, in which the human being and computer become elements of each other’s feedback loop, is often called Humanistic Intelligence (HI).
- **Quality of life**: Wearable computing is capable of enhancing day-to-day experiences, not just in the workplace, but in all facets of daily life. It has the capability to enhance the quality of life for many people.

\(^9\) Steve Mann, University of Toronto
4.2 Focus on the 10 selected functionalities

In the following pages, a subset of the identified functionalities is taken into account. For each of them, a table has been created in order to summarize how each functionality influences technology and what technologies are actually influenced some way by that functionality. There are many possible relationships between the functionality layer objects and the technology layer ones, as described in 3.2. In the tables contained in this chapter only the relationships really present between the functionality considered and the technologies affected by relations are shown. Therefore each table in the following sections includes:

- **FIRST COLUMN**: the list of technology clusters which are identified as influencing the functionality performance
- **SECOND COLUMN**: the individual technologies within each technology cluster
- **THIRD COLUMN**: The three time frame taken into account (2003, 2008, 2020)
- **THE OTHER COLUMNS** (one for each of the type of relations existing between that functionality and each technology - might be different from functionality to functionality): the weights of each relation (according to the Methodology – see Appendix A) in the three timeframes taken into account.

As an example: Broadband/bandwidth functionality is enhanced by the MPEG Technology with an intensity of 3 in 2003 and 2008 and with an intensity of 1 in 2010.

Note how the relationships are different from the one listed in chapter 3. There the focus was on the relation from one technology to all functionalities, thus providing a perception of the potential market for that technology. In this chapter the focus is on what and how technologies are being "used" by a functionality thus providing indication on what may be important from a functionality point of view, identifying alternatives and milestones. Notice how a technology may impact on a functionality (e.g. its availability will provide additional or increased features to a functionality) and how a functionality may impact on a technology (e.g. the increasing demand from a functionality, in turns deriving from the service using it and from the environment into which the service is used may displace a technology stopping any interest in its evolution, e.g. the form factor in the information display functionality is reaching such a level of importance that it is sinking the CRT technology).

4.2.1 Broadband/Bandwidth

Communication pipe able to carry information at high speed. The "Broadband" functionality aims at providing a set of capabilities to allow the transfer of huge quantity of information to a point of use. The more information is made available in the unit of time (usually measured in multiple of bits per second) the more bandwidth is provided, the more the receiving end is feeling a broadband connection with the "information". This is a crucial difference between a broadband seen as a functionality and broadband as a technology. The former is about the connection with information, the latter is about the transport of data. The functionality makes use and is supported by a number of technologies, most of them listed in the following table. The evolution of each of these technologies, as will be discussed in the following, impacts the evolution of the broadband functionality.
The first point to notice is that technologies in the area of broadband span over several aggregations, coding, communications, devices, processing and terminal points. In reality there are also other technologies in the area of storage that have an impact on broadband, but not so much in its provisioning, rather in the stimulation of its use. For this reason they have not been included. For the same reason technologies in the devices aggregation, like digital video recorders, digital cameras and camcorders…have not been included. They are very important in stimulating the broadband market but are not instrumental in the broadband provisioning.
Some of the technologies in the communications aggregation are providing alternative options, although some are used together. More specifically:

- optical fiber is always present in backbones and in many metropolitan area network thus providing the huge capacity needed to serve millions of broadband users. Optical fiber, however, becomes one of the many alternatives for the last part of the connection in the last mile. The trend is towards a more widespread use of the optical fiber and by 2020 this should constitute the main platform for interactive broadband communication both in the transport and in the local loop.
- ADSL is the main enabler for the broadband functionality in Europe. Another important evolution is in the offering of symmetrical bandwidth, thus responding to an increased demand for upstream bandwidth. In some areas the offering will reach tens of Mbps thanks to a replacement of ADSL with other kinds of DSL, mostly VDSL. This will be possible because of an extension of optical rings in the distribution network and an increased demand for bandwidth. xDSL is likely to be the dominant technology used in Europe with routers in the house terminating on a WiFi gateway (that will progressively evolve towards UWB in the next decade). In the longer term the availability of the optical fiber in the loop will decrease its importance and very little is likely to be left by 2020.
- Cable television is widespread only in some countries and there it plays a significant role in the broadband provisioning although not as much as it does in the USA. The provisioning of interactivity is not likely to be economically sustainable and its role will be diminishing as more communications fiber is deployed in the loop. This will not happen, anyhow, before the next decade.
- Passive Optical Networks give today a marginal contribution but in the next five years the situation is likely to change and they may play a significant role in the next decade.
- Power Line transmission is at an experimental stage and it is unlikely to become significant even in the longer term.
- Satellite is playing and will continue to play a minor role in interactive broadband whilst its role in broadcasting will remain particularly for difficult to reach areas. By 2020 the availability of a pervasive optical infrastructure may relegate the satellite to some niches.

This situation is depicted in the figure.
Access to the broadband infrastructure in several situations will be facilitated by other technologies such as:

- WiFi and UWB are alternative technologies to provide an un-tethered connection to the fixed network but are making use of any of the other technologies in the local loop. In this sense it can be said that WiFi and UWB are enhancing the broadband functionality, they are not enabling it, as it the case for the technologies in the local loop.

Other technologies are and will enhance the broadband functionality, such as:

- 3G is in its launching phase and currently it is not providing broadband (beyond few video clips downloading). By 2008 the broadband functionality is likely to increase its performances in terms of bandwidth provided, from current offering below the 1 Mbps to offering all above 1 Mbps. 3G and EDGE are likely to be used significantly also for high speed data communications although most of the traffic on 3G is likely to be voice or voice related (videoconferencing) and messages (narrowband). Cellphones will provide multistandard connectivity thus making it possible to connect through public WiFi in a situation that should see a good coverage in Europe for those areas where demand exists (airports, department stores, petrol stations, railway stations…). In the next decade all cellphones will be multistandard also by making use of software radio.

- GRID computing may provide an enhancement in some specific fields of application where the capacity is not enough and transfer speeds is important. Its real applications (there have been few experiments only) are somewhere around 2008 and beyond.

Several technologies are having and will have an impact on broadband provision, not to mention those, mainly software, related to the content creation. Two have been considered in this first deliverable of WP2:

- Coding has an impact on broadband since smarter coding coupled with local storage and processing may significantly decrease the need for broadband in a number of services. Video communication over wireless is easily provided using 3G capabilities but ingenuity in coding is making certain kinds of video communication feasible also on GPRS at a much lower speed.

- MEMS: Micro Electro Mechanical Systems will provide, in the 2008 timeframe and beyond low cost devices for carrying the broadband to the local loop, up to Gbps speed. Their dissemination in the distribution network and on the customer premises, not likely to happen till well into the next decade, may change completely the flavor of the broadband functionality relegating speeds lower than 10 Mbps to historical relics.
4.2.2 Communication

A functionality trajectory which groups:

- **Digital broadcasting systems**
  A system of transmission of radio and/or television based on a digital coding of information

- **Internetting**
  Communication transport via Internet infrastructure

- **Transport network**
  A communication infrastructure to carry information over a long distance.

- **Un-tethered communications**
  Communications that are performed without the need for a wire to connect the communicating parties.

An extensive discussion of the communication function has been given in 5.1.3. and therefore it will not be repeated here.

The communication functionality will evolve towards a seamless provisioning of connectivity (and its associated parameters, like capacity, speed, quality...) in any ambient. The aspect of the ownership of infrastructures is likely to be transparent to the users who will negotiate the service with one single service provider, most of the time unrelated to the particular infrastructure being used.

The following tables summarises the relationships between Communication and the technologies influencing it.

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<tr>
<th>Technology clusters</th>
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As shown in the table there are a core of technologies that should be considered as main enabler. Without these there cannot be any communication functionality. They are:

- **modems**: their role is crucial for internetting today and at least in the next several years. In the long term all network, up to the terminals’ access point will be digital and no more modems will be needed (they will be replaced by routers and bridges, by 2020 most terminals will embed them).
- **Optical fibre**: more and more the communication will flow on optical fibre. Their capacity will keep growing and this will let functionality to exploit it in different ways, like the adoption of a broadcasting architecture with D-WDM. Communications paradigms like client server or peer to peer will be managed at the end by the terminals themselves.
- **Trunk**: long distance pipes, both domestic and international, will maintain their crucial importance. Satellite communications in Europe will maintain its auxiliary role.
- **Digital signal processing**: it will remain the essential interface to funnel information on the communication network and make sense out of it once it reaches the fruition point.

What is remarkable in this list of enabling technologies is the fact that they are and will remain (with the exception of modems) an essential part of communications in the future, even 15 years from now.

The evolution of each of these technologies will be significant, but it is not going to cause any disruption.

Some of the technologies listed will enhance the communication functionality. They are:

- **xDSL** increasing the bandwidth on the local loop and hence the data communications. Its use for voice communication (voice over IP) is obviously a possibility. The uptake is going to be slow but the market may reach a critical mass within five years. At that point, however, many tariffs are likely to be “flat rate” thus cutting at the root the only reason to move to VoIP on xDSL: the flat rate. XDSL use for video communications is more likely to appeal the market and it might even become a reason to buy the xDSL.
  xDSL is likely to be the dominant technology used in Europe with routers in the house terminating on a WiFi gateway (that will progressively evolve towards UWB in the next decade). In the longer term the availability of the optical fiber in the loop will decrease its importance and very little is likely to be left by 2020.
- **Software radio**: currently in the definition stage in standardization organizations will make its appearance on the market in a few years, likely by 2007-2008. Its impact is going to be important in the next decade further fostering the peer to peer and clustering paradigm. Although it is not an essential component, nor it will be, its role on the market may be disruptive since it potentially decreases the importance of owning the infrastructure and increasing the importance of “knowing” the customer.
- **Cellphones**: clearly a most important player in communications it will continue to remain so, in spite of the variety of terminals providing access to the communication functionality. It does more than just giving a new access to the communication, one that is basically always available without having to look for it. It is shifting the perception of calling to a place to calling a person. Services tightly coupled with the person are successful on the mobile phone whilst they are not on the fixed line (e.g. SMS). Also it provides local capacity and functionality. That is why it has been linked to the communications functionality in the “enhances the functionality” and no in the “eases the access to”.
- **3G**: this technology is providing higher flexibility in bandwidth provisioning. This is useful for data and video communications. However increasing the data rate leads to a shrinking of the cells and therefore requires more dense coverage and higher cost. It is now in the early deployment phase and it will reach maturity by 2008. It will not displace the GSM completely and in the longer term it will coexist with other wireless technologies, particularly for data traffic.
- **PDA**: they are just starting to be connected to the network and their use is more in browsing information (looking at email) than real communication. The situation is going to change with the increasing availability of lower cost cellular connection and WiFi but it is not going to play a role comparable to the cell phone. In the next decade this may change (very low probability) but only in the measure it will morph into a cell phone in the
perception of the user. More likely to have the cell phone acquiring the features of the PDA.

- **PC**: a key player in communication for information communication and the main drive behind the peer-to-peer paradigm. It will also be a main drive in the dissemination of the sticker paradigm and it may become a main force in the cluster paradigm. In this area however the competition from consumer electronics will be particularly strong and the balance may tip in favour of this latter at the end of this decade. By the end of the next decade the PC will be faded in the background leaving on the foreground a variety of devices (appliances) having embedded processing power and communicating. The PC enhances communications by providing “additional” ways to share information and enhance the communication experiences.

- **Distributed processing**: Communications is enhanced by distributed processing exploiting the possibility of decreasing the number of data exchanged (thus making most out of the communication links capacity) and allowing local interpretation of data and creation of information. Its importance is bound to increase as more local processing and storage capacity become available.

Some technologies will ease the access to communication, both from a logical and physical point of view. They are:

- **Home networking**: Europe is lagging behind US in the diffusion of home networking today but this gap is likely to fade away within the next 3 years. There are a number of alternative standards trying to emerge and win the market. Probably WiFi will take the lion share although some other standards pushed by the entertainment world may prove to be a serious contender. Independently of the winner it is clear that appliances and human communications will be conveyed by the home networking when in the home. The communication functionality will need to extend from the network into the home to be able to provide the support required by the services.

- **WPAN**: it provides a low power communication environment to devices worn by a person. Basically non-existing today (only peer to peer connections between mobile devices) it should develop in the next few years (at that point supporting the broadcasting paradigm).

- **Bluetooth**: it provides a good communication channel (1 Mbps, growing to some Mbps in the next 5 years) over short distances and it is of interest for establishing connection among devices. It will be likely superseded by the UWB in the next decade, which has higher bandwidth and lower power consumption.

- **UWB**: only used in the military world today and not for communication, it is likely to become a significant player in the very last part of the communication links for its low power consumption making it fit for mobile devices.

- **WiFi**: it will play a marginal role, if compared to the other access technology from a business point of view. This is not to diminish its importance. It will widespread both within the home (but there will be no “access premium” for that) and in open places but it is unlikely to generate significant business. Several areas will deploy it to attract customers to other services and some telecom company will bundle it in their offering.

- **Public key cryptography** is likely to play a significant role in the access to information providing the perception of security to the end user and assuring it to the service provider. Its contribution is at the logical level, not at the physical one, although it consists of physical elements (software or hardware keys).

Another set of technologies will have an impact on the communication functionality and in particular:

- **Antenna**: The evolution of technology will provide tools for better management of the radio spectrum (in the spread spectrum coding) increasing density and thus supporting more traffic. Most impact expected from 2008 and beyond. Micro antennas and their progress will have an impact in communication of micro devices and this is likely to happen in the next decade.

- **Cable TV network**: fundamentally a broadcasting architecture. In some areas it will be enhanced to support also upstream communications. Where it exists it has an impact on the provisioning of broadband data communication.
• Power line transmission: Very limited impact. Problems still exist in providing significant capacity. It is fundamentally a broadcasting architecture. Even assuming the evolution will lead to increased capacity in most areas alternative means to provision broadband data will prove to be a too big competitor stifling its success.

• Rings: high penetration today, it will increase in the next few years. Beyond that the deployment of gigabit Ethernet in the long term will decrease their importance.

• Satellite: likely to became, in Europe, fundamentally a broadcasting media (both as architecture and paradigm). In other areas in the world its impact on data communication will be significant.

• Quantum Computing: unless a breakthrough happens it will remain confined in the provisioning of secure data links for businesses (starting in the next few years).
4.2.3 Data Capture

Acquisition of data from the environment and their conversion into a digital form. Data is present in the environment in various forms, sound, voices, images (still and moving), temperature, pressure, acceleration... and its coding in a digital form. Depending on the form of the data in the environment different devices are needed for its capture. A different degree of fidelity in the transposition into bits is required depending on the purpose of the acquisition. In the last decades significant progresses have been made in data acquisition and the parallel growth in computing processing power and data storage capacity has made it possible to obtain faithful representation in a digital form.

In the current and coming decade this progress will continue and devices will be available to continuously acquire data from the environment creating digital copies of almost everything. Data capture functionality is able to:

- Detect environmental parameters (both scalar, like a temperature, and vector, like the direction of a landslide)
- Identify objects (tagging will be more and more widespread, starting 2008 is likely to replace bar codes on products)
- Capture (still and moving) images and tag them (diffusion of video cameras for surveillance purposes in many places, whole cities will be monitored; growing capabilities to understand images with full understanding probably in the last part of the next decade).
- Capture sounds and their meaning (voice recognition, speaker identification and lock up..., detect malfunctioning in cars,...)
- ...

The evolution is towards both better capturing (comprehensiveness, speed, variety, cost) and making more sense out of what is being captured. This latter may lead to fine tuning of the capturing to intercept subtle phenomena. This is possibly one of the biggest advances in the next decade in the trend towards responsive and intelligent environments.

Technological advances will contribute in a variety of ways as shown in the table.

In the table the Data Capture functionality and the technology influencing it.

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Data capture is enabled by a variety of technologies. This first deliverable has assessed the following:

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3D Scanner: the representation of the environment will becoming an important asset for many services in a variety of environments, from education to the provision of tourist information, from medicine to design...3D scanning functionality can be used to replicate as faithfully as desired an object or an environment or for understanding it. Depending on the purpose and on the level of accuracy the functionality may be restricted (by cost and complexity) to professional users or it may be for the mass market. The evolution is towards the mass market but it is likely to be a very slow process. By the end of this decade most of 3D scanning will be done by professionals (although the results are likely to be used by the mass market). It is unlikely that this situation changes significantly also in the next decade although for some applications, like recreating a virtual environment by capturing and organizing 2D shots into a 3D representation, it may become available to the mass market.

Scanner: Scanner are today a low cost device widespread in the mass market in association to PCs. There are a variety of other scanning devices, like bar code readers, that are used in the business environment. Their diffusion in the mass market did not happen even though some PDAs support bar code readers as plug in. What is missing is an information infrastructure for the mass market. Each business has its own. The situation is likely to change in the next 5 years and by the next decade global infrastructures will be accessible to anybody to inquire about products and services, each one with its own tag (the offspring of the bar code). Hand held scanners are already a reality but in the future, by the end of the decade, scanners will become embedded in many appliances, fountain pens included. Communications capabilities will be a standard and most of it will be through a wireless connection. Scanning will become a normal activity, so normal that in many cases it will take place in the background without the need for a “command” by the person. Its development and usage will be fostered by software recognition of images, text, and environments. The information will be stored locally or in a distributed storage environment and retrieved based on needs.

Bioelectronics: a revolution in health care is likely to happen in the next decade with the prescription of drugs created for a single individual, based on her proteins blueprint. Bioelectronics is going to be pivotal, with biometrics, in the monitoring of the effect of the prescription. This is essential since it is not possible to test the drug in the usual way being engineered for a specific environment (that individual). Bioelectronics provides the connectivity between cells, body and the processing part (it may also include the delivering system). In addition it links the body with the communication network (possibly becoming one of the devices on the WPAN). In addition to health care there will be several other areas where bioelectronics will be used to capture data, like in biosensors to monitor the environment.

Biometrics: same comments made for bioelectronics apply.

Haptic Interfaces: these interfaces can both recreate a tactile sensation and capture movements. This latter is going to find a number of applications in the future like education, rehabilitation, design...It can also be used for modeling objects. Applications already exist in scientific and industrial environment. By the next decade some of these interfaces may enter the mass market.

Sensors: explosion in the number of sensors deployed. The data capturing functionality will exploit these sensors both in terms of the parameter detected and in terms of networks where single parameters are clustered and analyzed as a whole. Data capturing through sensors is already widespread. By the end of this decade sensors will be everywhere and by the end of the next decade they are likely to become a “public” infrastructure with third parties offering services to exploit it. Data capturing functionality will be crucial.

Tags: within three to five years they are likely to replace the bar codes and will provide a much more effective way to label objects. By the end of this decade there will be an information infrastructure supporting the understanding of the codes. The data capturing functionality will have to provide not just the data but also the correlation with the information and ensure the privacy and ownership. Depending on the context and on the desired characteristics optical tags or passive tags may be used. The information infrastructures as well as the functionality are likely to extend the idea of tags into virtual tags labeling bits (virtual objects and services...).

Wet ware: same comments of bioelectronics, biometrics and sensors.
Data capture functionalities are enhanced by:

- **Voice Recognition**: Data capture can be used to capture voice as wordings and also as characteristics (as an example for security and identification, growing areas of interest with technology maturing by the end of this decade for a mass market use). Additionally voice recognition may enhance the functionalities by triggering the capture based on what a person is saying or the way it is saying it (detection of emotion and therefore capturing of the context). This latter is likely to become available for mass market in the next decade.

- **Active tags**: the objects may identify themselves, rather than being passive. With active tags there may be a local processing able to provide more sophisticated data, based on the type of request. Data capturing becomes a negotiated activity. The current price of active tags restricts their application but the situation should start to change within 3 years with a widespread adoption by the end of this decade.

On the human body data capture is eased by the

- **WPAN**: the data capture functionality will make use of a variety of capturing devices and also of some control on what needs to be captured and how. Within 5 years WPAN on people should become common and they will facilitate the capturing of certain data.

There are several technologies whose evolution is having and will have a significant impact on data capture functionality. Those assessed in this deliverable are:

- **MPEG**: The way information is coded both before and in the capturing device has a significant impact on what can be done and at what cost. Coding technologies like MPEG are already having a major impact on image, video and sound capturing.

- **Cellphones**: besides capturing voice and images/small video clip in increased level of quality in the future cellphones are likely to be able to capture a variety of data in their surrounding, like that contained in tags. The hook up of the cell phone on the WPAN extends its connectivity to a variety of interfaces. By 2008 the advent of software radio will increase the possibility to run applications on the cell phone and therefore it is likely to increase its usage for data capturing.

- **PDA**: Personal Digital Assistants are quite widespread and their open (published) architectures stimulate the market to offer add on (both hardware and software). Tag readers are likely to become embedded in PDAs whose screen is better suited to display textual and graphical information. Industrial data capture is going to make extensive use of PDAs.

- **Micro piezoelectric**: Powering of data capturing devices can be a problem and this problem is going to become more and more important as more possibility to gather data (and interest to do that) are becoming available. The micro piezoelectric power generation may fill a powering gap for small sensors, MEMS...in those areas where movement is involved, e.g. the opening of a door.

- **Digital Signal Processing**: DSP can play a significant role in data capturing by processing the raw data to a more suitable (intelligible) form. It is likely to be embedded in many sensors and other data capturing devices within the next five years.

- **Molecular computing**: data capturing in some scientific/medical environment and by the end of the next decade on and within the human body can reach new level of performance through molecular computing. Nothing concrete is available but some approaches make it reasonable to expect applications early in the next decade (for real molecular computing for data processing the wait is going to be a bit longer).

- **Digital Camera Sensors**: digital cameras are becoming more and more widespread and the advances in the sensors (resolution and price decline) makes it applicable in many other context. Sensors are now available in cell phones, webcams...Security is furthering their deployment in public spaces thus increasing many fold the capturing of data from the environment.

- **MEMS**: instrumental in many capturing devices today it will be a fundamental component in future data capturing devices. The coupling with a mechanical part makes possible the exploitation of the micro piezoelectric power generation.
Nanotechnologies: their use in sensors and other data capturing devices is just starting and it will become quite common within the next five years. In the medical sector the hope is to be able to detect single viruses and bacteria through data capturing based on nanotechnologies.

4.2.4 Human Interfacing

A functionality to interface a human being with its context (mediated, for human to human interaction, direct for human to machine/network interaction)

Human interfacing is a set of capabilities letting a human being interacts with a machine (directly or via a network) for the purpose to get information or using services provided by the machine. The end goal may be to establish a communication with another human although mediated by a machine, as it is the case in real time translation systems.

Sometimes human interfacing is named "anthropocentric interfaces" that, enabled by "cognition technologies", will "enhance or substitute for our senses". Context-aware and proactive systems will "hide overall system complexity, and preserve human attention, by delivering to us only information which is rich with meanings and contexts". Faced with a "tera-world" filled with "open, unbound, dynamic and intelligent systems", we will soon need to "provide them with learning, and gracefully evolving capabilities, as well as self-diagnosis, self-adaptation, and self-organisation capabilities".

(Paragraph taken from Doors of Perception, desk@doorsofperception.com which are also warning that complexity of systems would be better resolved at design time rather than letting them be complex and trying to solve the resulting problems afterward)

Some believed, and still does, that the evolution of the human interface is towards a human like interaction. Robots should look like a human being to facilitate interactions, a video screen should mimic a person and interaction should take place via voice, as it happens in interaction among human beings.

Others feel that although in some areas human like interactions would indeed make sense and be a "progress" in most areas this is not so. The point is to make it easy and if it is easier to push a button to ring the door bell...so be it.

Interfaces will evolve following these two directions, human like and simplicity/effectiveness. A variety of technologies, many of them software, will provide for smoother interactions.

The overall environment will increase its complexity and human interfacing will become more and more important. In several areas the point where any progress and additional features remain hidden to the user because of the complexity has already been reached. Video recorders and cell phones are, but two, every day examples.

The importance of human interfacing is also stressed by a relatively new design discipline, the interaction design that advocates the need to design the interaction before designing the object or the service and construct it around the designed interface.

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Human interfacing is enabled by a variety of technologies (devices) each one providing its specific contribution. One can say these technologies are alternative one to the other but in reality each one is specifically targeting, enabling, a certain interfacing. Clearly there are many more than the one listed, as an example the cell phone has become a major human interface, but the decision has been to highlight those that have a specific goal in the interfacing (as such the cell phone may be considered more as an “access tool” whose interface is partly provided by the screen, partly by the touch pad and partly by voice recognition and syntheses).

- **CRT:** the main interface today for most of human beings, television outnumbers telephones and cellphones. It is used in special applications as an interaction device (with a touch screen). Associated to a set top box it is also being used to interact with television programs and sometimes to access Internet. Its evolution is nearing the end and it will be displaced by the flat screen technologies.

- **Flat Screen:** the form factor is winning the market. Used as computer monitors it is now conquering the television market in Europe (as it is doing in the USA and it has done in Japan and Korea). Some Flat screens have a touch screen to support interaction but the two technologies are not a perfect marriage. There is a need to place a glass screen to avoid touching the “soft” cover of the flat screen and this decreases the brightness and contrast. Other means are also available to provide interactivity, like connected pads, video cameras… Interaction with video cameras coupled to the flat screen is still in its infancy but it will rapidly evolve and is likely to become mature in the next decade. Image recognition software is crucial as well as the availability of faster processing speed.

- **Software:** Independently of the technology and device used software is always a key component in the human interfacing. Progress will significantly depend on the evolution of software. New interaction paradigms are likely to emerge although it is difficult to imagine which one will be successful (the next icon revolution). Today the interfacing software is strongly tied to the device and to the application. This will change in the next decade, as the interfacing software will be more tied to the person, the human, it interfaces. Profiling will become a very important aspect of the human interface functionality. Every person will have her own interface and that interface will evolve based on the reaction of the person to the interaction, to what she knows and what she learns. This is going to be a tremendous change in paradigm and an opportunity for service providers to attract customers. New companies specialising in profiled personal interface will create a completely new market.

- **Voice syntheses-recognition:** it will evolve significantly providing even better interfacing capability. In addition to better recognition (speaker independent, noisy environments, natural language and slang, detection and lock in on a voice among several...) it will be able to interpret meanings reading between the lines by taking into account the tone, the way of speaking of that particular person, the context. In some cases it will integrate data with the ones coming from video camera to take into account visual hints, expressions.... In spite of this voice interfacing will not take the upper hand on every other forms of interfacing. It will coexist and will dominate basically in the same areas where it is dominating today. It will, however, significantly contributing to ease the interfacing to several audiences that for a number of reasons are nowadays on the fringe of the ITC. An increased use will occur as result of the information appliances; some of them will be basing their interfacing on voice. Wearable may also exploit voice communications although performing interfaces are unlikely to become available till the next decade.

- **Bioelectronics:** in spite of its potential that should be fully displayed in the next decade functionality making use of bioelectronics is (and perceived as) quite intrusive. Because of that its use will be restricted to some areas, like health care, elderly care, disable care...plus some special professions. This situation is unlikely to change in the observed period. Some limited application in the entertainment and gaming area, with a “lighter” use of bioelectronics is possible.

- **Biometrics:** heavily used in the medical area it will also have some interesting applications for safety and security. Cars will be equipped in the next decade with biometric sensors monitoring the driver. Several professions will make use of biometrics to ease the job.

- **Haptic Interfaces:** the two usage areas of consumers (gaming) and professionals (designer, surgeons) are likely to converge somewhere in the next decade leading to a more intense use of haptic interfaces that will become a non standard but usual part of the
human interface. The capturing of tactile and moving data will become part of the interface and some entertainment program will make use of the knowledge of the emotion of the viewer detected through haptic interfaces.

- Wetware: only few experiments in lab environment today. It may start by the end of this decade to have some practical use but some real impact is unlikely before well into the next decade. The point when wet ware will be able to create an intelligent interface directly on objects is still further down the road. Only very specific areas will benefit from it before 2020.

The evolution of the human interfacing will be influenced by various factors, including the evolution of culture and habits. From a technological point of view the single most important factor is felt to be the:

- Information appliances: today the idea of “talking” to an appliance does not exist. One feels there is no interfacing with the fridge (opening the door, setting the temperature, reading the degrees are not felt as part of an interface). As appliances get more and more complex the interface should be able to hide such a complexity. At the same time it should enable users to make use of the added features. That is the reason leading to a development of information appliances interface development. In a number of cases the interface will not be restricted to a single appliance but it is likely to involve several of them and in a way it is independent of each of them. An entertainment system consists of several pieces but the users interact with the system (or would like to) as a single unit.

The functionality is and will be enhanced by many technologies. They are not essential (not an enabling factor) but in many instances the enhancement provided will be crucial and over time they may be considered as an essential part of the interfacing:

- Affective computing: interfacing is often unsatisfactory, and in some cases people are not even approaching it, because the machine has no knowledge of the feelings generated through out the interaction. Affective computing is addressing this point. There have been only few experiments so far and applications are likely to start in very limited fields and for specific audiences, like kids entertainment, education for the impaired... As technology gets better and cheaper it is likely to find a much wider area of application. This will start mostly in the next decade and by the end of the next decade the advent of personalised interfaces will make significant use of affective computing both to adapt to the person emotions and to learn from those emotion and reconfigure the interface accordingly. Affective computing is not trying to have the machine acting in a human like way; it does not have the machine faking virtual emotion. It aims at bettering the interaction.

- Agents: interfacing requires selecting what information is presented, how it should be presented, what needs to be processed. Agents’ technology can support doing that. In the next decade the growing importance of profiling will make agents’ technology a very important one for human interfacing.

- Avatar: delivering information through a character, human or non-human like, may in some situations increase the empathy in the interaction, making it more appealing in certain applications. Their effectiveness has been probably overemphasized and it is unlikely that the bettering of technology (more human like characters) is likely to increase the interest in them. Examples exist (Microsoft Joe, for one) of failure in applying avatar to human interface. Humanoid are more part of the science fiction than of a need in human interfacing.

- Robot: this technology has been used to augment (and/or mimic) human capacity in interacting with the environment. The interfacing between humans and robot has been dealt, by far, in the same way human to computer interface is dealt with.

- Graphic processing: graphic presentation of information and interactions based on graphics (also 3D graphics) is a tremendous facilitator for human interfacing. There is not going to be any change in this area in terms of use. It will remain as high as technology will make it possible, more important than voice interaction. As availability of graphic information presentation and manipulation grows more use will be done in the human interfacing functionality. The most significant advance is likely to come from the use of graphic manipulation through gesture capturing. This is marginal today but it should be
Growing by the end of this decade and should become the norm by the end of the next decade.

- **Gesture capturing**: basically a lab technology till a year ago, it is now starting to be part of human interfacing also in some mass-market application (Eye Toy for the Sony PlayStation). Its performance, in the mass-market class of devices, is today very crude and can sell only out of the curiosity generated. Sophisticated systems delivering significant performance are still very expensive. The situation should change in the next decade and gesture capturing should become a standard feature in most human interfacing functionality.

- **Holography**: the technology has limited used, when compared to others, in the human interfacing. Its cost, inability to represent moving images and the low resolution is clearly an obstacle in the diffusion. However considering holography not as a specific technology but as a set of technologies used to display 3D objects into thin air the situation changes since there are a number of new approaches to provide this functionality that may become of interest (like the one based on projection of generated fog…) particularly by using at the same time holography like technologies and gesture capturing. Human interfacing functionality in the next decade will make use of this in entertainment and education applications, to name but two areas.

- **Nanotechnologies**: increased resolution, larger, lighter and flexible screens are going to increase the effectiveness of the human interfacing in the next years. Nanotechnologies are going to be a great enabler for these screens and therefore a fantastic enhancer to the human interfacing functionality. The availability of large screens in several areas will dramatically change the feeling of the interface. People are no longer going to look at something; they feel they become part of it. This in turns shift the interactions paradigm, the same way people react differently when they are in front of a shelf or in a living room. No more “sequential scanning” but three-dimensional orientation with grabbing of several objects at the same time.

The access to the human interfacing will be facilitated by some technologies like:

- **Bluetooth**: wireless connectivity makes it easy, and transparent, to use a screen on one device to display information received or processed by another. An image coming through a cell phone can seamlessly be directed to a PDA screen or a portable screen. Bluetooth clusters features provided by different devices into a whole. The human interface can make use of features where they are best served. Penetration of Bluetooth will continue to grow in this decade, then slowly fading away in the next one as WPAN based on UWB will take the upper hand. With Bluetooth the handover from one device to another is not going to be completely seamless and usually it will be from one to another. Real clustering of devices is difficult and it generally will require a master device orchestrating the communications in a peer-to-peer way with the others. Input may be through one device whilst output is done through a different one.

- **WPAN**: it extends the features and interconnectivity of Bluetooth creating a real interface environment making use of whatever feature is available hiding all communication and feature interactions technicality from the user. It will pick up steam in the next decade (under this view of seamless composite human interfacing) and will be the normal interaction environment by the end of the next decade.

The human interfacing will be using a variety of technologies and devices. The one discussed is somewhat outside of what would normally be considered as human interfacing and it is for this reason that has been considered, to show the far reaching implication on human interfacing of technology:

- **Micro Delivery Chip**: it may become an inner interface used in health care to deliver substance to the organism. Possibly it stretches a bit too far the concept of human interface but it is likely to become more and more a companion in the every day life. Not soon. Probably by the end of this decade it will start to be used in an unconnected way (pre programmed to deliver drugs at certain times and in certain situation, coupled with a sensor). In the next decade it will start to be connected with the outside world and to interface with specific (medical) service centres.
4.2.5 Information Displaying

A functionality converting digital information into a form visible by a human being. Tremendous progresses have been made in displaying information, in various forms (text, graphics, still images and video) using a variety of technologies and terminals. The evolution is going to continue as far it can be seen. Evolution is in terms of resolution, visibility (brightness and contrast), dimension (larger and larger), thickness of the screen (thinner and thinner), flexibility of the screen, material onto which the display is made, power consumption, tagging of visual entities to allow interaction, cost (decrease).

A more subtle evolution, all in software, is also taking place: the capability of finding ways to represent in a visual way information so that it immediately conveys a meaning to the viewer; this includes the capability to generate emotions. It may be interesting to note that although holograms have been used only marginally for visual display they have been widely used as a form of art expression for the depth and involvement they generate in the viewer.

The information visual display functionality, as it evolves, makes information display possible in more and more environment and situation. It may cover the complete span from the complete immersion in the visualised information to the overlapping of the information on the environment and the visual flickering that draws attention to something without even raising the consciousness on the visual display.

In the table the Information Displaying functionality and the technology influencing it.

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Information visual display functionality is enabled by several technologies whose evolution is crucial for the evolution of the functionality:

- **CRT**: the main interface today for most of human beings, television outnumbers telephones and cellphones. From a technical point of view the quality of the images displayed with a CRT are still the best ones. However because of the form-factor its evolution is nearing the end and it will be displaced by the flat screen technologies.

- **Flat Screen**: the form factor is winning the market and there are a number of technologies to support this form-factor. The evolution is towards bigger and bigger screens with decreasing price. By 2008 a 20” screen should be priced around 300 Euros. This is the price one may expect a 100” screen may have by 2020. New technologies may even allow the integration of screens in walls within that time frame. Actually dimensions may start to disappear from the evaluation of a screen since one could obtain any dimension at very reasonable cost. The choice of dimension will be independent of the price one is willing to spend. Smart materials will provide sort of flat screens (see nanotechnologies). Used as computer monitors it is now conquering the television market in Europe (as it is doing in the USA and it has done in Japan and Korea). Interaction with video cameras coupled to the flat screen is still in its infancy but it will rapidly evolve and is likely to become mature in the next decade. Image recognition software is crucial as well as the availability of faster processing speed. Visual interaction will be used to provide better images by increasing selectively the quality of those areas where the viewer is looking at.

- **Projection Display**: information display through projectors has so far answered the need to provide larger image display at an acceptable cost. The decrease in contrast and brightness requires low illumination in the room. Evolution has been towards more brightness and contrast and better resolution that now compares basically with the one of

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flat screens. This resolution provides good images when the distance from the projected image is sufficiently large. This means that the angle of vision is basically the same, independently of the dimension of the projected image. Therefore the perception of the displayed information does not change. Projection display cannot be used to provide an immersion sensation to the viewer. Evolution will be in the direction of both increasing resolution and providing alternative approaches that can project on the retina of the viewer rather projecting on a surface. Miniature projection display, embedded in PDAs, may appear in the next decade.

- Software: representation software is playing a major role in any information display. It will continue to do so. The representation of very complex 3dimensional display may even require distributed processing and the software to do it. Image protection needs may also require software to support the ownership, with techniques like watermarking and data embedding in the display application.
- Nanotechnologies: the construction of lighter and wider screens can be achieved by the use of nanotechnologies (NED: Nano Emission Display). The Information Display functionality based on very large screen may provide the sensation to be part of the image and therefore make different perception of information possible.
- OLED: the high resolution and low power consumption make OLED an important technology for information display. Already in use in some cellphones screen and PDA it will become more common in the next 3 years. Information display on wider screen is unlikely to use OLED since other technology with lower cost should be available in the time frame that OLED may support bigger screen sizes.

The Information Display function is, and will be influenced by the evolution of some technologies. In this report WP2 considered:

- Digital Signal Processing: the decoding of digital information into a form that is suitable for display is done either in hardware through DSP chips or in software (in some cases both are being used). The trend is towards a hardware decoding. As coding evolves so has decoding to evolve. In the first phases the decoding may be done in software but once the standard is firm it will move to hardware. In the next decade SoC (System on Chip) is likely to take the upper hand and decoding will become part of any processing chip.

The information display uses several technologies whose evolution will have an impact on the users.

- MPEG: video information display is often coded in MPEG. Alternative de facto standards exist and will co-exist. The growth of coding systems in the direction of coding entities rather than pixels makes the display of information more efficient and enables manipulations on the entities. As an example it makes it possible to hide some entity thus revealing other information laying in the background.
- E-book reader: displaying of information through e-book reader is likely to become more widespread as their cost decreases and legibility increases. Over 10 million e-books have been downloaded in the last 12 months (June 2002-May 2003) and that is an indication of a growing market. In the next five years e-book readers should embed communications capability thus increasing their usability as information display.
- PDA: displaying of information on PDA is commonplace and will continue to be. The wireless connectivity of PDAs in the near future will increase their use as display of information, not just of that contained in the PDA. WPAN connectivity can make the PDA an ideal device to display information.
- PC: displaying of information processed by the PC is obviously one of its main activity. The connection of the PC to the internet makes it also a displaying device with very little processing attached. Its evolution in the next years towards becoming an aggregator of information within the home is going to emphasise its role in this area. In the longer term it is likely that information appliances and home gateways will take this role.

Information display can be enhanced by:

- Graphic Processing: as information display involves images and video graphic processing chips can boost the quality (resolution, frames per second…). Graphic processors are already tremendously powerful, tens of millions of polygons per second, and their
processing power will further increase. In the next decade graphic processing is likely to be embedded in the microprocessor and graphic processing will remain an important requirements also in some specific areas (like video rendering, special effects for movies...).

- Holography: representation of 3D floating images through holography, or different technologies achieving similar results, enhances the capabilities of the information display function. Due to cost and also because of its low resolution, it is currently marginally used. The evolution of these set of technologies may widespread the use of 3D floating images which may increase the effectiveness of information presentation.

The use of information display is eased by:

- Bioelectronics: although today only used in labs’ experiments it is likely that by the end of this decade bioelectronics will start to be used commercially. Information display to the blind is clearly a field of application. By 2008 it is expected that bioelectronics will be able to provide a vision to the blind sufficient to operate, unaided, in an open environment. By the end of the next decade the objective is to provide a quality of sight comparable to the one of a lightly sight impaired person. Other fields of applications are in specialised professions, like surgery, military...

- Distributed Processing: the computer power amassed by distributed architecture is already being used to create information display for movies. The rendering process is still very much processing hungry and may consume several weeks of processing power. The evolution of distributed processing, including the GRID, should make huge quantity of processing available at low cost for information displaying. By the end of the next decade real time rendering may become possible.

- Wetware: only speculation of possible applications today it may become a reality by the next decade. Experiments on mice have shown the possibility to display information directly from tissues, and cells. In the next decade medical monitoring systems will become available to display the insurgence of certain pathologies. Sensors can capture information displayed by single cells and transfer to where it makes sense.

- WPAN: the information display is facilitated by directing it to the most appropriate device available. Images received by the cell phone can be routed through the WPAN to a portable screen a person happen to have with him thus increasing the usability of the information.

### 4.2.6 Information Retrieval

The set of technologies facilitating the retrieval of information.

The complexity in retrieving information keeps growing as more information is available, both locally and in the network. Today information is mostly retrieved on syntactical bases. Textual information can be easily retrieved and the retrieval of other types of information relies on the existence of some textual tag attached to it.

As shown in the graphs the volume of information produced (expressed in TeraBytes; data from a Berkley study released in 2001 and referring to information production in year 2000) is tremendous and out of all this information the part that can be effectively retrieved is (although enormous) relatively negligible (that is the textual information on the web). The amount of information produced by individuals, as shown in the second graph (figures given in PetaBytes, thousand of TeraBytes), highly exceeds the amount of
information produced by all other companies who are in the business of producing information. This trend is going to continue and also accelerate. Digital cameras, digital camcorders are going to produce huge amount of information that is not possible to easily retrieve. Additionally the progressive availability of information on the web multiplies the number of information that can be potentially searched. The difficulties in accessing the information also have the undesirable effect of “hiding” information among a mass of data. Filtering of retrieved information is an essential part of the retrieval functionality. Ideally information needs to be searched not according to some identification string that is in the information itself or associated to it; rather it should be searched according to the reason why the information is sought. The information meaning (semantics) is crucial as much as the context in which the information has to be used. The most significant evolution is going to be on semantics retrieval. That will require the evolution and integration of several technologies.

In the table the Information Retrieval functionality and the technology influencing it.

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There is fundamentally one main enabler for this function:

- Software: progress has been made in the search algorithm and in the data base structure. Evolution is towards software able to filter retrieval based on the user profile, on the context and in perspective, by the end of the next decade, on the reason why information
is sought. New business models may become necessary to “price” the search of information both to the searcher and to the information owner. This in turns will place new demands on the retrieval functionality that will need to negotiate the retrieval with many actors.

The progress in this area may prove elusive, as it has been the case for progress in the artificial intelligence. Actually the next big step in information retrieval is very close to the merging with artificial intelligence.

A further step that is progressing in parallel with the semantic retrieval is the search of related information. Relationships, explicit or implicit, among information is information itself, in many cases a most valuable one. It is not “stored” anywhere so in a sense it is not retrieved but “computed”. Seamless communications between data bases and Data GRID are the enabler technologies.

The function is enhanced by a set of evolving technologies:

- Agents: profiling and negotiation for information retrieval will mostly occur in background and agents are the obvious technology. Agents can learn what the users want, adapt information to her needs, avoid duplication and try to complement with what the user already knows. Autonomous agents will roam the information on the network retrieving what makes sense and keeping it available on demand or push information immediately to the user’s attention as required. Research and standards in this area are likely to stimulate the market.

- MPEG: MPEG4 embeds some constructs to facilitate the retrieval of content by segmenting the overall clips and images into object. Research is required to automatically tag objects and create relationship.

- Semantic database: the retrieval functionality can derive the meaning of information through its analyses or the meaning can be stored within (associated to) the information itself. The semantic web (XML) is following this second approach. Independently of the approach the trend is towards an in depth understanding of the meaning of information.

The function use is facilitated by:

- Cell phones: more and more information retrieval will be funnelled through cellphones since these are becoming a “standard” wearable for people. The increased screen capabilities (small increases), the communication in WPAN with better screen, the availability of text to speech application conveying information in an aural form will all contribute to a growing use of the cell phone as a facilitator in information retrieval. Further more the cell phone, either directly or indirectly, will contain a user profile and some applications that autonomously can retrieve information and store it in the cell phone memory. By the end of this decade the cell phone memory capacity will be sufficiently large to accommodate a lot of information. This can remain in synch with information in the network (accessible through the network).

- Quantum computing: sieving through information using quantum computing can greatly accelerate the retrieval. It is unlikely to become available anytime soon. It is difficult to make a forecast for the next decade. Assuming the technology becomes available it will facilitate retrieval only in very specific cases.

- Optical Disk: beyond the normal support provided by the optical disk as storage device holographic optical disc promises to accelerate the retrieval through a massive parallel search of information made by the reading head, with no processing required.

- Voice syntheses and recognition: information retrieval will make more and more use of voice syntheses (to present information) and recognition (as input to request information). Other forms of request and presentation will continue to remain in use, even assuming a perfect technology for voice syntheses and recognition becomes available. In perspective, the evolution of voice recognition towards the identification of emotion will help the information retrieval functionality since it provides information on the “reasons” behind the request.
4.2.7 Pin-pointing

A functionality trajectory which groups:

- **Localization**
  - The ability to identify a place one is in. Conversely, the ability to identify where someone else is in is called tracking.
- **Tagging**
  - The capability to associate a unique identifier to an object (physical or virtual).

This functionality enables a variety of services (location-based services) that radically change the distribution chain, provide new ways to monitor patients in the health care domain, provide timely information to tourists... Additionally, this functionality will play a significant role in security and safety. Research in these areas is likely to provide interesting "boosts" to other fields.

The evolution is towards better resolutions at lower cost; the embedding of localization chips in many everyday objects and the wider availability of information systems relating identity and localization to context.

Clearly there are two factors playing into this functionality: the means to make oneself localised (e.g., by tagging or by making reference to a satellite signal) and the make use of the localization information (e.g., tag readers, GPS receivers...).

WP2 has investigated some of the underlying technologies in the first area, the one of providing the means for being localised, as shown in the following table.

The evolution of the receivers is clearly as important as the other but this will basically follow the evolution of electronics, sensors, communications and processing. For this reason it has not been considered here.

In the table the Pin-Pointing functionality and the technology influencing it.

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<th>Technology clusters</th>
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</table>
The functionality is enabled by:

- **Galileo:** the satellites system, to become operational around 2008, should allow the functionality precision in the order of few meters. Receivers will likely be embedded in a variety of mobile devices and the functionality will make use of other technologies, like inertial gyroscope, cell phone network antenna triangulation, local beacons to increase the precision and coverage inside buildings.
- **GPS:** offers lower resolution than Galileo, however it is available since the nineties and receivers have already decreased their price significantly.
- **Active Tags:** placement of active tags in some environment, like museums, can provide a reference point usable for pinpointing needs. The pinpointing functionality usage of active tags will be very limited due to the availability of alternative technologies serving the same purpose at a lower price. Once the active tags will have reached a competitive price, early in the next decade, the receivers will be using other technologies (Galileo and inertial gyroscope) for localization. Passive tags will obviously be widely used to pinpoint a specific object within a limited space, once it is known the location of the object (as an example looking for an object on a shelf...). This application, however, is not considered as part of this functionality.
- **Beacons:** usage of beacons may be of interest in buildings where the coverage from satellite systems is not available and where more precision may be needed. Existing communication systems may be used as beacons, such as triangulation through WiFi antennas.
- **Biomarkers:** Pinpointing of specific cells and organs will have a growing importance in the future of medicine. As drugs become more specialized and focused on a specific person the monitoring of their effects will be more and more crucial. Biomarkers will also provide reference points in surgery performed by robots. The pinpointing functionality will make use of biomarkers through sensors and bioelectronics.

The functionality makes use of a variety of technologies. Only two have been considered in this first deliverable:

- **Cellular base stations:** the functionality makes use of the capacity of a cellular base station to determine the relative distance of a cell phone by measuring the signal strength. Through triangulation by several base stations it is possible to achieve a resolution in the order of fifty meters. Third generation cell systems are at the same time more complex to use for the pinpointing of the terminal (because of the variable absorption of the signal by the cell) and more effective since they have an overlapping coverage of cells that eases the triangulation.
- **Optical tag:** their use by the functionality allows the pinpointing of an object without having to know its general identity. Different companies may track the same object under different labels, without disclosing one to the other the associated “private” information. Their use will be limited to pinpointing in the distribution chain and in some security applications.

The functionality is enhanced by:

- **Antenna:** the evolution of antennas towards the capability to distinguish the direction of the receiver clearly enhances the pin-pointing functionality. It will prove of particular interest
inside buildings and in those areas, like cities with narrow streets, where the satellite coverage is not available.

4.2.8 Printing atoms

A way to convert digital information into objects (both organic and inorganic)

Although often thought of printing information on a sheet of paper has made exceptional progress in these last 30 years (thanks to electronics and more recently to MEMS, special ink,...) and the world has been inundated by “paper”. The paper industry is the only one that has seen a continuous increase in volume, including the last years when all other industries entered a shrinking phase.

The printing functionality is on the verge of a significant leap by substantially reducing the cost of printing “objects”: it is the same process that happened in the 80ies when expensive printers were complemented by cheaper ones (1-2 orders of magnitude cheaper) thus opening their introduction in the mass market. The volume of paper (and ink) needed would support a completely different business model where the printer is basically given away and the margins are derived from the sale of ink cartridges and paper.

Today’s printers (or CAM, Computer Aided Manufacturing) for printing objects are extremely expensive, well beyond the ability of the mass market. Technological breakthrough is needed to achieve this substantial cost reduction, both in the printer itself and in the “inks” to be used.

It will be possible to print almost anything, a computer, a cell phone, a bike, a chinaware. This will have significant effect on the distribution chain, not as much because it will reduce the amount of goods being physically transported, because it will let producers to export at very lower price their goods. Developing countries may benefit from this evolution since it will open them rich markets abroad. Besides, those are the first markets that will have these technologies available.

A particular area of printing atoms is the printing of organic tissues and organs. This is a huge promise in the medical field, both for transplant and for tissue replacement (such as for burns).

In the following table the Printing Atoms functionality and the technology influencing it.

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<tr>
<th>Technology clusters</th>
<th>Technologies</th>
<th>Year</th>
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</table>
Several technologies are enabling the printing atoms functionality:

- **3D Printers**: these are clearly crucial in the evolution of the functionality. Cost decrease, today starting in the 100,000 Euro range, should decrease at least 2 orders of magnitude to start a mass market whose real take up will require a decrease to 3 orders of magnitude. In between their diffusion will start with retailers. In the book area it has already started with book printed-on-demand now available in some US bookstores and in mobile vans in India. It is important to notice that although a mass market atoms printing is unlikely to become feasible before the end of the next decade a “culture” of personal object printing may develop earlier through retailers providing printing on demand services, “Kinko” like.
  
  Significant research needs to be done in the whole printing process, from the description of the object in a digital form (that needs to be easy to manipulate and change by the end user to customize the printed object) to the inks used (materials forming up the printed object, to the warrantee.  
  
- **Bio-printers**: focusing in the medical field, the printing atoms functionalities through bio-printers will let tissue to be printed, out of scaffolding printed at the same time with living cells. This approach should reduce significantly the time to create artificial tissue, today done through culture cells in vitro (and only applicable to some tissues, like the skin). By the end of this decade refinement in the technology should allow the printing of more complex tissue and by the end of the next decade organs’ printing should become feasible. The functionality will require the coordination of several aspects, from the breeding of cells to the injection of the scaffolding and control of the cells growth on it.  
  
- **Printers**: increasing resolution is not going to be a leading factor beyond 2005. Printer speed will remain important characteristics till 2008-2010. New features are likely to replace in importance these factors. Direct connection to other devices, insertion of microscopic codes (both in silicon and in invisible ink), and in perspective the printing of both the “paper” and the text/images on it through nano particles.  

Printing atoms makes use of several technologies whose evolution will have a significant impact on the functionality:

- **MEMS**: already used in some writing heads they support higher resolution printing and the manipulation of the special inks required to print atoms.  
  
- **Micro Delivery Chip**: used to watermark printed pages, and objects, support authentication functions.  
  
- **Nanotechnologies**: applications are still far into the future. By the next decade one could expect some use of nano particles in special inks and in the tagging of bio-materials.  

Printing atoms will be enhanced by the evolution of:

- **Public Key Cryptography**: printers supporting PKC may become available in special task where security is a high concern.  
  
- **E-ink**: an alternative to paper printing its evolution will support the functionality by providing first higher resolution and then, in the last part of this decade, the possibility to print data and the applications creating chips on paper to perform whatever necessary, including the interaction with the person reading the paper and the one with the environment.
4.2.9 Processing

The capability to process data, as exemplified by a PC. The processing functionality will continue to deliver more and more processing power, leveraging on the microchip evolution. Additionally further increase will be derived by the emergence of highly distributed architectures and massively parallel architectures. Both of them, however, are likely to find applications in limited areas, scientific, medical, and environmental. For the mass market processing needs the evolution is towards a disappearance of the PC and the embedding in a variety of appliances.

On the contrary of the PC that is a multipurpose devices (that has been its strong point), in the future there are likely to be focused function devices, the appliances, that by being designed for a single applications can provide a much more intuitive interface. The need for managing the variety of applications and delivering those functions that result from the integration (e.g. Microsoft office by integrating text management, spreadsheet calculus, and drawings deliver in all three areas increased value) will be met by the communications between objects. This is therefore much more than a simple data interchange: it is a way to create, all together, an enhanced functionality. A cell phone can communicate via Bluetooth images received from the network but today this requires a (series of) command to trigger the transmission from one to the other. In the WPAN scenario this connection is functionally seamless. By having the PDA in one’s hand the reception of a call with the cell phone in the pocket of the jacket automatically route the information to the PDA with no intervention from the user.

The inevitable increase of processing power will soon exceed (in the 2008-2010 timeframe) the need of the vast majority of users and therefore it will no longer be a motivation to buy a new model.

The processing power leading edge will shift from PC to game console in terms of brute processing force. It is an open question if the gaming console can really steal the PC market. Surely that is not the target of the console manufacturer that would like to steal a yet to exist market, the one of controlling entertainment in the home environment. That is a market that is being contended by several players, including the telecommunications ones.

For high level processing needs GRID technology (and Linux) may become the leading solution in this decade. Further down into the future many more processing needs will be solved within a single machine thus decreasing the interest versus highly distributed architectures. Those applications requiring huge processing capability are more likely to turn to massive parallel structures.

Processing functionality will also evolve in the sense of processing environment (as small as sensors or as big as an enterprise) that will communicate with other environments through high-level information. There are a variety of technologies that will be contributing to the processing functionality as represented in the following table.

In the table the Processing functionality and the technology influencing it.

<table>
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The processing functionality is based today on the microprocessor and its evolution. In the next years few other technologies may come to play a basic role:

- **Microprocessor**: the microprocessor will remain at the core of the processing functionality throughout the observation period. Functionality performances will soon exceed most of demand and the price of the functionality will rapidly decrease. Research in this area is very difficult from an economic point of view. The lag existing with the USA is so big that it does not make sense trying to take the upper hand. In the long term, by the end of the next decade, other approaches to processing may become available but the microprocessor will maintain the undisputed leadership.

- **Mobile processing**: the processing functionality will be on higher demand in mobile environment, from cell phones to portable screens to sophisticated entertainment devices. The evolution in performances and a possible breakthrough in batteries may lead to a substantial equivalence of mobile microchips with the ones used in normal PCs by the end of this decade. The same trend can be expected for processors powering PDA and
cellphones although in the longer terms. However the mobile processors being used in devices like the SIM card are unlikely to reach any comparable processing power, even within the next decade. Their evolution is going to play a major role on the way the processing functionality can be delivered and in this area focused research may be advantageous for Europe with a good chance of taking the lead. This area may prove to be strategically important and with very wide applications in sensors, active tags, ambient communication.

- **Molecular Computing**: unlikely to play any role before the next decade it can occupy a niche in those areas where massive parallel calculations are required. In those fields it may see some applications by the end of the next decade.
- **Quantum Computing**: only theoretical studies and a few experiment to prove the theory but there is very little understanding on what should be done to implement a working quantum computer beyond a lab curiosity. A breakthrough may come at any time, but that has about the same probability of a brand new technology appearing out of the blue or of a gigantic improvement in any of the today’s lesser-considered functionality.

**Processing** uses a number of other technologies to complement the microprocessor:

- **Batteries**: the processing functionality in cell phones is obviously making use of batteries and any evolution in their capacity will result in an evolution of the processing functionality for these devices. Another important area is the one of sensors where these have to be left unattended for long period of time and there is no mains to power them. Evolution is expected in the next 4 years and by the next decade the use of much better batteries will greatly increase the processing functionality.
- **Digital Signal Processing**: a fundamental part of communications and of the conversion from environment information to the one to be processed (and for the display of processed information). Its contribution to the processing functionality will remain important, and stable. Its evolution will basically parallel the evolution of the processing functionality.
- **Graphic Processing**: it is now present in most processing devices either as a separated chip or embedded in the microprocessor. The trend is towards higher performances, to reach the billion of polygons by the end of this decade. At that point any further progress is unlikely to be noticeable by the end users and the amount of processing power available in the microchip will lead to the integration of this specialised processing into the more general one provided by the microchip.

**Processing** is enhanced by the evolution of several technologies:

- **Distributed processing**: the processing functionality provides better performances by exploiting distributed processing architectures. This gain in performance is usually requiring more efforts in the software coding (particularly if one is looking for a high efficiency, like a 60% one, that is the effective throughput is 60% of the theoretical total throughput obtained by adding all individual processing power of the various nodes).
- **GRID Computing**: by standardizing a number of interfaces and architecture GRID computing based processing functionality can deliver better performances with a lesser impact on the software coding. Widely used in a number of demanding applications it will grow till the end of the decade. Further on it is more likely to see a retrenching on single processing devices (leveraging of their much higher than today processing power) or in those few cases where processing capacity remains the highest priority massive parallel architectures may prove to be better suited.
- **Software**: no processing is possible without software but looking at it from the point of view of the impact of software evolution on the evolution of the processing functionality it can be claimed that this evolution is enhancing the functionality more than enabling it. Significant evolution should be expected in some areas like the management of distributed architectures, the massive parallel architectures in the high end. For the low end more efficient operating systems for the SIM card like processing, for sensors and for local networks, like WPAN, should be effective in increasing the processing functionality and should be the focus of research. Also the decoupling of various environment supported by the processing infrastructure are going to be essential to ensure security and reliability.
while at the same time stimulating applications development by third parties. This is another area where Europe should consider investing heavily in research.

- Nanotechnologies: in specific areas, like sensors, the application of nanotechnologies may increase the processing power decreasing power consumption.

The access to the processing functionality is eased by the evolution of a number of devices as listed in the following. Note that information appliances will take a lot of processing functionality out of the PC but they have not been included since they will not be used for processing, rather the fulfillment of their goals will require embedded processing, in the same way that today we are not associating any processing function to an injection system in the car.

- Notebooks: they are today a marginal market if one considers them in strict terms. By broadening the definition and including lap top computers and tablet PCs the market share becomes bigger, although not as big as the one of the PC. In the next years this market share will grow at the expenses of the PCs because of the form factor and the fact that laptop can have the same performances of their big brothers when connected to the mains. The cost differential will tend to diminish, as the LCD screen equipping them is becoming also the first choice for PCs. In the longer term, in the next decade, they are likely to become the dominating form of access to undifferentiated processing functionality.

- PDA: very little contribution to the processing functionality, since they are mostly used for the up keeping and displaying of information. Their processing power will grow in the next years, although unless a breakthrough in battery becomes available it is unlikely to become anywhere near the one of a PC. Also their area of application will remain the one it is today. The equipment with communications links will increase their use as display of information and some graphic processing may be embedded but just for that purpose.

- PC: the processing devices in all these thirty years in the mass market it will continue till the end of this decade to support the processing functionality. Its share on the market will progressively decrease in favour of notebooks and it is likely to disappear by the end of this decade from every office and desk. In the longer term the idea of a dedicated device to offer processing is also likely to disappear completely. Processing will become a taken for granted, hidden, characteristic of any device.

4.2.10 Storage

The capability of keeping data for a significant period of time making them available on request. As detailed in 1.3.1, there are a variety of technologies, each of them in a rapid evolution, providing storage capacity.

In the future the storage functionality will evolve, thanks to these technology evolution, towards higher capacity. The question if this capacity is going to become irrelevant since it will exceed the demand is not easy to answer. In all these last 30 years of evolution it has always seemed that the capacity that would have been reached in a five-year time would have been far exceeded any possible needs. This has not been so because of different causes that have played in different periods. However one main cause is the fact that communications make it possible to upload on one’s memory information produced everywhere else. The multiplication of the information reachable has made storage demand grow.

Given a hypothetical infinite local storage capacity some people (many?) would simply upload the whole Internet in their local storage. This is the result of a lack of trust in the communication network, which probably is an unavoidable characteristic of best effort networks like Internet. It is always best effort but some times that best is not sufficient.

Developments in the sensors area (at the core of projects like the Life Log of DARPA) and in the tracking of communications (like in Microsoft MyLifeBits) promises to generate a deluge of data in addition to the one already on the web.

The storage functionality, however, is going to evolve in two fundamental characteristics that have been somewhat neglected so far: the reliability, survivability and comprehensiveness of the storage on one side and the possibility to retrieve sensible information out of a huge pile of data. Both of these characteristics are based on hardware architectures and on software and both will drive the evolution of the “use” of storage, not of its increasing capacity that will go on as far as one can see.
Would storage functionality be able to forget the capacity issue? Not for the next 3-5 years in general. However, beyond that point, and in some niches sooner, the capacity issue will in effect be no longer an important one and will tend to fade away.

The recent iPod from Apple can store over 10,000 songs. Within 3 years from a technological point of view it will be possible to store over 100,000 songs, many more than any person has a chance to listen in a lifetime. In that specific area one might say that the storage capacity is no longer an issue.

From an architectural point of view this evolution of the “perception” is interesting since coupled with the evolution of processing it is leading to a binding of storage capacity within devices offering specific functionality (like the iPod). Storage kept becoming an issue when associated to a general purpose device like the PC since as one function was fulfilled with the available capacity (like storing textual documents) another one would require more capacity (like the storage of photograph). Clearly the architectural impact is significant. As more and more storage is confined in specific appliances the issue of how to retrieve information spread in various “pails” becomes a central issue for the storage functionality.

Software is obviously a main contributor to the evolution in this area.

In the table the Software functionality and the technology influencing it.

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The storage functionality is enabled by a number of technologies available today and more will be available in the coming years. In this deliverable a few of these have been considered:

- **DRAM**: the Dynamic Random Access Memory is at the core of the storage functionality applied to processing since it is fast and can be written by the microprocessor. Its evolution will boost storage capacity for processing; on the contrary it will have very limited impact on permanent storage of information. That is the reason why its grading is 3 (applied to niches).

- **Hard Disk**: the increased capacity offered by the hard drive, thanks to the evolution in the magnetic substrata and in the reading heads, will continue for several years. Current technology (both for the substrata and for the reading/writing heads) seems to pose physical limits before the end of this decade with a top capacity in the order of few TBs. This limit seems acceptable today and beyond the envisaged requirements for use in PC and DVR (domestic use). The evolution of the HD will continue to sustain the evolution of the storage functionality till the end of this decade and it will continue to be used well into the next decade.

- **Optical disk**: there are various technologies using plastic disk with a laser as a reading head. The writing may be done using laser or other technologies (like Millipede) and not all are read-write. Capacity will increase significantly and with some technologies it will exceed the TB by the end of this decade. The optical disk provides the storage functionality with approximately the same capacity as the hard disk but a lower access speed (except for some niche application for information retrieval when using, 2008 on, holographic disks). On the plus side it provides higher durability. The potential for some of these technologies is much higher and it should lead to multi TB storage in the next decade. It is likely to be used as back up storage in many environment and some approaches to maintain them accessible as technology evolves will be crucial in the future as more information is back up on them. This survivability in the long term (centuries) may become an important characteristic of the storage functionality.

- **Read Only Memory**: a set of technologies, partly based on silicon chip, to permanently store information with no possibility to erase them (even by mistake). Clearly there are important areas where this kind of memory can find application. The capacity will grow in a linear way for silicon-based memory, without reaching the sizes delivers by optical storage and hard disk. Other technologies, like the ones based on polymers, may deliver much higher capacity. By the end of this decade multi TB capacity should be readily available in a plastic card the size of a credit card. Application like the selling of access-protected information is an ideal candidate (music, movies...).
It uses a variety of devices, including some that have been listed in the “enabling ones” like the hard disk, and fabrication technologies:

- **Digital Video Recorder**: storage on DVR is going to be important in the home environment. This does not restrict to the DVR as such (which can have alternating fortunes in different markets and wave according to consumer electronics push) but extend to the concept of the digital recording of entertainment. By the end of the decade, sooner in some countries, the advent of the DTT will make additional information available for recording and the DVR may become a home information center. Some computer manufacturer are pushing for DVR like features in PC, other are planning upgraded game consoles...

- **Nanotechnologies**: new memory substrata based on nanotechnologies are already appearing in the labs (like Millipede) and more will come. Nanotechnologies promises higher storage density and the capability to read them. First products should arrive in the 2006 timeframe and become more widespread later in the decade.

- **Holography**: holographic storage provides a potential high storage density, in the order of TB and more, and the capacity to search for information directly on the disk with no processing involved.

Its evolution is influenced by the evolution of:

- **GRID computing**: the data GRID will have an impact on the storage functionality changing the way to store and access distributed information.
- **Distributed Storage**: similar to the data GRID in terms of impact. Possibly the data GRID will become the dominant form of distributed storage by the end of this decade.
- **Semantic Data Base**: the storage functionality will evolve in the sense of easing the retrieval on information. The semantic database and its sibling, the semantic web, will provide the underlying architecture for storing huge amount of related data.
- **Optical tags**: so far the optical tags, whose use has been described in the information retrieval functionality, are difficult to write and therefore their application is limited. The storage functionality will take advantage of the characteristics of the optical tag to store different patterns on the same tag making each of them visible to a very specific reader.
- **Passive tags**: the diffusion of passive tags should lead to a standard in the storage functionality based on them. The “number of bits” stored as identity and the possibility to store additional information is still open. The storage functionality making use of tags will have to write at the same time the tag and the database with the associated information guaranteeing its consistency over time.
- **Home Networking**: the availability of an home networking connected with the outside world influences to a significant extent the storage functionality. Information can be stored “in house” independently of the particular device capturing it, even if the device is a mobile one that will transfer information through the public network. Furthermore, the architecture of the storage made possible by the existence of a home network allows the development of sophisticated storage functionality.

Its use is eased by a growing variety of devices, including the cell phones and many appliances. The analyses in this first deliverable has been focusing on:

- **PDA**: information stored on a PDA will grow in number, as its capacity increases (in the GB by 2008) and it communicates with the environment.
- **Personal Computers**: for twenty years the sole repository of digital information it will continue for all this decade to be a favorite storage location and the way to access information (both the one it contains and that accessible via the web and home networking).
5 Technology Trajectories for the selected Functionalities

Technology is a word with a seemingly quite clear meaning but as one tries to apply it the definition blurs. A chip is a technology, no doubt. But is it a technology in itself or is it a composition of different technologies (for designing the logic, for etching the wafer, for doping the silicon). Is the chip a technology in the sense of the “packaging” technology that makes it possible to connect the silicon part to the board? And, if we accept the chip as being a technology, what about a PC? On a macro scale it is very like a chip, using basic components, requiring a sophisticated design, connection of components… packaging.

Over a hundred technologies have been selected as a starting point. The criteria have been to look into those that have a potentially strong impact on the Information Society. More technologies are “hidden” in the ones selected (such as the lithographic process which is not considered as self standing but it is mentioned in evolution challenges for silicon based storage and microprocessors…). Other technologies are considered at the edge of IST and therefore only mentioned in relation to the ones selected (such as the drug syntheses mentioned when dealing with molecular computing and the GRID).

Comments on this work and further discussion will surely lead to an extension of the present set in the second deliverable planned in Fall 2004.

Here it follows a brief presentation on the main evolution trends identified. Since these are general trends (that is, they are deriving from a mixture of technologies and their mutual interplay) they are reported in terms of functionalities. This allows a holistic view of the evolution that would not be possible if the focus is on a single technology. The discussion on the single technology evolution (and its relationship with other enabling/enabled technologies) is given in chapter 3. The potential alternatives, over the time frame of the Fistera observation, are given in chapter 4 when discussing functionality evolution.

In this chapter we try to provide the holistic view embedding the various forces that may play a role on the technology trajectory. This work is necessarily unfinished and partial. More information is expected from the interaction in the road show and this information will be used to reshape the trajectories so far identified and add a few others in the closing deliverable of WP2, September 2004.

5.1 Bandwidth

With bandwidth here it is meant the transmission capacity at the access level. Note that this is just part of the whole story since today’s network are not engineered to provide bandwidth connectivity to all their termination point. Assuming all connecting points make substantial use of broadband communications there would be a need to deeply re-engineer the whole network.

The network capacity on trunks is not considered here. That capacity has been growing linearly (with a leap at the introduction of the digital transmission in the 60ies and another one with the introduction of optical fibre in the long distance network) till the late nineties. At that time capacity multiplied hundreds fold with the deployment of D-WDM (basically a technique multiplexing hundreds of communication streams on a single fibre, using a different optical frequency for each channel). Capacity on fibre is likely to continue multiplying reaching hundreds of Tbps in the next decade. To this effect will contribute progress in both optical, optoelectronics and electronics.

Bandwidth in the access has become an issue when data communications has started on the local loop (or on termination to business location). It grew from 300 bps to current 100 Mbps on some fibre in the loop. In the next 5 years there will likely be a concurrent (though with different mix) deployment of xDSL (now reaching up to 100 Mbps on 4 km loop length) and optical fibre. In the long run optical fibre should become the preferred choice (not as much as speed performance, rather in terms of lower management cost). From a service offering perspective residential connections at speed close to 100 Mbps are likely to satisfy 99% needs well beyond 2020. It should be noted that this speed will anyhow be increased in terms of usability by a number of concurrent evolutions like GRID networking at the termination point (particularly for business customers) increased availability of storage at end points and near end points, more effective coding scheme. Bandwidth may remain at premium through this decade and part of the next one.
in a mobile environment (and not even in general since many high density areas will sport high bandwidth hot spots). If till the end of this decade bandwidth will remain the talk of the town by the beginning of the next decade the focus will shift onto bandwidth flexibility, bandwidth guarantee...the race for speed will be over.

At a research level the search for bigger bandwidth is likely to continue to satisfy very specific needs (holographic projection, GRID support in scientific – medical – security environment) and that effort will create fall out onto general infrastructures and applications.

The main actors are in Korea, Japan, USA, and Europe, probably in that order if one considers the deployment situation.

Broadband in the access, particularly in Europe and the USA, is steered by a potential market demand, much more than in Korea or Japan. The success of broadband in those countries, achieved also through a significant government intervention (true for Korea, less for Japan) should stimulate thoughts on which way to proceed in Europe.

In the next 15 years we are likely to see as main technologies:

- Transport technologies
  - **wire local loop** technologies are based on a variety of physical media: copper, fibre, coaxial cable, power line. A discussion on the evolution of these technologies can be found in the chapter 3. Their interplay can be summarised as follows:
    - copper based technologies (xDSL) will progress in speed reaching a plateau by the end of this decade in the range of a few hundreds Mbps. This is probably plenty of bandwidth and therefore the shift, which will surely happen, towards the fibre is not motivated by the increased speed, rather by cost factors. In particular the fibre promises to cut operation cost but it will take few more years before this is a reality in all environments. Vandalism, powering, environmental factors playing harsher in the open than in the closed environment of an exchange, are all contributing to higher operational cost that need to be addressed. The life cycle of copper varies, 10-15 years, depending on the country and the deployment techniques (aerial, underground...). It may be expected that in the next decade the copper will be on the demise practically everywhere.
    - fibre based technologies have the potential to provide extreme bandwidth. This is competitive today with respect to copper based technologies but the higher cost makes this proposition viable only in a few environments (business connectivity). In some countries like Japan and in some limited areas fibre in the loop deployment has started. In the longer time frame, as noted above, the top speed in the loop is not going to be the major differential factors since speed over 200 Mbps have limited demand in a residential environment. Various architectures are likely to be deployed for the distribution network, from rings to star to mesh networks with optical add drop for the last drop. Passive optical networks are likely to be deployed as well.
    - coaxial cable technologies, mostly used in television distribution networks (cable TV) in the last drop, are suffering from a shrinkage in investment and from the strong competition of ADSL. Only in the USA cable modem are more widespread than ADSL. Older infrastructures, like in Germany, have more problems in providing bandwidth, whilst newer ones like in UK are more apt to provide bandwidth. The situation in Europe varies from country to country, with a large penetration of CATV in the Nordic area. It is unlikely that these technologies will progress to a point of becoming the preferred means of providing bandwidth.
  - **wireless local loop** technologies will see a significant increase in variety and in performance.
    - The WiFi cluster (802.11a, b, g,...) will become more and more widespread throughout Europe in homes and in those areas having a high demand for data connectivity (some enterprise with nomadic working habits, airports, malls, hotels,...). The total coverage will be insignificant if compared to the one of GSM, or 3G, even in the next decade. However the traffic carried through these networks may be quite significant. The main actors in these areas are in the USA with a widespread impact everywhere. Evolution depends more on standardization and on the exploitation of electronics (industrial research particularly related to packaging).
    - The pulse based technologies (like UWB) will provide very high bandwidth in small areas. The major advantage is in the low power consumption. In the last part of this decade we might expect a significant dissemination, with a progressive substitution of...
Bluetooth and in some cases of WiFi. Many appliances are likely to be equipped with these technologies in the next decade. The main actors are in the USA. Research in this area is important for Europe since it will enable several applications, including the sensors networks.

- LMDS like technologies may find some application areas to skip the last copper mile. Within this decade they are likely to be focused on the provisioning of bandwidth to business and to some isolated spot. In the next decade they may come to be used also as an alternative infrastructure in several areas.

- cellular technologies (GSM, 3G, ?) will be dominating the market in this decade and also for the next one they are likely to be major players. The advent by the end of this decade of the Software Radio may blur the borders among several technologies enabling a single terminal to use whatever wireless network is available in a certain area. The number of services will grow significantly, also thanks to the broader possibility offered by WPAN. At the same time the bandwidth will grow but it is unlikely to compete with the one offered by pulse based technologies. 4G is still on the drawing board and is unlikely to appear before the next decade. It may well be a seamless integration of several radio systems in a seamless way from the user viewpoint. By the end of the next decade the possible solution of interference by cooperating terminals may increase significantly the bandwidth available (in the order of few Mbps) but more than that it would increase the overall usability of the bandwidth by many terminals at the same time (increase throughput by overlapping cells).

- satellite technologies will continue to face sharp competition from terrestrial systems and it is unlikely to see them playing a big role in bandwidth provisioning. However for some isolated areas their role is going to be essential and in some cases without alternatives.

- Edge technologies
  - **GRID structures** at the edges of the communication links can work to increase the communications speed beyond the limits of the optoelectronics conversion and the delays introduced by the communication protocol. Today using GRID structures at the edges effective speed has been pushed by about one order of magnitude over transatlantic and transpacific links. This increase in capacity is needed by some very specific applications and is unlikely to have an impact on the general market. However in the next decade some offers may start to appear to provide this kind of speed also to some enterprises. The main actors are in the USA. Some research is also taking place in Europe. It has mostly a scientific, non-commercial value and it may remain a low priority topic.

- **mirroring** technologies are likely to have a growing importance letting service, content and network providers to ensure bandwidth perception without the need to actually transport information across the network. By storing (mirroring) content locally, by the POP or in some convenient place, the user will be just one hop away from information. Research is basically on architectures for mirroring, shadowing, data relation and is exploiting the huge availability of storage. Additionally tracking systems, prediction algorithm and Clever like monitoring of web usage will take care of the optimisation of the mirroring.

  The main actors are in the USA. The issue of managing large quantity of data through optimised architecture is an important one and Europe should not be left behind since it has implications in many areas that will be fundamental for the e-citizen.

- Terminal technologies
  - **cashing** technologies let the terminal store information for subsequent use. The huge increase in storage capacity is leading to an increased use of cashing in the terminal. Background cashing in a variety of terminals is likely to become a common practice by the end of this decade and to have a significant impact in the next one. The availability of TB in local storage, by the end of the next decade even in pocket devices PDA-like, will change the paradigm of communications with devices downloading potentially useful information as they are within “hot spot” with cheap and fast communications links (e.g. UWB picocells).

  Research is in the area of software, profiling and artificial intelligence “a la Clever”. The deployment is in synch with the increase in storage capacity; this can be estimated, for mass market, in the area of 1 TB by the end of this decade and 100 TB by the end of the
The main actors are in the USA for the software part. Storage technologies evolution has been dealt with in 8.1.

5.2 Communications

Communications technologies have evolved significantly in these last 30 years mostly making it simpler to connect points on the whole Earth. A significant step ahead in the next 10 years will be on one hand the connectivity among ambient and the personalization of connectivity.

The advent of the cell phone has marked a significant shift from the communication paradigm of calling a phone in a certain location where a person was likely to be found to calling a specific person without knowing where she is. This paradigm shift has generated a tremendous amount of new opportunities and services. The fact that a cell phone is “on the person, at all times” has also increased the opportunity for that person to use the phone and communicate.

The advent of ambient to ambient communication, in a way, will push the pendulum back towards communication to a location (without diminishing the person to person communication). New technology is making (and will be making) possible to create a local communication area that connects to the main backbones (which will serve the purpose of annihilating distance) to mingle into other communication ambient. Each ambient will adapt communication to the local situation, that is the availability of terminals, their characteristics, the local processing and storage capacity, the inhabitants’ need and habits.

For the next 10 years or so the capacity offered by the fixed network, optical fibre, will greatly exceed any capacity provided by radio based communications. Hence the economics “per bit” will favour fixed network for transport. On the other hand any person, and many objects on the move, will be un-tethered. The last link will be wireless, independently of it being in a home, on the road, or a train. In this area a significant growth in picocells should be expected with the dissemination of hot spots (till 2008 in its various forms with speed up to 100 Mbps, later with UWB with higher speed reaching the Gbps by 2015).

Intra ambient communication is likely to evolve in the direction of local management and local communication capacity. Consumer electronics is likely to play a major role within the home, sensors networks and metropolitan hot spots are likely to play similar role outside the home. Beyond 2015 the emergence of wireless routers, ad hoc networks and possibly the resolution of the interference problem through inter-terminal communication may lead to a thousand fold increase in the wireless bandwidth leading to a radical change in the communication scenario (see 1.4.5, Infinite Bandwidth).

By the end of this decade the advent of software radio may create novel opportunities for peer-to-peer applications and services significantly changing the scenario. Current evolution on the MIDP is but a first step in that direction.

The enormous capacity of the fixed network won’t go spoiled by the increased capacity of the wireless. Approximately by the same time wireless capacity may grow a thousand fold the fixed infrastructure (at least in Europe) should have become completely optical, including the switching (actually the network hubs with routers and add drop multiplexers). This will enable the creation on a large scale of virtual private networks in the number of hundred of thousands. Business and social – government institution, as well as communities, will be able to “own” their own network with an unprecedented level of capacity and security.

Obviously this is not “granted”: it needs a lot of research and investment. It also needs a vision to focus in that direction.

In the next 15 years we are likely to see as main technologies:

- Transmission related technologies/infrastructures
  - wire based transmission will progressively consist of optical fibre. Current top speed of few TB will evolve to reach some tens of TB at the end of this decade and hundred by the end of the next decade. This top speed refers to record achievements in lab environment. The deployment of such capacity in the field will have a delay of at least 2 years and will occur only in very specific areas where demand exist. Average speed in the long distance network infrastructure is likely to remain at least an order (or two) of magnitude less than the top speed.
  - The penetration of the fibre in the long distance network will progress at a rapid pace and most of it should be fibre by the end of this decade in most European countries. At the
metropolitan level the trend is similar to the one in the long distance network but copper substitution by fibre will trail that one by five years on the average. Speeds are also likely to be similar.

The architectures are likely to evolve for few more years towards the deployment of rings with SDH based transmission (it will take possibly till the end of this decade to see the substitution of the PDH in the networks). By 2008, in some areas before, these ring architectures may evolve into star configuration with the deployment of Gigabit Ethernet that is likely to replace in the long term all SDH transmission. In the next decade, possibly toward the end of it, the architectures are likely to further evolve into mesh networks with a fading away of the distinction between the long distance and the metropolitan network. Wider use of IP over fibre is also a likely evolution, in line with the identified architectural evolution.

The evolution on the last mile is discussed in the bandwidth trajectory.

The described evolution requires the evolution of a number of enabling technologies, like:

- quality of the optical fibre (with an increase in the number of usable windows, \( \lambda \), decreased attenuation, refractive characteristics...);
- speed in the electronics for the electronic/optical conversion that in turns requires evolution of laser, packaging...
- optical switching and \( \lambda \) switching
- better management systems integrating into autonomic networks
- ...

The main actors are in USA, Japan and Europe, with a slight advantage in the USA in the networking aspects and basic component technologies. Short-term research is probably not needed but research on basic components that will pave the way towards a full optical network in the next decade is very important. Here Europe should fight to gain a leadership. More esoteric evolutions, like quantum communications, require research in basic fields, also at a theoretical level. It may be a low priority area.

- **wireless based transmission** will progressively see an increased mixture of technologies. In the next few years the 3G will be deployed throughout Europe side by side with the GSM infrastructure and its evolution (GPRS, EDGE). By the 2008 timeframe a significant use of software radio should have been started with full impact to be felt in the next decade. More and more appliances will be wireless enabled. Significant evolution in the picocells communication can be expected in the coming years. The diffusion of the WiFi will be accompanied by an increase in its speed to reach by 2008 100 Mbps. In that time frame UWB should become a reality with speed close to 500 Mbps but a different kind of use. Its low power consumption will make it an ideal wireless connection for many appliances.

In the next decade we will see a linear evolution of capacity in the wireless area as technologies are upgraded and more base stations are deployed. A breakthrough may come close to the end of the next decade if ways for solving the interference issue by a cooperation of mobile device become feasible. That in turn is likely to require the availability of much better batteries to support the higher processing capacity required. Satellite is likely to continue its evolution with most application in the broadcasting area. A significant evolution is to be expected in the next decade by the dissemination of ad-hoc wireless networks with micro nodes.

The main actors are in the USA, Europe and East Asia (chiefly Korea and Japan). USA has an advantage in the area of ground-breaking technologies, like microprocessors, DSPs, batteries and also in theoretical studies on the interference issue. Europe has an advantage on the density of cellphones, particularly important in voice area. Japan is on the forefront of deployment. The risk in the coming years is to see a marked acceleration of the USA. Europe should not lag behind and research efforts in the many technologies enabling the wireless communication evolution are essential.

- **switching technologies** will keep evolving both in performance (speed, delay...) and in architectures with more and more \( \lambda \) switching and routing/bridging.
If on the one hand one can see a trend toward macro switching (\( \lambda \) switching) on the other hand there is likely to be an evolution at the same time towards micro switching, that is the responsibility for path determination may progressively go into terminals (or at the edges of the network) that may format the communications in such a way that it can be delivered as a flux with no further intervention (minimal intervention) by the network(s).

Optical switching is a possibility in the next decade although the evolution in the network architecture will be significant even without real optical switching. Optical Mux/demux will be a reality by the end of this decade.

The main actors in this area are in the USA. Europe is slightly lagging behind, as well as Japan. It is an area where some basic research is required although it may not be a guarantee for breakthrough.

5.3 Data Capturing

Progress in data capturing has been growing constantly over the last decades but it is now on the brink of a strong discontinuity in terms of quantity and quality of data captured. Sensors as well as satellite survey, webcam, personal recording devices are become smaller, cheaper, simpler. Even 3D scans should become cheap and common in the next decade.

There are several technologies converging to produce this effect: electronics, bioelectronics, nano technologies, MEMS, communication technologies, fabrication processes (letting analogue, digital and RF circuits mix together on a single chip). More recent concern on security threats is pushing to speed up this evolution.

Sensors of many kinds will be deployed in the next years probably outnumbering people as communicating devices before the end of this decade.

Most objects in the next decade will embed “at production” sensors and sensors will be able to form autonomous networks to reach a communication gateway.

This spreading will contribute to push autonomous network technology beyond ad hoc networks with fall out in the wider public communication sector. The availability of a variety of sensors will increase the availability of data and push towards effort to address the information retrieval issue.

Projects like MyLifeBits (Microsoft) LifeLog (Darpa) will give a boost to the capturing of individual data and its relation with his environment. In one way or another they are going to open up new exciting service possibilities and are likely to raise significant concern on privacy, data ownership....

In the next 15 years we are likely to see as main technologies:

- from atoms to bits
  - Capturing shapes technologies of 2D and 3D objects, through still or moving images will make significant advances in the next years. 2D capturing is already quite sophisticated in terms of resolution and color accuracy by using scanners. These have very low cost when the object to be scanned is a 2 dimensional one (a sheet of paper) with dimension smaller than A3 format. Different systems are available for much larger scanning. Targeted to niche business they are relatively expensive and their price is not likely to decrease significantly. The resolution is already as accurate as needed in most application. Scanning of big object, from afar, is still a maturing technology, targeting a business market. Capturing photos from satellite of earth surface is in the consumer domain right now. By 2008 several activities will make use of satellite photography with a definition around 1 meter. Unlikely to increase significantly in the next decade.

3D scanning will make significant progress in devices, processes and algorithms. It will use laser measurements, aerophotogrammes, and satellite pictures. Cost will remain targeted to the business world in the observation period. The area where most progress may be expected is the one of capturing moving objects separating them from the environment. This will become feasible in the second part of this decade and will reach maturity in the next one.

There will be a number of business applications and in these areas no significant cost decrease can be expected in the devices and algorithm but the processing cost will decrease significantly as capture will be mostly done in software.

A completely different set of applications are in the gaming industry (based on gesture recognition, gyroscopic game pads...), in education, training....The cost of haptic
interfaces in these areas is likely to decrease significantly with consumer market products in the next decade.

- **Capturing writing technologies** will further progress from today’s “graffiti” where hand-written text is identified provided it is written letter by letter and according to a given notation to a more comprehensive understanding. By the end of the decade normal hand-written text should become an acceptable form of input with 99% recognition accuracy. Scribbling will remain a challenge through the next decade although the mixed use of profiling, context understanding will lead to some progress.

The main players today are in the USA. The situation is unlikely to change.

- **Capturing sounds technologies** will improve in the capability of discriminating and isolating sources. Melodies and voice identification is likely to be possible in the next few years. Recognition of timbres for identification (security) is already possible in a controlled environment and by the end of the decade it will become possible in non controlled ones. Voice capturing will result in the next decade in the acquisition of voice and in the association of context data (providing data that can be processed for meaning abstraction). The main actors are in the USA and Europe (particularly for voice). Security concerns are likely to bring a lot of effort in this area, particularly in the USA.

- **Capturing sensations technologies** will evolve making it possible to capture with a better accuracy, less cumbersome devices and at a lower cost a variety of sensations like touch, acceleration, weight, smell, taste...

Haptic devices focusing on business applications (like design, surgery training) will remain pretty expensive also in the next decade but some consumer model will become available out of the evolution of force feedback gaming devices. Bioelectronics and sensors, laser sensing systems will provide a wide variety of technologies for capturing sensations.

Business applications (and devices) are likely to see a continuing lead by USA whilst consumer ones will see a leadership from Japan. Europe may take leadership in some areas like industrial design.

- **Identifying objects**

- **Reading tags technologies** will increase the span of readability, the possibility to detect the location of a tag, the number of tags that can be read in parallel. The readers are likely to integrate filtering functionality to select one relevant tag among hundreds. This feature is going to become very important, as many more tags will be present in any given environment. Tag readers will decrease in cost significantly in the next decade and become embedded in a variety of devices, including cellphones.

The research is basically in the area of microelectronics, radio propagation and software (profiling).

The main actors are in the USA with Europe and Japan lagging (slightly) behind. In the next decade the situation may remain unchanged.

- **Bio-identification technologies** require the capture of a variety of data, from fingerprinting to iris scan....The evolution is towards easier and more practical ways to capture the required data. Device cost will also decrease and it may become one of the usual ways of authentication in the next decade.

The pressure posed by security concerns will speed up innovation in this area. USA is leading and has launched significant research so they are likely to remain the leaders. Concern on this sort of identification is low and should remain low since they require an explicit acknowledge by the person being identified.

- **Spotting technologies** requires the capture of data via digital cameras and the use of sophisticated software to identify a specific person through his/her anthropometrics data. Evolution of rendering technologies, like those in MPEG 4 is likely to lead to a significant capacity in the next decade.

Security pressure in the USA has led to the launch of LifeLog from DARPA, a major groundbreaking research program to develop spotting technologies.

These technologies will become available in the next decade and for the first part of it will be costly and used only for institutional purposes. By the end of the decade service providers for the mass market may use some of these.

The main actors are in the USA and they are likely to stay there given the amount of funding in this area.
Capture meaning

- **Capturing emotions technologies** are in their infancy but will evolve significantly to find a variety of application in the next decade. Capturing emotion data requires capturing video, aural, contextual and motion information. Where possible biological parameters are also considered. Sophisticated applications can derive the emotional state and provide this information to a variety of application, from bettering the interaction to safety, from education to health care....

The evolution is towards easier capturing of data, cheap sensors and quick response time based on a profiled history.

The main actors are in the USA and Japan. They should continue to lead also in the future although USA will probably lead in professional and institutional applications whilst Japan may lead in the evolution of capturing devices and in the consumer market.

- **Tracking “attention” technologies** are expected to be applied in the second part of this decade, first for safety applications. Tracking is achieved through the use of cameras following the eyes of a person. Evolution is towards less cumbersome settings, higher accuracy of the tracking taking into account the context and what is that person doing. Increased sophistication both in the hardware and in the software should lead to a dissemination of this kind of technologies in the next decade.

The main actors are in the USA and are likely to be there also in the next decade, since some of the research funding on security related technologies will contribute to the evolution of tracking.

- **Voice understanding technologies** will require the correlation of many data that need to be captured and related. Voice understanding goes beyond voice recognition. A sentence may be correctly recognised but its meaning may differ depending on the environment. The single word help may have many different meanings, requiring different answers, depending on the context. It goes from life and death situations to an expression of fun...(like in a roller coaster).

Evolution is towards a better understanding of the context. An acceptable understanding (although a limited one in particular environment) may become available early in the next decade. Later the evolution is toward more comprehensive understanding in “normal” environments.

The main actors are in Japan and the USA. These latter are likely to take the leadership given the significant amount of money to fund security related research.

- sensing the environment

- **Scalar parameters capture technologies** have been evolved significantly and their further evolution promises to bring sensors everywhere and in every day objects. From temperature to presence of pollen, from pollutant detection to bacteria detection...there are and will be sensors practically for everything. These sensors will be progressively consist of a single “chip” that provides for local processing of data, converting what senses into a digital representation. Furthermore by the end of the decade most of the chips will include a communication part for a wireless (usually) transmission of information. Software radio will find application in the second part of the next decade (because of cost consideration) and will allow the reprogramming of sensors based on needs. Particularly the reprogramming will affect the internal processing and conversion of the sensed environment into the digital representation.

Evolution will also be towards a wider possibility of detecting parameters, less cumbersome devices and overall less costly systems to deploy and operate. Battery evolution (long lasting) is going to play a significant role in this technology trajectory for many areas of application.

The main actors are in the USA, Japan and Europe. In the next decade the USA may show a stronger leadership because of its prominence in the processing part. It is, however, basically an open field.

- **Vector parameters capture technologies** are likely to follow in this decade a similar evolution pattern promised by the scalar ones. They provide information on values with as associated “directions” such as the strength of the wind and where it is blowing. Some vector data will be derived in this decade by a higher level integration of data provided by scalar sensors, e.g. detecting the level of pollutants in an area is good, but knowing the likely direction of where a pollutant is coming from is even better. This can be done by
analysing several scalar data all together associating them to the position of the sensors. In the next decade, however, the availability of re-configurable sensors (and re-configurable sensing devices) and the possibility to create autonomous sensors network will push down at the sensors level this integration making it cheaper and more effective. Rather than receive several scalar data one would receive on vector data. The main actors are in the USA with Europe and Japan slightly behind. It is likely to remain this way also in the next decade.

- **Bio-sensing technologies** provide the capacity to detect data from biological systems, human’s body being high in the interest ranking. It is not intended to denote the use of bio/organic components to sense the environment (this is covered in both scalar and vector data capturing technologies).
  The evolution is towards better accuracy, easier “integration” with the bio part (e.g. the human body), better processing capacity to make sensors able to interact with the sensed environment.
  The main actors are in the USA. This area is in between medicine, biology and engineering and research will draw funds from various sources. It requires, however, an integrated approach.

- **Sensors’ networks technologies** are just start to appear. They will have a significant evolution in the coming years leading by the end of this decade to the first autonomous (mesh) sensors networks. Each of these networks will have at least one gateway to a global network (or to a private one) letting application to get the data captured. The evolution is towards more local processing capacity and adaptability so that it will be easier to make sense out of the data captured. Sensors are likely to embed, on a single chip, the sensor part, the processing part and the communications part. Communication in general will be short-range using low power and minimal draw on the batteries. Hopping from one sensor to another can cover relatively large distances. By the second part of the next decade smart dust like technologies should become available dramatically decrease the cost of creating these networks and making them much more flexible. UWB is likely to be the choice for the communication among sensors, at least in the first part of the next decade.
  Within the next decade sensors’ networks may become a real public infrastructure that will be open for public use (of course with all due ownership, security and safety controls). Network Operators may actually consider these networks as extension of their telecommunication infrastructure and offer services exploiting their capabilities.
  The main actors are in the USA and this situation is likely to remain unchanged given the significant amount of funding related to security concern now being poured in the USA.

- **Track-and-follow networks technologies** are a cluster of quite different technologies, integrated to make it possible the identification and tracking of a person, an object (like a car) among several others. Although there can be some business applications, as an example in the distribution chain, most of focus today is on security aspects, like detecting suspicious behaviour, identifying the person and following him as he moves around, on foot, by car on a plane. The diversity of the environments require a variety of “spotting” and “tracking” technologies, from video cameras to tags. At the core are some software technologies for the intelligent monitoring, image recognition, coordination of the communication environments and of the various tracking devices.
  The main actors are in the USA, although some significant work is being done in Europe as well. Japan is dedicating funds to research on some of the software enabling technologies. Leadership is likely to remain in the USA where a lot of money is funding research in security related aspects.
  It should be noted that some of the enabling technologies are likely to find application also in other environments, like elderly care (monitoring), traffic (car) safety…In these areas alternative technological approaches are viable (and used today). In the long run, however, as track-and-follow technologies become widespread they may also be used outside of the security area.
5.4 Human Interfacing

The area of human interfacing has seen significant progresses in the last thirty years through some discontinuities, like the introduction of video displays, the adoption of images to supplement text (and windowing paradigms introduced by Xerox in the 70ies) the use of multi channels interaction (mouse, video, sound).

In the next years new ways of discontinuities are likely to happen as new technologies come to fruition. Haptic interfaces, 3D information visualization, touch pads embedded in a variety of objects, gesture capturing are but some of the technologies that will allow new interfacing paradigms as soon as 2008 (with obvious niche applications coming much sooner).

A significant progress may come from completely different directions, the one of understanding the context and therefore the capability to interpret the “interaction”. Technologies like affective computing may customise the interaction to the mood of the person in the first half of the next decade. About the same time the capability to single out a person and its behaviour in a given environment will let machine to keep track of his wandering, communicate with its local profile and adapt the interaction and derive meaning from it.

In the second part of the next decade sophisticated shadowing mechanism will take over part of the hidden communication interplays that is so important in human to human communication and that today lacks completely in human to machine communications.

As communication will become more and more based on “understanding” and less on formal commands new problems will come up. Issue like who is responsible for any misinterpretation are likely to delay progress.

Artificial intelligence, agents based dialogue, and many more will be both instrumental in the discontinuities and stumbling blocks. In several areas there are ideas of exciting possibilities but there is lack of firm ground to build upon.

In the next 15 years we are likely to see as main technologies:

- Human to human interfacing
  - **Real time translation** technologies are likely to become available by 2008 at a level of quality that will stimulate their diffusion. Significant impact can only be expected in the next decade. For this decade the translation is likely to remain possible only in a closed context (e.g. through a telephone line) and will require some considerable “patient” and adaptation from the users. Few languages tuple are likely to be available by 2010 (although IBM is targeting 28 languages).
    In the next decade the evolution should be towards more fluent and responsive translation, context understanding, integration of profile information, more languages and accents...
    The substitution of a human translator is unlikely to happen in the next decade, although by the end of the decade making use of automatic real time translation should become “normal”. This is also likely to extend communications use.
    For real time dubbing of movie (and television broadcast) we should be waiting much more, possibly as far as 2050.
    The research area spans in different fields, the more as more sophisticated it should become. At the forefront are voice recognition and language understanding, artificial intelligence, cognitive science, profiling, agents. Enabling technologies related to wearable computers are also important.
    The main actors in this area, by far, are in the USA, although some significant results have been obtained in Japan. In the USA there is a growing interest and research effort in the cognitive science and that may lead to a fundamental advantage. Europe is lagging behind, in spite of some projects funded so far at European level. This is an area where results would bring significant fruits and a deep impact in Europe, given the many languages being spoken by its citizens.

- **Expert to lay person-interfacing** technologies will allow people with different experiences to talk to each other. Few prototypes may become available by the end of this decade (stemming from the works on the generation of text summary once it moves from the syntactical level of today to the semantic level).
    In the first part of the next decade some applications in specific fields may become available and first timid use in the education environment are likely to take place. For more widespread applications one is likely to have to wait till the end of the next decade.
Research is in the area of expert systems, machine understanding, and cognitive science. The main actors are in the USA.

- **Avatar to people communications** technology is likely to go beyond today’s rendering of a voice through a character (even the one that uttered the voice at a different time). By the end of this decade some convincing interface with avatars really playing an autonomous role in the communications may be expected. The delegation of communication to an avatar may take place with progressive space of autonomy in the next decade. Total autonomy however, is unlikely to be possible even by the end of the next decade. Research in this area is in the field of artificial intelligence and cognitive science. Other technologies, like rendering and affective computing are also needed and will progress likely at the same pace of these, so they should not pose a constraint. The main actors in this area are in the USA and for some of the enabling technologies in Japan. Europe is lagging behind but this might be considered an area of low priority.

- **Human to machine interfacing**
  - **Human like interfaces** technologies will progress significantly but will not dominate the communication paradigm. Only for special situations and for dealing with certain “machine” a human like machine interface will be adopted. Research is in the area of avatar, rendering, affective computing. The main actors are in the USA and for some enabling technologies in Japan. Europe is lagging behind. Probably it is not a high priority area.
  - **Interaction design** technologies are likely to provide a significant contribution to this area steering the creation of objects whose shape provides direct hints on their working and the way to work with them. Research involves cognitive science, pragmatics, human observation and engineering. The main actors are both in the USA, Europe and Japan. Some basic research as well as trials is needed to accelerate the creation and the adoption of an interaction design culture.
  - **Ambient mediated interfacing** technologies are yet to come. They would provide ways to transfer the interfacing responsibility (management and actual interaction) to some point or to a collective endeavour in the environment thus simplifying the interaction. This area is going to keep up steam by the end of this decade and have some deep impact in the next decade as more and more intelligent ambient will be available as well as more and more objects will be able to network together and coordinate the interactions among them and with third parties. By the end of the next decade ambient mediated communication should become “the norm”. Research is needed as in the other forms of human interfacing plus the research in the area of intelligent ambient and cooperating objects. This involves both software and standardisation. The main actors are in the USA and East Asia. However Europe by extending its effort on intelligent ambient to this sector should be able to play a significant role and even gain a leadership.

### 5.5 Information Display

Information visual display has been growing at a much slower pace than processing and storage. This is not an intrinsic slowness of innovation in this field, rather a much stronger requirement on standard and compatibility from a very broad market with long replacement cycles. Moving from analogue television to digital one requires a phasing out measured in 5 to 10 years versus a replacement time of a PC measured in 1-2 years… Furthermore the network value effect is much stronger. The upgrade of a PC main board leads to an immediate increase in performance perceived by the user. The upgrade of a television screen to high definition will not lead to any advantage unless broadcasters provide content in High Definition. Similarly, a better performing cell phone screen will provide no value to the user in a video call unless her correspondent has a similarly performing camera (and screen).

A third limiting factor is the need for a parallel increase in performance in other technologies, like battery power for use on mobile devices. A new screen technology, to succeed, needs to provide better quality (on an exponential scale since our eyes work on a logarithmic perception scale) and
at the same time it needs to be power savvy...Better resolution is not sufficient unless it comes with higher contrast, increased brightness...

CRT displays are on the way to demise, with LCDs (and the likes) set to take the market within the next five years. On a longer time frame technologies like OLED and quantum dot display are likely to become dominant for mobile equipment whilst smart materials may provide completely new ways to display information in fixed environment, like home and theatres. The demise of fixed displays devices in favour of symbiotic displays (through the use of bioelectronics) is unlikely in the 2020 timeframe.

New forms of visual information display, like holographic, 3D, touchable images are likely to become common in the next decade but are unlikely to displace 2D imaging even by 2020. However these new forms of information display may prove crucial in several sectors (design, medicine, some form of entertainment) and may create new market opportunity significantly churning on existing ones. The trend, therefore, may be summarised as: better displays in fixed and in mobile environment likely in the next 5 years. 2D imaging will dominate for the next 15 years but will progressively become a commodity leaving very little margins. New display technologies in the mobile area will boost services and provide greater margin to those companies controlling the advanced technologies. 3D displays will be confined to niches for the next 5 to 8 years to become more common in the next decade enabling new services and eventually pushing 2D into the commodity reign (even though it will remain the dominant display mechanism). 3D display technologies will not be “per se” a disruptive technology; rather it will enable disruptions in communications mechanism if new communications paradigms can be created. Investment on these is more likely to produce wealth than investment on 3D technology as such.

In the next 15 years we are likely to see as main technologies:

- **Screen based information display**
  - **CRT** based displays are on the demise although they will maintain a significant market share till 2006 (as sales) and 2010-2012 as usage in the homes. In the office environment they should be out by 2008 (much sooner in many hi tech companies). Its survival for the next few years is due to the lower cost and to market strategies that for the next 3-4 years still put a premium price on flat screens. There is very little incentive to fund any research. The main players are equally divided between Europe, USA and Japan.
  - **Flat screen** technologies (including LCD, SED, Plasma) are clearly winning the market. The higher cost in production is likely to decrease significantly not because of scale factors rather by breakthrough in production processes. The printing-like manufacturing techniques, as used in SED, are particularly effective for cost reduction. Japan and Korea are on the forefront both in research and production. Taiwan is among the leader in production, mostly for the low labour cost. USA is investing in research and has significant innovation in the labs but prefers to decentralise production in the East Asia to leverage low labour cost. Europe is lagging behind and has very little hope to catch up.
  - **Micro screen** technologies, like OLED and small LCD used in goggles and eye television, have a number of niche markets, in professional environments and for entertainment, gaming. Future applications involve cell phones screens for displaying television (new low consumption chips will be on the market in a few months). The market is likely to remain a niche one although the number of these niches creates a big revenue flow for a technology that is basically a horizontal one. The main players are in Japan with USA lagging behind, both in research, production and market. Europe is basically non existent.
  - **Nano Emission Display** screen technologies may become a competitor in the second last part of this decade. The advantages are both in the production process (lower cost) and in the product characteristics (higher resolution, better contrast). High definition television and monitors would love this kind of technology. The screen size is not subject to the waste factor that multiplies normal LCD production cost; hence this technology may become a killer of Plasma screen. USA and Asia are leading the way in research with strong investment in nanotechnologies research. Europe stand a chance of catching up in terms of time frame but that would require some reconsideration on the level of funding for nanotechnologies.
  - **E-Ink** based screens meet the needs of a different market sector, more in synch with the usage of paper. Their resolution and contrast is growing and should lead b something similar to the usual ink on paper in the second part of this decade. In the longer term this
technology may fill a market niche, that of rewritable paper. Originally a USA technology is now seeing a strong contribution from Japan. Europe is basically non-existent.

- **Smart materials** based screens are mostly at lab stage. Some promise, in the next decade, to create screen of any size by “painting” them on walls. Some others to display information on fabric, on our dresses. Demonstrations have been made but the way to a workable product is still a long one. The resolution is poor, although it will improve in the coming years and the procedure for creating the screen is far too complex for the mass market. Research is going on in USA and Japan with basically no contribution from Europe (that is lagging behind in all researches on smart materials).

- **Projection based information display**
  - **LCD** based projection is largely used in the business area (and in what may be considered as a niche market, the movie theatres), only marginally in the residential, mass market. Its strength is the large displayed image, its drawback its lower brightness, the noise of the fan, the line of sight between the projector and the screen surface (retro projection requires a certain space that for very large screens becomes a problem in several ambient). Retro-projection has found a market space in the home theatre, large screen, mostly because of the much higher cost of alternatives (plasma, large LCDs). The evolution is basically in line with that of the LCD screens, with higher resolution and better form factor (including less noisy fans). The application is unlikely to win the mass market (retro-projection will remain a minority for television sets) since the slow evolution is going to be overtaken by the one of the flat screen display that are surely more appealing to the mass market. The very large image that can be obtained by the projector is useless in most home environment where the available space (as well as the viewing distance) is likely to limit image size to 50 inches. This limit will increase to roughly 80 inches with the advent of high definition television (this will allow a smaller ratio view point distant/diagonal length).

  - **Micro projectors** are a brand new technology that can display images in a relatively large size using a projector that can fit on the small edge of a cell phone. The technology is in its infancy and it is still unclear its impact. Symbiotic display and OLED may be too strong competitors for its take off. The potential, however, is great in the sense that it can embed information display capability in any object at a very low additional cost. The evolution is towards better resolution, higher luminosity and ease of packaging. First products may appear within two years. Real impact is not likely before the end of the decade and as mentioned it will have strong competitors.

  - **Holographic** projection is today a typical niche application, more a curiosity than a market. It is likely to evolve in the next five years but unless a breakthrough happens it is unlikely that holography can become a mass-market technology (and not even a business one). It will remain, possibly till the end of this decade, in niches like advertisement, as it happened in these last 20 years. The difference from the past is that there are now alternative technologies, based on different principles that are likely to kill holography as a technology for image display.

  - **Laser on fog** projection is a (set of) new technology(s) allowing the projection of 2D images in thin air, in a way that the image looks like it is floating in front of the viewer. By using special tricks it is possible to recreate a 3D imaging. This technology is in its infancy and it should progress significantly in the next five years in terms of resolution and cost. The image displayed is now about 28 inches but this should be increased to 40 in a short
The main players are in the USA. It is however a very new area and there is chance for anyone to play a major role. This type of display should be seen more as an innovation in way to display images than a specific technology to stress the fact that in the area of information display there is a wide area of opportunity for innovation where investing in research can have significant payback. On the other hand investment on existing “semi consolidated technologies” like LCD where the major issues are more related to the production process than to the product may be a waste of money.

- Symbiotic information display
  - **laser display** technology can be used to project images directly on the retina. The applications are in the area of some critical professional activities (surgeons, pilots, military…) and in entertainment. The main barrier is the acceptability of the technology; the cost is quite low. As culture evolves and wearable becomes more common, even fashionable, by the end of the decade we can expect some uptake of this technologies that may find applications in areas like tourism, education, training… Main actors are in the USA, with some significant research programs funded by the DARPA in several universities.
  - **retinal implant** is clearly targeting a niche application area: restore vision to the blind. It involves bioelectronics and medicine plus a lot of software related to cognitive science, an area that is very fashionable today in the USA (NBIC: nanotechnologies, biotechnologies, information science, cognitive science). All three factors need to evolve to progress this field. The evolution should lead to (functionally) acceptable implants in the second part of the next decade. If the optical nerve is preserved this kind of implant will be the preferred one by the end of the next decade. Main actors are in the USA. The market size, per se, does not stimulate investment, however the type of know-how that can be derived from researches in this area may find a variety of important applications in many fields.
  - **cortex implant** is another niche application area. The same considerations made for the retinal implant apply. Its evolution should lead by 2008 to the possibility of restoring a sufficient sight to the blind. The vision provided will progress in the following years however the “sensation” of the image that would be stimulated through a normal eye cannot be recreated. The cortex implant deployment is easier than the retinal implant. By the middle of the next decade the retinal implant should take the upper hand but the cortical implant will remain the only viable solution for those cases where the optical nerve is damaged.

### 5.6 Information Retrieval

The astounding production of information, that in a way is characterising the Information Society (it is estimated that in the last 20 years human kind has produced more information than the one produced till the dawn of humankind and that in the next three years the amount of information will double), is likely to continue in the next 20 years at the same pace, a doubling every 2 to 3 years. What really doubles, however is not information but data. The conversion of data into information and the information retrieval are going to be the real challenges in the coming decades. The two are strictly related. A railway timetable is a collection of data. Part of this data becomes information at the precise moment I am looking for it. It goes for a medical exam. The data resulting from a scan (PET, TAC) need to be transformed into information. Such a transformation is not necessarily possible looking only at the set of data, it may require external input, e.g. where and when I need to take a train, the class I am used to travel…what my previous exams looked like, what symptoms I am showing…Sometimes even the “why” is important, e.g. I am interested in getting there for a meeting (as soon as possible) or for leisure (cheaper fare, scenery route take the upper hand…), I felt unexpectedly sick, I just want to keep an eye on my health…

Leaving aside the issue of data capturing (which is dealt in 8.9) the retrieval of information has not seen a tremendous technological advance in these last decades. The impression that today we can get much more information than in the past is of course well founded but it is just the result of having much more information available (digitally stored and accessible from remote). There is no better way than we had 20 years ago to access music, voice, images, movies. Anything is still
basically accessed through a tagging system. I tag a picture saying it is about a dog so that a search engine can spot it when the word dog is given. If the picture has not been tagged (associated) to the word “dog” there is no way I can get it.

Technological innovation is required in order to be able to retrieve information in whatever form it appears (it is stored). Pattern matching (a syntactical search based on pixel rather than on letters) is making progress by exploiting crude processing power. The understanding of an image is still very limited and restricted to specific environment. The same hurdles that have lamed the artificial intelligence field are laming image recognition...

Voice recognition has improved (again because of greater processing power –and storage capacity) but we are not there yet, really.

Significant progress in this area is most needed but is not easy to predict. It may still be an elusive goal for the next 15 years although the assured progress in processing capacity is going to improve information retrieval performance...in a linear way. Specific research projects stimulated out of security concern (specially in the USA) may produce as fall out some breakthrough in this area. A signpost can be placed around 2008. At that time a number of basic technologies may have progressed to the point that a more precise forecast can be done.

Surely solving at the root the information retrieval problem will dramatically change the landscape allowing the “exploitation” of the Information Society. At the same time those same solutions are likely to generate an enormous concern onto privacy, information ownership and protection and generate enormous challenges. Criminality as well as the well being of citizen has similar stakes, and opportunity, in this area.

In the next 15 years we are likely to see as main technologies:

- Variety of information
  - **textual information** technologies abstract information into a “verbal” representation, using an enhanced alphabet (capital, lower case letters, fonts, styles, ...). There is very little semantics associated to this extended alphabet and most retrieval tools are indifferent to styles...Textual information can also be formatted and some tools let formatting be part of the searching criteria (search in the index, in the header...).
    The evolution is towards an association of some contextual semantics to text. This is already present, to a certain extent in information produced through a word processing tool (where info on the date of creation, updating, who did it...) is present, although seldom used.
    Retrieval tools will evolve to become able to take into account all aspects associated to the information, beyond the information itself. Research projects in the USA are looking into capturing the whole context along with the “main” information. Retrieval tools will evolve to take this associated context into consideration up to the point, in the next decade, that the associated context will become the dominant searching criteria.
    The strength and the value of information retrieval as it departs from the pure matching of characters requires some agreement on the way information is associated and tagged. International groups are at work on different aspects.
    In a longer term, in the second part of the next decade, textual matching will fade away with a prevalence of semantic and contextual based retrieval.
    The main actors, particularly in advanced textual search strategies, are in the USA. Some interesting work is going on in Europe as well. This is a crucial area that is likely to open up enormous service opportunities. The software is obviously the dominant area of research.

  - **image information** technologies have been focusing on the efficiency in storage, compression, and in the fidelity of reproduction. No attention has been given to the “retrieval” aspects. These have been handled by tagging the image with a text string.
    Digital cameras are routinely associating several information to the snapshot taken (technical as well as timing information plus some information that depends on the way the photographer decides to organise the photos). By the end of this decade the dissemination of tags and peanuts-cost of localisation system will enable other association. Furthermore new coding techniques, like MPEG4, potentially allow the identification of elements within an image (still using textual tags).
    In the next years, till the end of this decade, the syntactical tagging of images (in a textual form) will grow significantly thus stimulating textual oriented retrieval. In the next decade
new image analysis technologies will work on the image independently of the textual annotation to identify elements (a face of an old person, a ball…). By the middle of the next decade more sophisticated tools may be able to associate the various elements identified to derive a meaning. This is likely to take advantage of any associated information (textual or other). Although the progress will be significant it is unrealistic to forecast a complete understanding of an image even by the end of the next decade (see below under the semantics of information).

Main actors in this area are in the USA. Security concerns have directed significant funding to the image recognition and understanding. This is likely to create a variety of basic technologies that will be leverage in the offering of many services in many fields. Europe is lagging behind and the gap is likely to widen in the coming years. This may prove to be a bad situation hampering competition with USA in several fields related to the information retrieval, a stepping-stone in many areas.

- **video information** technologies are following a similar evolution path followed by the image information. Efficiency in storage has been even more an issue and the retrieval is solely based on associated textual information (often relating the movie director, the actors, the screenplay, a title…). MPEG2 has met the need of efficiency versus the desired quality, MPEG4 is meeting the need for interactivity. New researches are looking into the reaction of people watching video information and ways to store this information to adapt the presentation at a later stage.

  The evolution within this decade is likely to keep focusing on tagging of the video in textual form with the tagging progressively using automatically generated tags. Like for images in the next decade the focus will shift on the automatic identification of the elements. The understanding of a “plot” is unlikely to be achieved by the end of the next decade.

  There are some new researches in the USA focusing on security related aspects, like spotting and following suspicious looking/behaving people. In Europe very little is being done. In Japan effort is focusing on the animation of characters which requires some basic technologies that can be used also in the identification and hence retrieval of video information.

- **sound information** technologies with a few focused exception is only based on textual tagging (music and songs can only be retrieved by providing a title, an author, a singer name…). Some sensors have been studied to listen to the “dripping” of water, to detect the walking sound of a specific person….

  The evolution will be slow and nothing fundamentally new may be expected in this decade. There are some researches going on in understanding patterns and melodies particularly in the USA. Even that it is unlikely that significant practical progress will be made leading to melody searches by “whistling” in the next decade. There is little market incentive to do that.

  The main actors are in Japan and in the USA. Very little in being done in Europe although this does not seem to be, even in the long term, a disadvantage.

- **voice information** technologies have been the focus of interest and research effort for many years now. Results are many, although less than it was expected when the effort started. One of the problems is that voice is stored in a textual form for all retrieval purposes. That nullifies the meaning deriving from inflection, volume, tone…Even the most sophisticated tools capturing the voice for subsequent retrieval convert it into a textual form with a verification of the text sentence by sentence. That is a word is considered “correctly recognised” if it fits syntactically and grammatically in the sentence. Some tools may go as far as seeing if it makes sense within that sentence. There is no tool to check the entire dialogue, nor the context.

  Voice stored as a sound falls, obviously, in the “sound technologies”.

  Evolution in the next few years should lead by the end of the decade to a 99%-+ ability to capture the words being spoken. Research is going on in the area of affective computing to understand emotion and therefore provide additional information to the voice.

  In the next decade this research should start to produce usable results enabling more sophisticated voice retrieval. The far increased availability of processing capacity and storage are likely to enable, within the next decade, a storage of voice as sound and its retrieval as “voice”, that is according to the meaning it contains.

  The main actors in the physical layers (voice recognition, translation in to text, dictation…) are both in Europe and in USA. Japan is also very active but the deep language difference
makes it an independent player.
At the voice understanding level the main actors are in the USA with Europe lagging behind. Research in this area may lead to results providing significant competitive advantage. The variety of languages in Europe provides a further complexity in this area. The fields of research involved for advanced understanding are those surrounding the cognitive science (profiling, context understanding, affective computer) and leverage on several “physical” technologies (storage, data capture, processing...).

- Semantics of the information
  - tagged information technologies are mostly tagged by some manual operation (this includes the definition of a syntax to be followed when storing information; relational data based are but syntactic tagging framework).
  The evolution is towards automatic ways of tagging information, independently of its form. An image can be tagged textually, but it can also be tagged by outlining a contour of objects and creating links between this contour and “standard contours” being referenced. This is what is being done for automatic detection of chromosomes in a solution or to spot a tumour mass in a mammography.
  Main actors are in vertical industries, both in USA, Japan and Europe, looking for straightforward solutions to a specific problem. International standardization groups are also looking into providing guidelines for automatic “syntactic” tagging. Research can help in finding specific solutions, however long term direction is towards untagged information. That is the meaning of the information is not captured when the information is stored but when we look for it.
  - interpreted information technologies are a step beyond the tagged information. Tags still exist but the associated information is fundamental in the retrieval to interpret, and therefore restrict and provide a better fit between the search and the result. There will be in the second part of this decade significant development of these technologies as more associated information is provided. Tags inserted at the moment the information is stored is still crucial since the first retrieval is based on that. The associated information is used to refine the search on the first set found. The evolution will continue towards an increased sophistication in the analyses of the associated information. The semantics is not in the information sought but in the associated information. Some of this semantic will progressively be stored automatically along with the information. Some others will be created as relationships among information contained in the query and the ones associated plus others that will be dragged in the processing.
  The main actors are both in Europe and in the USA. Europe may risk lagging behind if not sufficient effort is dedicated in the next 5 years.
  - semantic web technologies, which might be considered as an evolution of the semantic data bases concept. provides a further step in the direction of looking at the semantic of the information, also by considering its relationship. In a progressively connected world the association among information may indeed provide insight on the meaning even without a real understanding (as the research on the Clever –IBM and Columbia University- retrieval engine shows). Research activities are partially funnelled into an international consortium with the hope of providing guidelines that would facilitate the semantic search in the next few years.
  Further down the road is truly understanding of information. This will be enabled by a variety of technologies, including crude ones like processing and storage. The growing storage of context relationships along with the information is another strong enabling factor.
  The effort is spread out worldwide although probably there is a little advantage in the USA. The interest of all parties in sharing tools for facilitating advanced searches is a strong motivation to have the research in this area played in the public environment. Europe should pay attention not to be left behind.

- Access to information
  - keypad access technologies (through a real or a virtual keypad) are obviously well fit for textual retrieval. This form of information retrieval will remain throughout the forecasting period one of the main ones. No particular innovation is expected.
• **click access** technologies are already an important way to retrieve information using links. More sophisticated retrieval is likely to become available where the click is associated to the profile of the person clicking. The evolution of image recognition or at least the splitting of an image into composing objects will further increase the use of clicking. In the next decade the clicking of video will also become a common way to retrieve information.

There is no particular innovation that will significantly change the information retrieval through “clicks”. Hand movement recognition, stare recognition will be additional ways to click.

• **voice access** technologies will surely become extensively used. However this is not likely to replace the other forms of interactions, as some may believe. Voice access, particularly in the next decade, may reach a level of sophistication making it possible to infer the meaning of the request from the way the sentence is being uttered. Application areas where security and safety concerns are important are likely to privilege this way of access. Persons with certain disabilities may also find more appropriate interacting using voice as well as people that have no computer literacy. For this reason voice interaction may become an important tool to make information available to a larger audience.

Research is mostly in the software area. Research on applications of voice access are being conducted in many places and given their social impact may be better promoted by European level funding.

• **deferred access** technologies provide means to retrieve information independently of a specific action by the person needing it. This type of retrieval is so far scarcely used, lacking appropriate tools, but it is likely to become the most common one by the end of this decade, beginning of the next one. People will be surrounded by information and it will be difficult even to remember to look for information in the various situations.

- **Semantics of the retrieval of the information**

  • **context dependent information** technologies makes it possible to retrieve information based on the query and on the context in which the query is being made. This provides both for an extension of the query and for a filtering of the searched information. More and more sophistication is going to become available in the next few years as more capability for sensing (first) and understanding the context (later) are becoming available. The technologies are software based although the interaction with the context is mediated through hardware like webcam....

  The main actors are in the USA although some research is going on in Europe.

  • **agent based retrieval** technologies provide software tools to facilitate search and also to make it possible in a deferred mode. An agent acquires in various ways knowledge and uses it to search and filter information.

  There are standardisation groups working on the definition of agents’ interfaces and some ground-breaking work is being done in the USA. Europe can easily become a main actor if it wishes to do so by organising a programme focused on agents for the retrieval of information. It can be done by looking at some vertical sector (e.g. retrieval for the e-citizen, for health care through out Europe…) using basic technologies available and the agents platform being developed in the international forum.

  • **personalisation of information** technologies provide the means to filter, reshape and correlate information to the ones of interest to a specific person. There will be a significant evolution in the next few years with widespread impact by the end of this decade. The next decade will take the personalisation of information “for granted” and the evolution will be on the degree of intelligence in the personalisation. This will take into effect first the particular terminal available and then the local networking of terminals potentially available to establish, wherever feasible, multimode communications. At the same time the personal profile of the person is being used to shape the search, selection and presentation of the information. Terminal, content provider and network service provider interact in delivering the technologies.

Most of the evolution is provided by software. The main actors are in the USA with Europe tailing close for the part related to the static profiling and the use of mobile devices (with significant evolution expected in the last part of this decade and in the next one with extended capabilities provided by the SIM). The evolution in the dynamic profiling, taking into account the user growing experiences is seeing a major gap between USA and
Europe. This is possibly an area where closer attention should be given by European research.

- **Negotiation of information** technologies provide the means to negotiate the acquisition of information in a background/deferred mode. There will be a slow evolution of these technologies because of the trust issue. As security and trust will meet the perceived needs, probably by the end of this decade, the technologies will start to become widespread. Significant impact is however unlikely before the second part of the next decade. In the meantime these technologies are likely to be used as "assistant" under the full control of the user.

The main actors are international forum and the USA. Research in the area of m-commerce may greatly contribute to these technologies and in this area Europe is surely well positioned.

### 5.7 Pin-pointing

Tagging, beacons and satellite constellation like the GPS and Galileo will become so widespread in services that by the end of the next decade people will rarely think about them. Being able to retrieve a lost pair of key by “calling on them” will be as normal as looking into an electronic organiser to remember where one was at a particular day. With the difference that such an organiser by the end of the next decade would be able to show recorded images and voices of what happened that particular day.

Tagging is going to revolutionize the production process, the distribution chain and the customer relationship. This is starting now (at the production and distribution chain level) and will start to have an impact in the second part of this decade. By 2008 most products will have a tag. In the following decade also soft product (like services and information/content) will also have a tag. Security and privacy concern will be heightened till the end of this decade but as the next one comes by it is likely that these concerns will move to the backstage as the advantages greatly overcome any potential inconvenience.

Several technologies are going to play a synergistic role taking us into the “tagged Society”, the likely evolution of the Information Society.

Electronics, bioelectronics and biomarkers, communications, powering, terminals, storage, local processing, information retrieval...are but few of the evolving technological areas that will change the way we interconnect with our environment.

Progresses in disciplines at the edge of the IST, like medicine and biology, are likely to provide even greater opportunities towards a tagged world. Today it is already possible to “tag” a protein (or a virus). By the end of the next decade tracking of these tagged protein will be much easier opening up the door to revolution in healthcare in close synergy with communications and more generally with IST.

In the next 15 years we are likely to see as main technologies:

- **Location awareness**
  - **Satellite based technologies** will provide a worldwide location infrastructure. GPS, Glonass, and from the 2008 on Galileo, are a set of satellite that allows any device receiving their signal to calculate the location on the earth (as well as the altitude) with a precision reaching 7 meters (12 for altitude) in the Galileo system. The evolution is on the receivers' end in terms of lower cost leading to the integration of the chip in all those devices that can exploit location information. By the second part of the next decade the cost of the receiver will no longer be an issue.
  
  USA and Russia have been the leader in satellite based location system, with the USA GPS having had the major impact. Europe is planning to take the leadership by the end of this decade with Galileo and with a coherent set of programs to develop applications. The chip for the receiver may still produced in the USA.

  - **Cell based technologies** can provide a radio receiving device with location information based on triangulation. Cell phone cells (both 2G and 3G), WiFi hot spots and by the end of the decade UWB can determine the location with varied level of accuracy. Their interest is mostly for indoor location, e.g. in museum to provide location based information. These systems are likely to coexist with satellite based location technologies within a single device. The advantage of these is the cost free solution from a device point of view since
the location is done externally of the device that will then be notified (either of the location information or by the reception of location relevant information). The main actors are in Europe with some work going on in Japan and USA. The situation is unlikely to change in the next decade.

- **Tag based technologies** can provide location information by associating it to a specific tag. The location can be “embedded” in the tag or the tag identity is used to access a information data base providing the location information. Evolution is on the side of the reader that will likely be embedded in cell phones and the likes by the end of this decade. Its availability will stimulate the use of tag for location awareness. In particular it can provide very precise location information (like standing on front of a museum specimen). It is used for different purposes than the satellite based location. One main application is within production and delivery processes.

Main actors are in the USA, Japan and Europe. The situation is unlikely to change in the next decade.

- **Tracking**
  - **Tag based technologies** will replace in the coming years the bar codes. By the end of this decade one can expect a complete replacement as cost will have gone down to the point of being equivalent (taking into account both the tag and the tag placement cost). The cost of the reader is already basically equivalent to the bar code reader and in most application the reader cost is irrelevant. The reader will have an embedded communication link to ensure the centralised tracking of object. In some cases tagging may also be applied to people for identification purposes and in these cases it may also be used for tracking.

The main actors are in the USA and Europe and the situation is unlikely to change in the next decade.

  - **Satellite based technologies** combine with a transponder or with an alternative communication link (PCS or 2G/3G) to track objects. Services are already being offered (tracking cars, kids, pets, elderly…). The evolution is towards a decreasing cost of the receiver/transponder and in its miniaturisation making it fit to be embedded in many everyday objects.

The main actors are in the USA. In the next decade Europe may take a stronger position.

  - **Image recognition based technologies** are seeing a significant boost because of security concern. Coordination of tracking through different devices and networks is essential to ensure the follow up over a wide area.

Several projects are being funded in the USA to be able to identify a person (or a suspicious behaviour) in a crowd (or in a complex environment) and to lock on him following his movement across a wide area. The fallout from these technologies may be significant in several business areas and it is important to have access to them.

USA have the clear leadership and the situation is unlikely to change in the next decade.

### 5.8 Printing

Although not often noticed, printing processes have evolved significantly from a technology point of view, completely rewriting the business rules in the field, enabling new services and changing the way of working and communicating.

Printed material has kept growing at a 17% rate over the last 20 years, in spite of predictions of doom for the printing industry because of an alleged displacement of the market by the soft information display.

Colour printing was outrageously expensive only 10 years ago. Now it has become affordable. Photo quality printing is still expensive (relatively speaking) mostly because of a cartel to keep price up and to indirectly finance the sale of the printers.

Colour printing has reached a quality threshold, in terms of resolution and colour accuracy that is sufficient to meet most needs. Increases in performance are likely to be in the speed, in the capacity to print on different material (niche markets though) in the shrinking of the printer.

Disruption, on the longer term around 2015 and on, may derive from printers “embedded” in objects (as a standard alternative way of displaying information) and in the embedding of the printer in the printing material itself (e-ink).
Evolution may be expected in the capacity to print 3D objects as well as printing with different "inks" including biological ones for human tissue printing.

Industrial processes may be revolutionized in the next decade by construction processes based on "printing" rather than "moulding", "pressing", "assembling".

The printed object, starting 2010, is likely to show some dynamic behaviour, such as being able to interact with the user and to update itself autonomously. By 2020 printing objects rather than just putting micro drops of ink on paper is likely to become the standard meaning associated to "printing".

DRM is likely to become part of the "printed" stuff rather than being a commitment on the user of the printed stuff. This can change the way we are looking at Digital Rights Management. Even a single page of printed text may be able to interact with the personal area of a user and negotiate reading rights before actually displaying whatever is negotiated.

In the next 15 years we are likely to see as main technologies:

- Paper-like printing
  - **ink-jet printing** is the widest spread technology on the mass market. It has reached very high definition, over 1,000 dots per inch. In the next few years, before 2008, it will reach a threshold of definition that exceeds the perceived quality (beyond the resolution of the human eye). The same goes for colour (hues) accuracy. Contrast will remain higher than film but that is more a characteristic of the paper than the ink technology. Evolution may be expected in some added functionality, like water marking and micro printing to associate scanner detectable information associated to the printed information (or sheet).

Definition of 4000 dots per inch is sufficient for this kind of applications. A single page may contain a few MB of information. This will start to happen in the business world as a protection mechanism. By 2008 it may enter into the consumer world but first impact is likely to occur well into the next decade. This will be enabled by the growing creation and management of information by the consumer market (e.g. digital photos) resulting in the piggy back of additional information to the main information stream. The paper copy will keep its "feeling" and appeal. Using a printed photo with embedded a printed code, invisible to the eye, that can be used to insert information on where, why the photo was taken and also some voice comment. Clearly this requires the availability of reader that can detect the micro printing.

The main actors are in the USA particularly with the advanced applications, although both Japan and Europe are well positioned. Investment in research in Europe may prove to be fruitful, particularly in the advanced applications area.

- **laser printing** is a widely adopted technology, particularly in the business environment, mostly because of the higher printing speed (negatively balanced by the higher cost with respect to the ink jet technology). Price is coming down although it is still significantly higher for colour printers, a must have for the consumer market. This price differential is likely to remain unchanged for the next five years and it will limit the market space. In the next decade the evolution are similar to the ink jet (particularly for water marking) but it will suffer from a smaller market. Tagging of sheets, which may become common in the business environment, may further decrease the interest for added value applications to be "printed" by the printer.

The leading actors are in Japan with USA lagging behind. Europe may not find as beneficial research in this area as it may be in the ink jet technology. However innovations developed on that target may well be re-applied in this one.

- **thermal printing** is a niche application technology (sale slips…) that has a relatively slow resolution but assure a the consistency of the information (very difficult to tamper with). Its progress is uncertain in the longer time frame. It is likely to remain basically unchanged throughout this decade. In the next decade more effective systems to protect information and assure tampering control (micro coding, tags embedded in the sheet) are likely to become a too strong competitor to this technology. Its survival is assured for the next 8-10 years because of its low cost. There is no significant research going on, it is a mature technology.

- **electromagnetic printing**, also known as e-ink, provides the advantage of being able to change the printed information and a paper like contrast. It has as drawback the low definition, poor colour quality, slow updating of information (slow means a tenth of a second: this is not slow if you need to read the page but it is too slow if one wants to
display moving images). Its evolution is on four directions. Better resolution, better colour
rendering, faster switching time, and the possibility to change the information from far
away via wireless. E-books may become heavy users of this technology, although this will
have to way till the next decade.
The evolution is steering the e-printing to competition with some display technology.
Widespread use in niche markets, like supermarkets labels where the definition
requirements are not too high and the lower cost in the updating is appealing.
Basic research has been carried out in the USA and still progress there. However Japan is
now investing in this area and innovative products see Japanese manufacturees on the
forefront. Europe is mostly absent. Probably it is not a high priority area for the
competitiveness of Europe.

- Object printing
  - **laser printing** is applied to the printing of objects using special polymers that condense
    and harden when hit by the laser beam. The technology is applied into some narrow
    niches, mostly for mock up. The evolution is both on the printing and on the polymer that
    can be shaped by the laser. The advantage is in the relative fast printing process, the
disadvantage is in the printing of an object that has to be in a single material (plastic) and
cannot contain “inner” shapes (only the outer part of the object can be modelled).
In the next decade laser printing of objects will become more affordable but it is unlikely
to become a product targeted to the mass market. Its lower price will allow its dissemination
in a wider professional market, mostly for mock up purposes and in the education field.
The main actors are in the USA. It is doubtful that Europe has an interest in funding this
kind of researches.
  - **layered printing** is a technology that creates an object by assembling and gluing micro
    beads layer after layer. Some of these beads are not affected by the glue and can
therefore be removed after the object has been printed, thus allowing the creation of inner
 cavities. The evolution is in the area of faster printing, use of a broader range of materials,
integration with robotics, lower cost. Even assuming a spectacular evolution, it is unlikely
to see this technology in the mass market within the next decade. However it can start to
be applied in the retail area, including, by the end of the next decade in do it yourself type
of retail (a la Kinko…). Hence it may have a significant impact on the evolution of the
design, production and distribution chains.
The main actors are presently in the USA but the situation may easily change during this
decade. It is still an open field where Europe, if desired, may have good chances of
playing a significant role. The need for a parallel evolution in robotics and material science
is a further element when considering the strategic value of this area.
  - **self assembling** is a set of technologies, deeply entrenched in the science of materials
    and nanotechnologies that result in the creation of objects, on a micro scale dimension, by
assembling of molecules into basic structures and these into more complex ones. The
drive towards these technologies is both as a way to surmount difficulties in shaping
objects as they become smaller and smaller (like the reading head of Millipede, a nano
scale storage technology) and as a way to decrease cost. In fact selfassembling promises
to be a much more cheaper way of building things. The technology is clearly at the edge of
the IST, much more related to chemistry and in some case to biology (living beings
manufacture themselves through self assembling).
The expected evolution is towards the increase of the manufacturing speed, the capability
of building more complex objects and the integration of self building with other
construction techniques. Although some self assembling is already used in production (in
the medical field) a real impact may be expected in the next decade., e.g. in the
construction of NED screens, nano scale memories…
The main actors are in the USA, although Japan is investing significant amount of money
in the nanotechnologies. Europe is also investing on nanotechnologies, although much
less than Japan (50%) and of USA (25%). These technologies are likely to have a crucial
impact in the longer term and serious effort in this area should be considered.

- Biological printing
  - **2D printing** is a technology providing a tool for faster creation of layered tissue, like the
    skin. Cells are grown into a solution and rapidly multiply, much faster than in a culture
plate where growth happens in a 2 dimensional space. Special printers laying them in such a way to facilitate the aggregation to form a “tissue” use the solution of cells as ink. The evolution of these technologies is towards an increased productivity (involving the biological growth of the cells in the solution broth) and a more precise structuring of the tissue. For skin tissue this is not a main issue, since cells can structure themselves as they please. For other types of tissue, like muscle (still beyond the current feasibility), the structure is essential to deliver the required functionality.

By the end of this decade skin printing will be mainstream, substituting completely the present approach to culture skin. In the next decade it will become possible to print other biological tissue.

The main actors are in the USA. Europe may play its role although this is an area that is looking for funding from other fields than IST.

- **3D printing** is going a step further aiming at creating organised biological structures. Difficulties are greater than before. In a way it is like moving from black and white to colours. In fact there is the need to merge in an ordered way the various types of cells, like colour pictures are formed by appropriately mixing the basic colours. Hence any progress in this area depends on progresses in the other. There are more hurdles in the evolution of 3D printing, though. There is the need to create a 3D structure containing different sub structures, like the arteries and veins. Research is still in its infancy and first applicable results are expected in the second part of this decade. In the next decade it will become possible to print more complex structures and by the end of the decade also some organs.

The main actors are in the USA. Europe may play its role although this is an area that is looking for funding from other fields than IST.

### 5.9 Processing

Processing has been evolving at a surprisingly predictable pace, a doubling every 18 months over the last 30 years. This evolution made possible completely new services and new industries. The progressive decrease in cost has enlarged the market from a few computers per country to a computer (PC) per family and beyond. The leading edge market (PC, Mainframe, Supercomputer) managed to keep remunerative pricing thanks to a demand that consistently exceeded offer. This is likely to change in the next 5 years. By 2020 basically all processing needs will be satisfied through commodity chips.

The drive towards better processing power will continue, in spite of a decreasing demand, because of the need to decrease fixed cost (production plants) through higher and higher volume production and squeezing of size (which in turns lead to higher performance).

By 2020 every conceivable object is likely to have some sort of processing capability embedded. It remains an open question if such an embedding will be a commodity that any industry can acquire or if it will become part of the production process so that the dominance of processing technology will create a leading edge on the market. In other terms: processing can evolve in the direction of giving equal opportunity to everyone (and every country) to develop products and services or in the direction of locking in the market favouring those that can control processing capability.

In the next 15 years we are likely to see as main technologies:

- **Processing dedicated to “calculus”**
  
  - **microprocessors** will continue their increase in performance at least for the next 7-9 years. However, mass-market demand for increased processing speed is likely to level out within the next 4-5 years maximum. This will create an overreaching offer that is likely to translate in a steeper decrease in the price of the lower speed processors. In turn this may decrease the interest of chip manufacturers to chase higher speeds. In the next decade this situation should become even more pronounced leading to a halt in the increasing of speed (processing performance). The Moore’s law, then, may come to a halt not because it has reached a physical barrier but because it progress (and the underlying economics) is no longer desired. The main actor (by far) is the USA and there is basically no hope to bridge the gap in the short medium term. In the longer term it simply has no sense trying to do it.
  
  - **supercomputers** have already changed their basic architecture moving from specially developed processing chips to the use of common microprocessor organised in a
massively parallel architecture. The market for these supercomputers is obviously a marginal one if compared to the one of PCs. That is the reason why PC microprocessors have been able to evolve faster than supercomputer-dedicated chips. The main players are in the USA and in Japan.

In the next decade the likely sharp decrease in the evolution of PCs microprocessors is likely to increase (relatively) the demand for supercomputers by companies that will see their computing need growing and no corresponding growth in the PC capacity. That will create an increased demand for massive parallel processing. In this area the leading actors are likely to be the Americans, given the level of research currently funded in the USA.

New areas that will require significant processing capacity beyond the one available by the next decade PCs are likely to be in the health care (personalised drugs) and environmental sector.

The processing capacity of supercomputer is expected to reach the hundreds of PFLOPS (e.g. BlueGene P) by the end of this decade and potentially several EFLOP (Billions of billions of operation per second) in the next decade.

- **GRID processing** is in full deployment to harvest the distributed power of hundreds/hundred of thousands microprocessors. Services are being offered to provide processing power based on GRID infrastructure. In the coming year some companies will take advantage of this offer (main actors are HP and IBM) as a substitute to a supercomputer. By the end of the decade GRID processing should reach a peak and then it will probably decrease under the pressure of local processing availability on the one hand and access to massively parallel architectures either local or remote. At that stage GRID processing may be used at the termination end of a high speed connection to increase connection speed (for those applications that might require it; a minority in term of market share). Most of the market is related to scientific activity, medical (mostly related to the scientific aspects of medicine) and very limited rendering application in the movie sector.

- Processing dedicated to the capture of information
  - **Microprocessor** will be included in the evolution of sensors. This is not going to present any particular evolution in terms of processing whose main characteristics will remain the very low power consumption. There is no clear domination in this sector. Europe can be a leader as well as USA and East Asia.
  - **Digital signal processing** will continue to be a main component in various devices for data captures and by the end of this decade it should be included in the micro processing chip (SoC). USA is currently the leading area. Europe is lagging behind but for the communication part (see below).

- Processing dedicated to the display of information
  - **Graphic microprocessors** will continue to evolve in this decade to reach several billion polygons per second. Once the thresholds of hundred billion polygons is reached this will fulfill any demand of the market as far as it is possible to forecast today. This is likely to happen at the latest early in the next decade. No further evolution is going to be needed. Actually in the next decade it is likely to see an embedding in the microprocessor of the graphic processing features. USA are currently leading the innovation and the market and this is likely to remain unchanged till 2007. At that point Japan may become a strong contender (the off spring of “The Cell” from Sony may signal a turning point in favour of Japan). Europe is out of the game and it is unlikely that the situation may change, independently of the research effort.
  - **Television image processing** is likely to become embedded within the next few years in the screen itself. Korea and Japan may become the dominant player. However the all area of Digital Television is still an open field.

- Processing dedicated to communications
  - **Microprocessors** in communications will continue to grow in performance. Depending of the application areas their evolution will be in processing speed, in lower consumption, in direct optical interfacing. Europe is positioned as well as USA and Japan in many of the application areas. Of particular interest the increasing processing power of the microprocessor on the SIM.
5.10 Storage

Storage has been evolving in the last 10 years at a pace of doubling capacity at a 10% decreasing price every year for hard drive (current leading edge is 300 GB at a cost of 1 Euro per GB approximately), invention of new storage media every 5 years with a technological breakthrough every 10 years (floppy disk in the 70ies, diskette in the 80ies, CD ROM in the 90ies, DVD in the first decade of the 2000, holographic disk – thin film polymer based memory expected to take the upper hand in the next decade) leading to a market disruption.

Each disruption cycle has had a profound impact on industry, from manufacturing to software application to content production, delivery, management and protection.

There is no sign of a slowing down of evolution both in capacity and in price decrease. Capacity is rapidly reaching a point to support local storage of huge quantity of information creating virtual local “internet”. At the same time everything will be potentially recordable enabling new services and creating completely new industry.

By 2020 one can expect to have as much storage capacity as needed on every appliance changing the usage of (data) communications infrastructure from access and download to update and synch.

It is interesting to note that there is no convergence in sight of the various storage media. Progress in polymer memory is not likely to kill optical storage, flash card progress is not likely to kill hard disk evolution.

In the next 15 years we are likely to see as main technologies:

- Read only memory
  - Silicon based memory will grow in capacity in the order of GB and it will be applied in association to processing chip for its high speed reading cycle. Japanese and Korean companies are the dominant actor now. Taiwanese companies are coming up strong. In the longer term with a growing embedding of silicon memories in the processing chip the American companies may take the upper hand. Europe is lagging behind. An opportunity for reversing the trend may come from the growth in the area of information appliances and with white goods (the entertainment sector will be a playing field of Japanese and Korean companies for the near future). The SoC area will be making massive use of ROMs and Europe may play some role in this evolution in conjunction with the said areas.
  - Polymer memory will become available within the end of this decade and may become the main distribution media by the middle of the next decade for encrypted content whose access can be enabled by an appropriate decrypting algorithm (this would be activated in various ways, mostly via a telecommunication link). TB content capacity will be the “normal” size. This is still an open field with no main actor. Europe can surely take leadership.
  - Holographic memory will increase its storage capacity to the TB scale by the second part of this decade. It is likely to be used for archiving of information by enterprises where high-speed information search is required. Although the optical support is likely to allow for writing (and rewriting) like a normal CD the use of holographic memory is unlikely to become mainstream for R/W support.

- Read / write memory
  - Silicon based memory (DRAM and the like) will grow in capacity reaching several GB. A significant application is in conjunction with processing chip. By the middle of the next decade it will be likely incorporated in the SoC. Japanese and Korean companies are the dominant actor now. Taiwanese companies are coming up strong. In the longer term with a growing embedding of silicon memories in the processing chip the American companies may take the upper hand. Europe is lagging behind and it is unlikely to reverse this situation.
Another significant area of application (Compact Flash and the like) is in the provisioning of portable storage capacity to appliances. In the next few years the FAT standard will be widely used leading to up to 170 GB of storage capacity by the end of this decade. Further progress may be expected in the next decade although it is difficult, at this time, to see compelling applications. Their read write cycle will slowly approach the one of DRAM. Korean, Taiwanese are the main players. America is lagging behind, Europe is basically non existent. This situation is unlikely to change in the short term. However in the next 5 years compact flash cards will evolve towards (limited) processing capability, mostly to support communications. In the next decade this may further grow and in this case the American may lead the way. That is an area of potential “catch up” for Europe, particularly in relation with the cell phone market (including its use by objects).

The SIM card evolution is still another area and Europe and East Asia is particularly interested in the possible applications. So far the main players in the production are in the East Asia. It may become another interesting area to “catch up” for Europe.

Use of silicon based memory in sensors, tags...will become more widespread in the last part of this decade and in the next one. However the main driving technology is not the storage but the processing and the sensing and storage is likely to grow for these applications in the SoC.

- **Hard drives based memory** will continue its growth through breakthrough. This is an area where Europe is basically non existent (main actors are in the USA) but given the characterization of the evolution through refinement (no way to play a role for Europe) and breakthrough research may open opportunity to whoever has the capacity to “invent” disruptive technologies.

The current technologies (storage medium and reading/writing head) will reach a limit before the TB on a single disk (today is around 360 GB). Evolution in the storage magnetic substrate in the reading head may break this limit in the next 5 years.

- **Optical storage memory** will keep growing in capacity to reach in the next decade the TB. USA and Japan are today on the forefront of the evolution with Korea chasing. Europe is basically non-existent in spite of some important research work (by Philips). The situation is unlikely to change in this decade. New breakthrough technologies may change this situation in the next decade. It is an area where Europe may have its saying if appropriate research is funded.

- **Nanotechnologies based memory** is still in theoretical stage, although some prototypes have been developed. Its promise to deliver very high-density storage is unlikely to be fulfilled before the next decade. A significant number of technological evolutions needed to create nano-storage memory is in common with other nanotechnologies applications. USA and Japan are investing more than what Europe is doing (4 and 2 times more respectively); this is a high risk research area but it is also one that may create significant disruption and where lagging behind would seal off several areas in the next 2 decades.

- **Organic based memory** is still in the theoretical stage and its potential applications are related to medicine than to IST. They have not been considered in this report.

- **Storage infrastructure**

  - **Local Storage** has been limited in all these years to “local” infrastructures, clustering many storage devices (from tapes to hard disks) to deliver M/G/T bytes of capacity. In the coming years a growing number of companies will require PB storage capacity and by the next decade may of these, plus some new entrants, will require EB (billion of GB) of storage. Evolution will be both in the storage elements, as seen before, and in the architectures connecting the various “storage building blocks” to deliver the desired capacity.

  Approaches like IBM Ice Cube are in this direction.

  - **Distributed Storage** is an alternative approach based on the connection of large storage capacity geographically distributed. The Data GRID is based on this approach USA can be considered more advanced today but the area is open for any other contender. The market is, however, likely to remain relatively small and therefore there should not be a high motivation in investing by the private industry. Scientific endeavour, in selected areas, may benefit from progress in this area, as well as some social applications like health care.

  In the next five years storage on demand through geographically distributed architectures...
will keep growing with related services offering. In the longer term the growth of local storage capacity is likely to decrease its interest. However the existence of huge data banks, but also of massively distributed information, such as the one in sensors networks, is likely to generate an increasing demand for accessing distributed storage as if they were a single massive local storage. This does not require particular hardware evolution, rather evolution in the retrieval software. Again this area is likely to be the darling in scientific endeavour rather than in the private business.

- **Synchronised storage** is a set of technologies to make sure that a variety of different storage media are synchronised. This is already the case in the synchronization of PDA data with the PC or the cell phone agenda with the PDA. In the coming years many more devices will contain data updated at different times, partly on command by the owner partly as consequence of some applications running in background. The management of these data banks will be of significant importance. It will not happen just at the personal level, also in the business environment and in the network environment where mirror sites are going to disseminate and ways to make sure they are in synch will be needed. Sophisticated mechanisms already exist and more will be needed. Research in this area will be a significant enabler for seamless operation of our environment. Main actors in these areas are the big software companies in the USA.
6 Disruptions ahead

Technological evolution, the availability of novel (or just significantly enhanced) functionalities and the widespread adoption of new services over a long time span is likely to create new ways of living and novel perception of values driving to the evolution of the culture. On a shorter term some mix of technology, production, distribution and adoption may disrupt some market segments as we know them today opening up opportunities to new players and changing the competitive advantage of whole countries. Although it is almost impossible to predict the when and what will cause a disruption it is possible to outline the “why” a disruption in a given area may occur. Understanding the “why” is important from an investment point of view since it can provide further parameters to evaluate investment strategies.

In evaluating technological trajectories WP2 has tried to understand the macro phenomena that would, if met, enable a disruption. In some cases a timeframe can also be provided but again not in the sense of predicting the time it will occur, rather the time frame when it may occur. The actual occurrence is conditioned by a variety of parameters that are external to the technology itself. In many cases some of these parameters may be controlled, or at least influenced, by a social government set of policies. As an example the availability of technology to provide broadband on the residential local loop has been an enabling factor that in Korea has been leveraged by a government policy for its widespread adoption. This is currently being followed up by a strategy to deploy hot spots in most metropolitan area and consumer electronics giants Samsung and Sony are riding the way by creating a completely new set of appliances that may lead to new paradigms of use of appliances extending the home environment to the outer world. Consumer electronics may take the upper hand in the whole information society processing and storage infrastructure thus disrupting current rules where there is a dominance of the US industry.

Disruptions are a threat to established business actors but are a big opportunity for newcomers. Furthermore, disruptions create a brand new market thus transforming mature business in new ones. It makes the evolution spin one more. Because of this disruption should not be considered as “bad” by established businesses. The fixed line telephone market has been disrupted by the advent of wireless. This created a completely new business with new rules. The key was the enabling of personal communications versus the place to place communication. This is valid at country level as well. Potential disruptions are an essential ingredient to guide strategic investment in research and in innovation.

What follows is to be taken more as bread for thought than as a forecasting exercise. For each disruption the following aspects are discussed:

- **Technological Enabling factors**
  - What are the technologies whose evolution is enabling the disruption?

- **Market driven factors**
  - Market factors may be an enabler to the disruption, as well as technology.

- **Industry Impact**
  - What is the likely impact of the disruption on the existing industry and how is the industry likely to be reshaped by the disruption?

- **Market Sectors Affected**
  - There are normally many market sectors affected by a disruption. What is listed has to be taken as an example, not as an exhaustive list nor as the list of the “main” sectors.

- **Likelihood to happen**
  - What is the time frame in which the disruption may occur? In many cases the time frame varies depending on the market sector.
6.1 Towards a transformation of Products into Services

There are several indications pointing toward a transformation of Products into Services. There are advantages and disadvantages from a manufacturer’s point of view in this evolution. Selling products limits the interaction with the client at the selling point (in space and in time). Once the client has bought the product he is no longer a client. Any interaction occurring after the sale is likely to be activated by a disappointed client who comes back with some problems. The losing of contact with the client is obviously not an efficient way to exploit the advertisement effort. In a service sale the contact continues through the usage of the service and the service provider has a continuous monitoring on when, how, how much the service is used. It has the opportunity to interact with the user keeping close ties with him.

On the other hand selling a product means making the intended margin as the sale is sealed. In a service relationship revenues are distributed over time and only a repeated use of the service leads to margins for the provider. It is not sufficient to sell a service once: it should be sold over and over again. In product sale it is good to have a satisfied customer (mostly to spread by word of mouth the brand and generate other sales). In service sales it is essential to have a satisfied and “addicted” customer in order to generate revenue.

Technologies (both those involved in production and those actually making up the product) are getting cheaper and cheaper. At the same time accessibility to central management, distribution centres is becoming easier (and cheaper as well). This is enabling the transformation of products into services. Rather than selling hardware companies are moving into providing hardware (at very low cost or even for free) to run the services. It is, in a way, the telecommunications operators model. Car manufacturers are starting to sell services along with the car. Here the hardware is still too expensive to allow a full transition into a full service paradigm but the shift may start by the end of this decade and may have some effect by the end of the next one.

Health care is today structured into services (doctors, hospitals…) and products (drugs, prosthetics…). By the end of the next decade a clear shift towards a service based health care will be visible opening the field to a number of other players.

Appliances are definitely products today, but, by the beginning of the next decade, their widespread connectivity to the network may lead to the rise of a service model paradigm. Technologies like applets, tiny OS, software radio are paving the way for a service paradigm to take over the product paradigm.

Information is “soft”, as are applications, and this may eventually drive towards a Service Society rather than a Product Society. The mass production enabled by the production chain is giving way to a “personal” mass production enabled by the greater flexibility of the production processes on one hand and on the other hand on the surplus capability embedded in many products letting users customise them to their needs. These two factors are still difficult to manage (ordering process, personal customisation…) and do not meet dynamically changing possibilities (on the producer side) and needs (on the user side). The step towards a service paradigm would address these aspects, disrupting, at the same time, whole value chains.

Usability, understanding of the client (changing) needs, creation of a trusted relationship will be key asset in this evolution.

**Technological Enabling factors**

- **Embedding of communication capabilities** in any product let manufacturers (and resellers) keep an open line with the user. This open line will be exploited both to deliver the service and to increase marketing opportunities.

- **Rising of profiling technologies** with a shift from the marketing targeted profiling to the function delivery targeted profiling.

- **Cheaper production processes** squeezing the “value” of the objects produced. Printing on demand (3D printing at home or in a nearby service centre will contribute to this). Any disposable object tends to be marketed more in terms of service than as a product.

**Market driven factors**

- **Commoditisation of products** is progressively reducing margins driving companies to look for alternative ways of making money. In a way the transformation of a product into a service serve a similar purpose of offering monthly payment, diluting the customer expenses.
• **Loss of differentiation capability** because of a product in itself is no longer distinguishable by the functionality provided, but just by its brand. This brand value, in several market segments will be losing appeal in favour of lower price, as it is already happening in the growth of brand-less products.

• **Increased copycat possibilities** contribute to the loss of value in product. It is possible to copy a product (like a song) but not a service (this has to be delivered any time, over and over).

**Industry Impact**

• **Transformation into service companies** with much greater attention to customers evolving needs.

• **Shortening of products’ life cycle** or alternatively greater flexibility in functionalities with remote update.

• **Strong increase in call centres** in a first phase then drive towards **automated customised assistance** and relation with customers and users.

• **Increased globalisation of the market**, since the delivery of service in many cases is not requiring a physical presence. At the same time winning on a global market requires geographically rooted knowledge (including capability to speak the local language).

• **Restructuring of the value chain**, with a seamless integration of the production phase, the delivery phase and the customer care phase. This may lead to an extension of reach for some industries or to the emergence of new actors providing the added value, the delivery of the service over a commoditised product.

**Market Sectors Affected**

• **Health care**, including preventive care, tele-medicine, drugs delivery/monitoring ....

• **Entertainment**, including music, movies ...where a new model needs to be found to make piracy of content irrelevant (not impossible...)

• **Transportation**, including flexible cars, multimode transportation, goods versus people transportation/synchronisation with impact on distribution chains....

• **Consumer appliances**, including cellphones with targeted services, prevalence of the SIM-card over the hardware, digital cameras where the value is in the photos (management), not in the equipment, digital video recorders given away at minimal price and charging on the services delivered through them...

• **Education**, like books and training material may be bundle into a service.

**Likelihood to happen**

• **Disruption is already occurring** in some market segments. It will spread to other segments over this decade.

• **Connectivity bundled as a service feature** in a variety of appliances. One will buy it from the appliance reseller, not from the Telecom Operator. This will happen within this decade.

• **Appliance bundled in connectivity** as a gateway to a service, e.g. a radiographic system is sold directly by the Telecom Operator as a bundle, a photo frame display is offered as gateway to an ADSL line...This is already happening and is likely to grow in the next few years. Beyond that, in the next decade, it depends on the various strategies adopted by the Telecom Operator. It is likely to oscillate over time.

### 6.2 The Disappearance of the Computer

Computers have already disappeared, at least most of them. For any PC that is sold there are over 100 microprocessors that are being embedded in everyday objects, being it a television remote control, a wrist watch, a hotel room lock.

A new car has tens of computers (the new Lancia Thesis has over 50 of them). If this looks impressive, it is nothing with respect to what is likely to happen in the next 5 to 10 years. The ratio of microprocessors produced versus those perceived as a PC will skyrocket. Additionally the PC themselves are going to become less and less conspicuous fading in the backstage. As new appliances will embed connectivity and processing capabilities, and they will seamless interconnect with each other making it possible to display information on the most appropriate
device (a television for a video clip, a personal screen for “that” particular clip, a cell phone screen for an e-mail, a Bluetooth enabled earphone for listening to a music or voice message...), the PC will drop from the stage.

At the same time the appearance of storage, processing, sensing and communication capabilities in every day object as well as in the environment will create tremendous opportunities for new services.

The leadership of the USA in processing may continue but it may not constitute a significant advantage. Japan may take the upper end in processing thanks to investment in both high speed computing (super computers) and in consumer electronics. The investment in supercomputer may not prove to be a significant factor, particularly given the emergence of the GRID where huge amount of processing power may be harvested at relatively low cost and basically “on-demand”. On the contrary the leading edge in consumer electronics may become a significant factor. Today top graphic processing is provided not by supercomputers but by specialised graphic cards developed for the consumer market (gaming) at a cost that fits those pockets (a hundred dollars or so). By 2005 gaming processors (like “The Cell” announced by Sony with a processing power in the TFLOP range) may become the fastest processing machine and take the upper hand in the market.

Europe is lagging behind. This may not be an issue since the processing power will become a commodity and will be available at low price. However if processing becomes an embedded property of basically any object the capacity to develop processing as part of the object may become a crucial capability. In fact packaging will remain a (relatively) high cost activity and products having all functionality within a single chip (including the processing) are likely to be more competitive than those having the functionalities split over several chips.

Research investment in the SOC (System on Chip) is therefore a priority for Europe.

**Technological Enabling factors**

- **Diminished cost** of production of the wafer and of packaging will make it convenient to package processing power in any appliance.
- **System on Chip** (SOC) technologies will basically lead to embed processing power in any electronic chip.
- **Wearable computers** will bring processing power in dresses and gadgets that are not perceived as “computers”.
- **Increase in connectivity and ubiquitous access** will fuzzy the perception of where a computer, processing power, is.

**Market driven factors**

- **The need to increase volumes** steers towards the embedding of PCs in everyday objects.
- **The need to increase flexibility** in the usage of objects will foster the embedding of processing power inside many of them thus decoupling the perception of processing from the PC.
- **The need to provide easier use** of objects pushes towards the interaction design with one object-one design-one function. Embedded processing power can provide the needed easiness in the interface and give the object the capability to understand its users needs adapting to them.

**Industry Impact**

- **The existence of processing capability** in any object, along with the capability to communicate, changes the architecture of the environments. An object can no longer be designed in isolation but needs to take the environment into account.
- **A new level of competences** will be required to sustain the competition among industries, consumer electronics, white goods, appliances but also, in the longer term, furniture.....This is not available today in most of these industries.
- **The value chain will see new actors** both in production and in the customer care with the possible demise, in the long run, of “artisans” as it has happened in the car maintenance where little workshops had to give way to larger organizations not being able to sustain the new electronic technology.
Market Sectors Affected

- **Appliances** of all kinds will embed processing power and communication capabilities.
- **Household environment** and objects will contain (at least several of them) some level of processing and communications capabilities.
- **Transportation** “tools” (including cars, bikes…) will embed processing and communications capabilities.
- **Security** will be embedded in many environments and will be made possible by exploiting local processing capabilities.
- **Environment control** will be heavily based on intelligent (processing and communications enabled) artefacts (video cameras on power lines, illumination poles…).
- **Information retrieval** as the periphery can understand what makes sense and provide focused information. This may significantly change, in the next decade, the data mining architecture (and needs).
- ...

Likeliness to happen

- **The thresholds of processing power** offering exceeding significantly the demand is likely to be reached by 2008 in many “consumer” sectors. The first impact will be felt at the PC level although there is going to be till 2010 an intermediate stage where the home PC will play in a number of cases the role of the home media centre (Microsoft push).
- **Dramatic cost reduction** and significant processing power will be experienced early next decade. It will affect “important” appliances (like those in the entertainment sector). Other “smaller” appliances will embed marginal processing power with no real competition with the PC.
- **Final demise of the PC** a reality in the second part of the next decade.

### 6.3 Ubiquitous Seamless Connectivity

Fixed line telephony in Europe is widespread. More important cellular coverage is almost ubiquitous. However the price of connectivity, particularly on mobile, is still at premium. Picocells, initially serving data traffic and then also voice traffic, may provide a significant increase in capacity and increase connectivity options. Korea has launched a plan to deploy a significant number of hot spot within 2003 and some European cities have also expressed (or initiated) similar plans.

By 2008 high density areas are likely to be extensively covered by hot spots and new technologies such as UWB will become available to further extend the set of options (although their even more limited coverage would make them fit for WPAN best).

By 2015 terminals (having solved the issue of battery power consumption) may become point of autonomous networks thus further increasing the connectivity.

All this evolution may prove to be disruptive in the traffic model of both fixed and mobile operators. The assumption that a client is tightly connected to a line (physical or virtual) and that spectrum is a limited resource to be regulated and “licensed” may become moot.

Connectivity may really become a commodity. Connectivity services, however, may remain high value merchandise.

Ubiquitous connectivity, for both people and machine, is likely to significantly increase the breath of service offering and it will result in a general increase in competitiveness of an area. There are, however, several technical, economical and regulatory issues related to this. Close attention should be given by Europe in fostering pervasive communication and in avoiding that disruption sinks current players opening the gates to worldwide colonization of European market.

Technological Enabling factors

- **Increased capabilities of any object to connect** to networks and establish communications.
- **Variety of infrastructures** making communication access ubiquitous, from cellular to WiFi, to UWB and fixed lines connected to many appliances in the home.
- **WPAN** local connectivity bridging wearable devices with communications network will make communications transparent to many users.
• Mesh, ad hoc and terminals networks are, in the second part of the next decade, making it possible to piggyback on intermediate infrastructure to reach a communication backbone, thus greatly increasing the ubiquitous ness of connectivity.
• Software radio by the end of this decade will automatically adapt the terminal communication to the access infrastructure available.

Market driven factors
• Mature market going towards flat rate subscription, sooner in the fixed line offer then in wireless line as well (at least in some market segments).
• Demand for transparency particularly by business users to be able to access seamlessly services independently of the type of infrastructure locally available.
• Bundling of communications into services and goods will further diminish the perception of a communication infrastructure and of communication “providers”.

Industry Impact
• Shift from connectivity to service by telecommunication operators.
• Bundling of services to the clients with negotiation among infrastructure owners to give rights of access
• Seamless Service Hopping across access gateways like the establishment and holding of a transaction across several disjointed WiFi hot spots in a urban environment to support tourists roaming.
• Crucial importance of profiling as a competitive advantage simplifying use and proactively creating the customised environment independently (up to a certain point) of local condition. Virtual connectivity can go as far as providing information even when no connection is possible (by mirroring likely demanded information on site, like on an airplane, in a car...)
• Embedded Connectivity Demand on a variety of objects including cars, appliances, ...
• Increasing opportunities to offer new services and potential rise of new industries, sometimes at the expense of existing ones that were filling a communication gap.

Market Sectors Affected
• Communication providers will have the opportunity to go beyond their infrastructure to integrate services accessed by other infrastructures (as it is done today, probably just one tad more) and to integrate other infrastructures in their management (e.g. sensors networks).
• Goods producers will benefit from the embedding of communication services into their products and the market will come to expect such an embedded communication.
• Resellers areas, malls, shops...can take advantage from a ubiquitous communication in their environment to talk to their customers (marketing, customer care in the shop...) and can set up their own local communications infrastructure for doing so. At the same time a widespread deployment of these local infrastructure will likely stimulate operators to support them by making virtual infrastructures available over their physical infrastructure (a la “Centrex”).

Likeliness to happen
• A certainty. The point is not if but when and how. Regulation will have a big impact on the way it will happen and on the speed.

6.4 Changing traffic patterns

Telecommunications traffic has reflected the use of people talking on the phone: a symmetrical communications, low speed (between 10 and 64 kbps), for an average connection time of three minutes.
Data traffic has completely different characteristics; the number of bits being sent may vary from very few to huge quantity, the connection time may be fraction of a second or extend through the day. The speed requirements are also variable.
These requirements are set by the end user perception and these differ from human to machine. The terminal plays an important role in setting these requirements: a television needs a continuous
feed of data to be able to display a video. However if that television is equipped with a hard disk and there is a decoupling between the data sent on the line and those displayed on the screen the continuity in the transmission is no longer an issue. Such continuity is ensured between the hard disk and the screen.

In the future the trend is towards local storage availability as well as local processing capacity. This in turns translates into lower requirements on the network for data streaming. This latter may remain needed for voice and for people to people videoconferencing. Movies download may be accomplished through data burst in the network.

The last mile today often provides asymmetrical speed (higher in downward, lower in upward). By 2008 the significant growth of both peer-to-peer traffic and of uploading of information generated by individuals (like digital photos) will require higher speed on the uplink. Symmetrical capacity may be needed only in a few situations whilst the possibility of selecting the required bandwidth in whatever direction will be important.

The need to stay in touch with a changing environment will grow the demand for always on connectivity, such as those provided by GPRS, EDGE, UMTS, WiFi and ADSL. These changing requirements will be felt particularly in the last mile (both wire-line and wireless) and in the metropolitan networks.

Traffic will also sport much more random effects with surge in an area because of unpredictable events. The phenomena of self made reporters that is picking up in Japan along with the publishing of Blogs is just one of the several indications of this evolution.

Networks will need to be engineered to support dynamic reconfiguration; there will be less planning and traffic engineering and more self-dimensioning.

Flexibility of networks in Europe should be a high priority. All infrastructures, present and future, shall provide seamless capacity to any party (maintaining, of course, accountability and charging for the service provided).

The US is significantly ahead in this area from a research point of view.

**Technological Enabling factors**

- **Huge amount of local storage** can provide access to information locally in any required way acting as a mirror to information anywhere. Communications with the local mirror can use burst mode.
- **Sensors, tags** generate transaction-oriented traffic.
- **Digital camcorders, cameras...** increase the amount of locally created content and the request for higher speed up-link to share this content.
- **Agent communications** steers towards “unpredictable” traffic patterns. It may occur at any time and with a broad range of bandwidth demand.

**Market driven factors**

- **Growth of peer-to-peer** steers demand for higher uplink speed (not necessarily symmetrical bandwidth wince the higher speed on the up link or downlink may be needed in different communications).
- **Flat rate and always on** stimulate higher traffic demand with different pattern.

**Industry Impact**

- **Significant push towards Gigabit Ethernet** in the metropolitan area networks.
- **Push towards the transition from ADSL to VDSL** in the local loop.
- **Transition towards an optical access**, in the longer term. However this is likely to be steered not by an increased demand in bandwidth (that can be satisfied by the VDSL migration) but by easier operation. In order to become economically interesting the aspects of powering the network terminal (and terminators) should be solved. In the next decade, in Europe, optical access is likely to be increasingly deployed.
- **Always on wireless connectivity** (like GPRS, WCDMA, WiFi) is likely to serve an increased variety of services.

**Market Sectors Affected**

- **Telecom Operators** will need to re-think their infrastructure and upgrade it to follow at best market demand.
- **Advertisement** will need to look at the different ways of using communications to piggyback effectively.
Likelihood to happen

- **Asynchronous traffic patterns** are increasing significantly in volume; however they have not resulted (with fewer exceptions like SMS) in a significant growth of revenue streams. This pattern is unlikely to change in the next few years. Operators are now cautiously looking at what investment is bound to increase revenue and significant evolution in the network (which involves significant investment) is likely to proceed at very slow pace. Completely new business models are needed, possibly extending outside of the network and from horizontal into vertical sectors to see increased revenues and hence the drive to evolve the network.

- **Bottlenecks in the metropolitan network** are on sight. Depending on the areas it may happen within the next 2 years or in the second part of the decade. It remains to be seen how the market and the operators will react to them (and to the decreased quality perceived by the users). If there will be a willingness to pay by customers technical solutions are available. If not the evolution (which will happen anyhow) will take a much longer time.

- **Wireless traffic** is likely to remain quantity-wise dominated by voice at least in this decade. Cellular traffic (3G) is likely to remain so also in the next one. More pervasive availability of hot spots (in a variety of flavour) and the parallel increased demand for data traffic may change the scenario—but just a bit beyond 2008.

### 6.5 Infinite Bandwidth (on wireless)

The Shannon theorem limits the amount of bandwidth relating it to the power of the signal being transmitted vs the background noise (interference) and the frequency used. In practice this result in a fibre capacity that is theoretically 1 million times greater than the radio spectrum. With the additional advantage that a fibre can be multiplied in capacity just by laying more fibres, something that it is not possible to do with radio spectrum.\(^{10}\)

However the Shannon theorem has nothing to say in the case of multiple channels. Recent theoretical studies have pointed out that provided there is a sufficient number of receivers (equal or greater the number of transmitter) it is possible to resolve any interference by a dialogue among the receiver to sort out the desired signal.

This is easier said than done but there is a growing consensus that by the second part of the next decade this feat may indeed be achieved. That would result, for any practical purpose, in an unlimited availability of radio spectrum thus undermining the need for spectrum regulations and licensing.

This would be another area (in addition to networking, processing and storage) where terminal related technology would provide a completely new way to provide and use services with deep implications on the market and a displacement of current players.

In this area Europe is well positioned, at least it pairs with Japan and slightly better than US. However CDMA technology is a strong asset of USA and that may be seen as a first step in this direction, hence the importance for Europe to invest and not fall behind.

**Technological Enabling factors**

- **Advances in theoretical studies on propagation** are likely to find algorithmic ways to solve the interference problem by cooperating receivers. A mathematical demonstration of this possibility is already available. Progress is expected in the way to implement it so that calculation and the related processing power required can be reduced to a minimum.

- **Terminals as network nodes** provide the technical infrastructure for computing and resolving the interference issue. Increased processing capacity within the terminals (as well as improved storage and battery) will allow that. Multimode terminals will also facilitate intra terminal communications.

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\(^{10}\) Actually the cellular radio is a way to multiply the spectrum by ensuring that the signal in a certain area does not interfere with signals, using the same frequency, transmitted in other areas.
• Cognitive radio with intelligent antennas will provide increased opportunity to use the spectrum “reducing” interference by the end of this decade and possibly solving the issue at the base station side by the end of the next decade.

• Software radio may provide an intermediate solution to increase the utilization of radio spectrum by changing dynamically the frequency used to reduce interference.

• Mesh networks on the receivers side can provide the way to negotiate and resolve interference.

Market driven factors

• The need for ubiquitous connectivity steers towards solutions providing bandwidth “on demand” which also requires flexible reallocation of spectrum.

• The emergence of a variety of local operators makes pre-allocation of spectrum an increasingly complex issue. Technical ways to have a common fabric potentially usable (and negotiable) by anyone (with all the regulations, charging and strings attached) are demanded by the market.

• The great variety in traffic demand both in quantity and in quality (like transaction based and high volume burst) pushes towards a much more flexible spectrum usage.

Industry Impact

• Incumbent Mobile operators are seeing, on the bad side, the value of spectrum sharply decreased since so much of it will become available. On the bright side the key issue once spectrum becomes abundant is to find ways of making use of it and mobile operators should be well positioned to make the most of it. The drive towards services and the shift of business value from infrastructure to services will have been occurred well before the spectrum becomes a commodity and therefore its abundance will only result in an increased capacity to offer services.

• New mobile operators will not be stemming up from the increased spectrum availability. They are like to have appeared before leveraging on UWB, WiFi, OFDM...In a way the unlimited availability of spectrum by making it less valuable will decrease the appeal to enter the “carrier” business.

• Service and product industry can leverage from the spectrum availability and can be transformed by the embedding of communications into every service and product. More complex value chain can be established and a new business for managing embedded communication will emerge.

• Regulatory frameworks both will act as a facilitator for this disruption and will be deeply affected by its occurrence.

Market Sectors Affected

• Wearable devices of all kinds will embed communications leveraging on the availability of spectrum.

• Any mobile object, cars, bikes but also pets, kids, parcels...will in the long term become communication enabled thus increasing the relations that can be established with them.

• Healthcare will be revolutionised by the possibility to have a constant monitoring of people with potential need (and in perspective of any person).

• Education will largely leverage on the communication capabilities to provide continuous learning at the best time and best spot.

• Environment monitoring will be pervasive, both for the ecosystem and for safety – security purposes.

Likelihood to happen

• Increased spectrum availability will become apparent in many areas by the end of this decade by leveraging on cognitive radio, hot spots and pico cells.

• Unlimited bandwidth capacity may become available by the end of the next decade. There are still some theoretical issues to be solved and the hurdle of processing and managing intra terminals communications that in turn requires significant progress in the battery capacity. Unlimited does not mean “infinite”: it is used to highlight the abundance of capacity versus demand; in the same way that one can say that the transmission capacity over an optical fibre is “unlimited”.

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6.6 Disposable products

The increased efficiency in the production chain, as well as the potential for products to be “printed” locally by the end of the next decade will make it possible to dramatically increase the number and variety of disposable products. From a market point of view disposable products have the advantage of customisation. One may design that particular piece to fit a very specific (narrow) means. That simplifies the interface and shortens the life cycle thus speeding up innovation. Additionally it may cut into the deployment speed and get rid of legacy issues.

The potential low cost of many disposable may eventually lead to the pricing of the service provided through that disposable. The hardware cost may become completely embedded in the service.

Clearly there are issues like the increasing challenge of recycling plus the accountability of the provider (that has to include both the disposable object and the service).

The challenge for Europe is to be part of this evolution. Lagging behind would not just mean abdicating to a growing share of the market, but also to slow down the innovation cycle spun by the faster life cycle of the disposable.

Investment in fabrication technologies is of paramount importance.

Technological Enabling factors

- **Diminished cost** of high volume production will make the single object cost negligible and marginal with respect to the price of the service bundled on the object.
- **Increased flexibility and customisation** leads to a standard object that can be replicated in million of pieces although it may appear significantly branded to the end user (as it is the case today of key cards used by hotels where the basic object-plastic and chip- is the same but the serigraphy and the functions enabled by the card vary considerably.
- **3D printers** allowing the in-house or retail production of objects.
- **Long lasting batteries** providing few hundred hours of power will be a strong enabler for disposable. The availability of a stripped down cell phone with powering lasting several hundred hours makes it suitable for use as a guarantee card to access a customer care...
- **Short range embedded connectivity** can diminish the features on the object (thus keeping it cheaper) that works more as an enabler to access functions that are residing on a different –wirelessly reachable- object. The SIM card may be playing this role and be “the core” for orchestrating functions accessed by a variety of other objects. Tags are a particularly important area where connection with a SIM may prove exceptionally fruitful.

Market driven factors

- **The faster pace of fashion and design** steers towards shorter product life cycle.
- **The shift from products to services** topples the balance toward "soft values" hence decreasing the importance of the hardware.
- **The function oriented interface** push towards more simplified objects that are needed for shorter time since the function keeps evolving therefore stimulating the need for changing the object frequently.

Industry Impact

- **Evolution in the value chain** with new players providing the “commodity” objects and others providing services by piggyback on them.
- **Faster evolution cycles** will have a profound impact on many industries accelerating service innovation, increasing the need to monitor customers behaviour and preference, different relation with retailers that may become part of the production cycle themselves (taking care of the customisation, a crucial part in the value chain).
- **Evolution in the customer care** with no more repair but increased need to replace object maintaining the functionality and overall profile-ambient...

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11 Both through 3D printers and through new fabrication technologies like electronic spraying of components and self fabrication.
Market Sectors Affected

- **Small Appliances** of all kinds including cellphones.
- **Soft services**, based on information will be packaged into “fruition objects” with a strong branding on the service.

Likeliness to happen

- **Fashion Branded Objects** are the first step towards disposable objects at a perception level. This is already happening in watches, it is starting in phones (Xelibri, but also in the offering of some Mobile Operators to include the phone in the price of the service and to guarantee its replacement every year). It will increase in the next 5 years expanding to other goods including white appliances.
- **Disposable Objects** are already on the market in some niches, including cell phones. Today there are a few and all are manufactured through industrial processes. By the end of this decade there will be several others and in the next decade in-house printing (or by retail shop) will further increase the range of products “perceived” as disposable. Basically all gadgets used in advertisement are disposable (in perception terms) and this includes pocket calculator, memory storage...Given the expected cost decrease, PC (stripped down PCs) will become disposable in the next decade.

6.7 Autonomous Systems

The complexity of the environment and the presence of communications infrastructure that are connecting everything together is loosening the role of a centralised entity charged to ensure the appropriate workings of everything.

To contrast the progressively lesser support that will be available from a centralised entity research is leading to architectures that foster autonomous behaviour (and local adaptation) based on a perception of the relation with the local environment.

The trend is towards autonomous systems and in a way it mimics the way decisions are taken in living organisms. Most of them survive through the capacity of taking local decisions whose effect percolate like away and affect other local decisions. Clearly, sometimes the system goes awry and the absence of a central control may have catastrophic results.

Autonomous systems (also know as autonomic systems) are, in general, much more responsive, they are better fit to a changing environment and approach at a fundamental new level the issue of interoperability.

This new approach will find various fields of application and beyond 2010 we are likely to see a number of effects in areas as far apart as business relation, government, health care, road traffic management, standards definition.....Europe, possibly, is less culturally prepared to the idea of autonomous systems than the US (although better positioned than Japan). The increase potential and ubiquity of the communications network, the wider variety and growing number of sensors, the availability of enormous amount of data are going to favour the proliferation of autonomous systems and with them impact the competitive advantage of companies and economic systems.

Technological Enabling factors

- **Increased processing power in objects** makes local decision taking possible. The parallel processing occurring in all the nodes in the local network multiplies the increasing processing power. This is actually what distinguishes an autonomous system from a “stand alone system”.
- **Increased flexibility in the terminals** making up the nodes in the autonomous system. This makes it possible to have a variety of behaviour and adapt the local one to the needs of the system as a whole. Software radio will play a significant role in the most complex

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12 A typical case is the one of anaphylactic shock. Here local decisions of increasing the number of vessels to contrast an exogenous substance ripple the body causing death since the capacity of vessels outpace the quantity of fluids available thus reducing the pressure below the minimal threshold supporting life. A centralised system would never make such a mistake.
autonomous systems in the next decade. Initially the behaviour variation is likely to be
“pre-programmed in the nodes.
• **Agent technologies** will play a significant role in certain kinds of autonomous systems,
like those used in customer relation, e-commerce, and negotiation.
• **Ad hoc communication networks** enables a local autonomy and understanding among
the various components leading to a coordinated inner behaviour and consistent overall
interaction with the environment. This aspect is a fundamental one in the effective
operation of an autonomous system. Complex behaviour, as the one resulting from
the cooperation of the various elements, is providing the level of intelligence required to be
adaptive to an environment that is not controllable.
• **Local World Mirroring** through software applications that are progressively able to learn
more about the environment and the reaction of the environment to local generated
interaction makes it possible to create loosely coherent aggregation.

**Market driven factors**
• **Sensors and sensors’ networks** are best seen as an autonomous system reducing the
burden on maintenance and adapting their data capture to the local situation.
• **Overall increased complexity** is best addressed by having autonomous decisions being
taken locally.
• **Heterogeneous systems** and a lack of (time for defining) network wide control interfaces
pushes towards autonomous decisions and behaviour. Heterogeneity refers both to the
technologies being used that may vary significantly from place to place, to the regulation
and policies applied in different environment, to different ownerships.
• **Fast asynchronous evolution** makes system wide agreements difficult to reach and
maintain.

**Industry Impact**
• **Network Operators** are seeing a further flattening of their networks and a displacement of
the intelligence beyond their edges” Some operators may elect to keep their networks
frontiers as they are today providing only transparent connectivity, some may offer
management services (at various levels of complexity) to the autonomous systems
through their gateways, some may enter actively in the arena of autonomous systems
(e.g. for sensors’ networks) making them become an integral part of their infrastructure. In
the longer term, in the second part of the next decade, whole public network areas (like a
gigabit distribution network) may effectively become autonomous system on their own thus
leading to a significant architectural change in the overall operator’s network.
• **Service providers and Virtual Network Operators** will see an increasing demand for
management services and may become trader of functionalities provided by the
autonomous systems (particularly in the case of sensors’ networks). This will happen later
on since in the first phases these systems are likely to be strongly owned by the party
using them and it may be unwilling to delegate responsibilities to a third party.
• **Engineering** will have to take into account opportunities offered by local autonomy in
complex system and at the same time it should introduce higher intelligence in them.

**Market Sectors Affected**
• **Telecommunications** will see both an opportunity in the opening up of new areas where
they can provide services and a threat resulting from a potential less dependency on any
particular infrastructure. This latter will push further the commoditization of the network
infrastructure in a competitive environment.
• **Enterprises** of various kinds will be transforming their own systems into autonomous one
over the next 10 years.
• **Environmental enterprises and institutions** will make significant use of autonomous
systems embedding action capabilities into their monitoring systems.
• **Customer relationship** will probably make use in this decade of autonomous systems
although initially there will always be the possibility of rolling over to a human interface and
controlled behaviour.

Likeliness to happen
On a small scale it is already starting in very specific areas like monitoring and control with robots.

Large scale autonomous systems will probably become an “unavoidable” fact early in the next decade. This will create significant problems in safety and security assurance and systems getting out of hands will delay widespread adoption. The problem is that the more crucial an activity is and the more benefit would be derived by the use of an autonomous system. At the same time, because of the crucial characteristics of the activity (like a nuclear plant…), the confidence on autonomous decisions is put at test.

Commodity autonomous systems, like those that may be used in the mass market for negotiation purposes, are unlikely to see a pervasive application before the second part of the next decade. Here the possibility to perform the same actions in a fully controllable way and the uneasiness of people in delegating to an invisible actor will delay the adoption.

Enterprise-wide autonomous systems are already starting to be used in information retrieval, know how management, customer relations… Their full impact will not be felt before 2008.

6.8 From Content to Packaging

Content keeps growing at a staggering pace. It is estimated that humankind has produced more content\(^\text{13}\) in the last 30 years than in all its previous history. And the expectation is to see this amount of content doubling every 3 years.

The abundance of content is displacing the perception of content value. It is no longer the content “per se” to have a value, rather it is the way the content can be digested and put into “context”. The disruptive force of this evolution can be seen in areas like the record industry (where different packaging is disrupting the sale of content) as well as in the information industry (where companies like the Encyclopaedia Britannica have been forced to release for free their content).

In a number of areas Europe is lagging behind US in content production. In the entertainment area the problem is big since the content produced (and delivered) is shaping the culture and the expectation for further content (i.e. by getting exposed to more content from US we are likely to desire more content from US.…).

Packaging is going to play a most significant role in content related products (and services). Packaging is a technology of its own and has been evolving significantly over the years, although at a less spectacular pace than other fields. Investing in packaging technologies (in its various forms) is going to be crucial to foster competitiveness of Europe.

Main research efforts, like the one of Microsoft, MyLifeBits, the DARPA’s Life Log, and HP, One Shot, may seem to be very distant from this issue: however they will result in the evolution of basic technologies, not available today, that are likely to have a profound influence on the packaging of content and on the competitiveness of a broad range of industries.

Technological Enabling factors

- **Diminished cost** of production is leading to an “explosion” of information.
- **Consumer produced information** are at least one order of magnitude more abundant than the one produced by “vested” enterprises. The production is made possible by digital camera, digital camcorder, personal web servers… The quality is not “necessarily” worse than the one of information produced by professionals although on the “average” it is.
- **Information as a by-product** of the production processes stimulated by the need to track anything and learn from it and made possible by the computerization of the production process. An example is the new way of making movies, in digital form. A single movie is producing at least 100 times more “information” than the one embedded in the final movie and this information can be valuable to several audiences.
- **Multimedia and multimode** packaging can make information more digestible and attractive. Rather than leveraging on the resources available at the source of the

\(^{13}\text{In science, culture, entertainment…}\)
information (information repository, server…) in the future the packaging will be made at the fruition point to leverage on the best functions available. The information shall be packaged in such a way to make this possible.

- **Profiling** technologies will greatly contribute to enhance the possibilities of packaging and its value thus further shifting the perception of value from the content to the packaging.

**Market driven factors**

- **The abundance of information** makes it impossible to create a differentiating proposal based on the content itself. In 90% of the cases 90% of the content you are looking for can be obtained for free and you are usually unaware that there is a 10% missing. Packaging is what can make the difference.
- **The need to get rid of information**, since there is too much of it, is shifting the customer focus on the packaging. This is the part that makes information fit in his specific context.
- **The difficulty in controlling the content** in spite of encryption schemes pushes companies toward a service view of information (content targeted to specific needs at specific times). This in turn pushes towards emphasizing the packaging value.

**Industry Impact**

- **The content industry** is already undergoing a profound reshaping. The direction is not clear yet with current emphases on maintaining present business models and attempts to protect the content. New content protection technologies will become available but it is unlikely they will be 100% tamper-proof. Besides alternative “similar” content is likely to be freely available. Hence the current protectionist strategies are very unlikely to succeed. New business models will have to be devised and implemented. This creates a disruption in the content industry.
- **The packaging industry** will likely transform itself with a resulting evolution in the value chain. Packaging may evolve in terms of an independent service provisioning both towards the end user (as it is mostly today) and towards the content’s owners.
- **The telecommunication industry** will try to become a major player in the packaging leveraging on the ambient management capabilities and on the profile management and related services. Providing a billing platform will not be sufficient by the end of this decade as a number of other industries will be able to provide the same service.

**Market Sectors Affected**

- **Electronic entertainment** of all kinds, including music, movies, games.
- **Information providers sector** will see an increased number of services being packaged along with the information provided.
- **Knowledge management sector** will increasingly shift towards more sophisticated services to make knowledge accessible when it is needed.
- **Continuous education** will shift from the university environment to the enterprise processes. Content will be delivered within the enterprise processes based on the employee profile and the specific activity she is doing.

**Likelihood to happen**

- **The second part of this decade** will see a marked transition towards packaging offering. In this time frame it is likely to occur as an addition to existing ways of delivering content. The disruptive effect may not become apparent till the end of the decade.
- **Full impact in the next decade**. The whole content industry will need to reposition itself.

### 6.9 The emergence of virtual infrastructures

The easiness of communications, its ubiquitous availability, the fading away from the user perception of an intermediary role will likely speed up the evolution of the distribution chains. The end user may be captured, potentially, by any ring in the chain, the one who can have the better grasp of the users needs and provide most visibility to the user in terms of trust. Disney may, in the next decade, provide entertainment services from US to tourists visiting the Pompei area (or the Bastille in Paris…) leveraging on the local riches and using technology to deliver their services.
A stroll into a Jungle can be organised by a local community but tourists may prefer to get the narration from the National Geographic. Companies around the world may create their own virtual presence and virtual infrastructures for people to hook on.

These virtual infrastructures will prove disruptive to local (and country wide) business. As lower and lower cost characterises the various ring in the value chain those owning the fundamental skill that may attract clients are going to reap most of the benefit painstakingly assembled by the variety of actors in the value chain.

We have used the example of tourism but others are equally viable, from health care to education…. European strengths need to be evaluated against these potential evolution of the distribution chains to support investment in an area with the appropriate investment in connected areas thus ensuring that the benefit can be reaped.

Technological Enabling factors

- **Ubiquitous seamless communications infrastructures** are a reality in most of Europe for what cellular wireless is concerned. Fixed networks are also pervasive. However we are not yet to the point of a seamless connectivity since users need to select the access for their communication and depending on the access services (and bandwidth) differ. The deployment of WiFi, UWB, Software Radio, Multimode Terminals and WPAN will create this seamless infrastructure by the end of this decade.

- **Wireless broadband** is a technical reality but not a viable economical one for this decade in the range of several hundreds of kbps. Hundred kbps should become economically viable in the second part of this decade. Mbps will not be available till the next decade at a price making it a commodity. However by the end of this decade many places will support wireless access in the Mbps range through local access networks deployed in such a way to meet most demands.

- **Increased local storage** will make it possible to mix huge local data with some accessed through the network. This will enable, within the second part of this decade, high intensity data services at low cost, thus creating a mass market and a significant offer.

- **Agents’ technologies** are making it possible to adapt general information to specific environment and may take care of the uploading of required information in the local memory through a variety of access gateways as these become within the range of the WPAN.

- **Intelligent ambient** makes it possible to recreate virtual environments in a variety of location. Local processing, connected terminals and the interaction with the ambient “inhabitants” will progressively become available in the coming years. Intelligent home environment are not likely before the next decade in Europe (at least to the point where there is a significant number of them, sufficient to stimulate a service offering based on them). “Theme” environments developed with the goal to offer services will become available in the second part of this decade but the business will be very focused.

- **Mixed reality technologies** like semitransparent goggles, retinal projectors…..are already available but will not reach the mass market till the last part of this decade. They are not likely to become commodities before the second part of the next decade.

Market driven factors

- **Globalisation of business** stimulates provisioning of services beyond geographical boundaries.

- **Increased circulation of people** provides opportunities to enterprise to keep serving their domestic customers when they are abroad. This is not a tremendous market (although for certain segments of business customers it is an interesting one) but it contributes to create a sense of belonging and increase customer’s fidelity. This is particularly true for telecom operators.

- **Leveraging on global investment** let enterprises to focus on their services and piggyback on evolution in other sectors. The growth of communication-enabled objects and of processing-embedded makes it possible to third party the exploitation of innovations in other areas.

Industry Impact
• **Telecom Operators** are both threaten and stimulated by this evolution. Part of the evolution is resulting from a greater transparency of the(ri) infrastructures and by the emergence of other infrastructures in the access area. This is clearly leading to a shift in value perception by the end user diminishing the value of the physical infrastructure. At the same time the effective provisioning, delivery and operation of the virtual infrastructure is a complex business that can generate vast revenues. Telecom Operators are ideally placed to harvest it. The key issue is to maintain the skill of communication providers in a network that consists of pieces that are not part of a telecom operator culture, like home network, enterprise network and devices (terminals). Higher software skills (in a systemic as well as specific ways) are also essential.

• **Virtual Telecom Operators** will find new opportunities from this evolution. However the problem they will be facing is similar to the one of Physical Telecom Operator since the issue is to take hold of a much broader communication infrastructure (including services as well).

• **Consumer electronics** may leverage on their control over terminals to become a major player. Their business model and “modus operandi”, however, will need to be completely rethought. It is no more about linking them with single customer, rather linking customers with one another “through” them.

• **Computer industry** may leverage on their skill in software and configuration to become the main provider of virtual infrastructure. The attempt of doing this by the sole control of PC and software (see current Microsoft and Intel strategies) is unlikely to succeed. Partnering with consumer electronics and, possibly, with some network operators will be crucial.

**Market Sectors Affected**

• **Personal productivity** including the management of information, negotiation, communication, continuous education....

• **Entertainment** on the road, theme parks, tourist services....

• **Delivery Chain - Customer Care** will see a significant revolution. Potentially every product being sold can be seen as a terminal of a virtual infrastructure connecting the client (and the user) to the service provider(s) related to that product. Very complex relations become possible with a hierarchy in the backers of the virtual infrastructure.

**Likelihood to happen**

• **Some application niches** in this decade.

• **Full impact in the next decade**. The open question is who will take the lead and benefit.
7 How to navigate the web site

The information described in the previous chapters (meaning the Technologies, Functionalities and Technology trajectories) is organised according to the four layers defined in the Methodology (see Appendix for a full description) and displayed on the WP2 Web site http://fistera.telecomitalialab.com

This chapter aims at providing a synthetic description of the structure of the web site, and a quick guide to access the information contained in it.

Of course in order to be able to fully understand the content described in the Web site the user should access the Web once the Methodology chapter has been read.

7.1 The left fixed part

The left part of the screen is fixed and comprises a bookshelf for documents, an area for communications and a pointer to each of the four layers in which the database is structured.

The bookshelf function brings the visitor through several topics, as it is divided in one section for the **News**, one for the hot and still undefined issues described as ‘**Keep an eye on**’*, a third area devoted to **Disruptions**, and finally an area which collects the **Papers** produced either as synthesis of a discussion or as short presentations.

The ‘**Comments**’ button is to be used for writing and sending enrichments, validations, critiques on any content of the web site. It aims at opening a dialogue not only with the masters of the Technology Trajectories part of the FISTERA project but also with all the participants to the enlarged FISTERA community.

The four words Ambient, Service, Functionality, and Technology correspond to the four layers in which the database is structured and assist the visitor allowing the navigation in the main centre-right part of the web site. At the beginning of your visit, the four layers are present also in the main part of the screen, but as you select one of them, you get into the selected layer. Any further click will bring you in depth into the layer. If you want to change layer, you can use the four words on the left. When you click on one of them, the elements of the corresponding layer will appear in the screen. These four words allow you to shift from one layer to another while you are already in one of them.

7.2 The dynamic centre-right part

When you select one of the layers, namely Technology or Functionality as the core of this web site, the centre-right part of the screen changes and you get to the real representation tool. Several objects on the screen are dynamic ones, sensible to the touch of your mouse.

The vertical list of elements can be scrolled by using the two upside and downside arrows. First a condensed description is provided to let the viewer understand what a (technology) name is about. By placing the mouse on an item in the list of technology
a pop up with a yellow background is displayed with a brief text that should be sufficient to understand what it is meant. A description should serve a purpose, in our case it should convey a meaning and facilitate the understanding to an expected target audience that may not have a technical background.

By clicking on the name, a box is shown in the relationship area, the coloured area on the right (along with a number of lines connecting it to other boxes). It appears in its layer, i.e., in the blue area if it is a Technology, in the green area if it is a Functionality, in the orange one if it is a service and in the red one if it is an Ambient.

The sand-glass indicates the pointers to three years – 2003, 2008 and 2020 – to be used when the coloured part is populated by objects and relations.

For each of the three years, the corresponding content of the database is shown on the coloured part of the screen: new relationships, new ranges both for each of the objects and for the relationships, new alternatives or complementarities.

![Diagram showing relationships between technologies and functionalities]

Technologies: Agents

- What is it?
- Performance trends
- Challenges ahead
- Cost trends
- Application areas
- Main actors
- IST relations
- Countries projects
- News monitoring

What is it?

Agents (software agents): technology area: char | Act as a human being in cyberspace

Performance trends

Till end of 1990's was used for very specific pi

Clicking on the corresponding box (which appears in the coloured part, as origin of the lines representing the relationships) brings up the information characterising that technology as shown in the picture at the side.

The first information provided is a description of the technology, i.e. “What is it?”. This description is given in plain terms to help people with no specific technical background to understand the feature of that technology, how it can be used, what are the strength and weaknesses.

This description is normally supplemented by a pointer to some places on the web where a more in depth (technical) explanation can be found.

The other topics dealt with are: Performance trends, Challenges ahead, Cost trends, Application areas, Main actors, IST relations, Countries projects, News monitoring. For each topic, a synthetic text is provided, with images, graphics and pointers.

Now, let’s go back to the dynamic part of the web site. To get into the different content that is synthesised in the coloured part, it is necessary to devote one minute to the ranking system adopted.

Relationships are represented in the relationship window of the browser as shown in the screenshot on the side. Clicking on an object, in this case 3D imaging, activates the relationship window. The relationships shown are the result of a processing of the relationships defined in the database.

The object is drawn in the middle of the layer it belongs to, in this case the functionality layer, and is connected to all objects it has relation to. These objects are drawn in the layers they belong. In this case there is a relationship with the Wearable functionality, three relationships with objects at
the service layer (bandwidth on demand, education and healthcare) and two relationships with objects at the technology layer (Flat screen display and Holography). Each object is identified by its name and a number in parentheses indicating the stage of the object in the life cycle.

Each relationship is represented by a line, a red one to denote an active relationship (the evolution of the object affects the evolution of the other), a yellow one to denote a passive relationship (the evolution of the object does not affect the evolution of the other).

The thickness of the line provides a first glance information on the “strength” of the relationship. By passing the mouse on the dot over the line (approximately half way between the connected objects) a pop up is displayed to provide information on the type of relationship, on its strength and the comment associated to it as shown in the screenshot on the side.

Because of this representation it is important to structure the comment in a synthetic way so that in just a sentence or two the viewer can get the understanding of the role such a relationship plays between the two objects.

The relationship map shown relates to a specific year, in this case 2008 (highlighted in red by the sand-glass).

Moving the mouse over the years cause the change in the relationship and this is a powerful help to perceive, at a glance, how an object can evolve its relationship over time, as shown in the screenshot at the side.

In the first screenshot, related to year 2003, the functionality 3D imaging shows relation with another functionality in the same layer and another one in the upper layer. There is no relation with the technology layer since 3D imaging today is still in its infancy and it uses a number of technologies (some special software to render images in 3D, some special display in niche application…) none of which can be connected to 3D in a significant way.

By 2008 two technologies are likely to be used for 3D imaging, LCD and holography. Both of them will contribute just a bit to the functionality, the 3D software is still playing a major role and in several niches special equipment will still be used. More applications area (services) will make use of 3D imaging.

By 2020 3D imaging will become much more common in association with the same areas identified as application in 2008. The thicker lines connecting the boxes show the stronger relationship. Also the support from the LCD and holography will be stronger and the thicker yellow lines reflect this.

A Technology moves through various stages in its evolution and in its relation with the market. The number in brackets at the right side of the Technology name three fields on the top right of the form are used to indicate at what stage the technology is presently and in what stage it will likely be in 2008 and 2020.

The stages identified are:
Functionality moves (although at a slow pace, usually) through various stages in evolution with respect to the market demand (and technology available).

The stages identified are:
0 = Not available  
1 = Experimental  
2 = Niche application  
3 = Broad Market  
4 = Commodity  
5 = Embedded

This information is shown in the functionality box displayed in the relationship area as a number in brackets after the name as shown in the screenshot on the side where the functionality Data Capture is considered to be in stage 3 (Broad Market).

For the Services layer, the stages identified are:
0 = Non existing  
1 = Trial  
2 = Niche Market  
3 = Widespread  
4 = Mass Market in selected countries  
5 = Mass Market ubiquitous

For the Ambient layer, 6 penetration levels are provided. They have to be understood in reference to the description of the ambient and the assumption on the "location" of that ambient. As an example one may elect to describe the home of the future by looking at the cutting edge technology available in rich countries and there inhabited by technology geeks to bring to the edge the vision of what can be done from a technological point of view. Hence the need to understand the number in the context of the ambient proposed. These are the 6 levels of penetration:
0 = <5% of target population  
1 = <20% of target population  
2 = <40% of target population  
3 = <60% of target population  
4 = <80% of target population  
5 = Ubiquitous

Note the fact that percentage points refer to a target population for that specific ambient not to the whole population in a country or throughout Europe.

### 7.3 The relationships

Objects sharing some sort of dependencies are connected together by a relationship. There are several types of relationships. First of all relationships can be passive, in the sense that the object
does not influence the evolution of the other it is related to (like “use”) or active in the sense that the object influences the evolution of the other (like “enhances”), the former are represented in yellow, the latter in red, as shown in the screenshot below.

In any layer objects can be related one another and relations with other layers can be established. In general relations across layers occur only between contiguous layers. An object in the technology layer may have connections with objects in the functionality layer, not with objects in the service layer. An object at the functionality layer can establish relations with objects at the technology layer and with objects at the service layer. Some exceptions can be made and will be explained in the following.

If object “A” at layer “x” establishes a relation with object “B” at layer “x+1” a symmetrical relation is implicitly established. As an example if Bluetooth technology “enables” the broadband functionality, as shown in the screenshot above, the broadband functionality is “enabled” by Bluetooth. However not necessarily, when representing the relationships of the Broadband functionality, the one with Bluetooth will be listed unless it is deemed to be a fundamental one. The purpose of establishing an explicit relationship is to draw the attention of the reader to that particular relationship from a certain point of view. Now from the point of view of Bluetooth the fact that this technology can provide a 1Mbps bandwidth is important since it can support video communications, but when one is considering the Broadband functionality the micro grained view of a communication channel based on Bluetooth can be disregarded. However, in the data base the relationship established from Bluetooth to Broadband exists and a tool (not developed so far) mapping the objects into a relationship tree can consider it.

Clearly there can be several relationships between two objects. So far WP2 has identified and used the following relationships (black are active, red are passive):

### ACTIVE:
- **Impacts on:** The object evolution has an impact on the evolution of the other object. A comment can be associated to the relationship to clarify what kind of impact it can have (increase usability, performances, reliability, size...);
- **Increases processing power:** The object increases the processing power of the other object. This is not necessarily related to the evolution of the object itself, it may derive from the fact that the object is used by the other, as it is the case of a graphic card that is improving the processing power of a PC.
- **Enhances the functionality:** The object enhances the functionality of the other one. The latter can operate independently of the former although it will not be able to do certain thing at all. An example is the adoption of haptic interfaces to provide tactile sensation.
Interface can exist without this feature but its use would provide an additional (sometimes highly valued) functionality.

- **Enables**: The object is a fundamental component of the other in order for the latter "to exist". An example is the storage capacity that is essential for any PC. However there may exist alternative solutions to enable that "existence". Storage capacity, as an example, can be provided by hard disk, CD ROM, DRAM, Compact Flash...and so on. Clearly each enabler has its own characteristics and advantages. Every time the Enables relation is used there should be some other relations explaining the alternatives. If that is not the case the latter object cannot exist independently of the former and there would be just one. Enabling dependencies are very important from the point of view of decision makers since they create value chain and alternative options for investment. Enabling dependencies change over time, they may become stronger or weaker as it will be explained later on.

- **Easies the use of/the access to**: The object does not play a fundamental role in the existence of the latter but its presence would contribute to the success of the latter.

**PASSIVE**

- **Is Influenced by**: The object evolution is influenced by the evolution of the other object. This relationship is symmetric to the active one “Impacts on”.

- **Is Enabled by**: The object existence depends on the other component which is fundamental for its functioning. This relationship is symmetric to the active one “Enables”. There may be alternative enablers that is one may be absent provided an alternative one exists.

- **Uses**: The object is using the features and functionality of the latter. It has no influence on the latter, apart from creating market pressure in terms of requirements. The evolution of the object may benefit from the evolution of the latter but not the other way round. Often it is quite the opposite, the evolution of the object “kills” the need to use the latter (and when this is the case a comment should be inserted to point it out).

- **Enhanced by**: using the latter object enhances the object functionality. Such a use is not crucial (as it is the case in the "use" relationship). In a way it is the symmetrical of “Enhances the functionality”. The decision to use one or the other depends on where one wants to put the focus. It does not make sense to duplicate the relationship (i.e. attributing to object A the relationship “enhanced by” object B and attribute to object B the relationship “enhances” object A).

- **Its use/access is eased by**: The object is not fundamentally depending on the evolution of the latter but its presence would contribute to the success of the former.

- **Part of**: The object is a component of the latter.

More relationships may be added as required.

**Relationship strength**

A relationship can be assigned "strength" to define how much it binds the two objects. The weights that have been defined are:

- 1 Very low
- 2 Low
- 3 Medium
- 4 High
- 5 Very High

The strength is useful both to indicate the degree of binding and to express how it is likely to change over the years. As an example the image display functionality “uses" the CRT today as standard, hence we can associate “very high” as strength but by 2008 that use would have been declined significantly, probably to “medium" and by 2020 the grading may be “very low” (possibly nil, in which case there will no longer be a relationship between the two objects. At the same time we can grade the “uses" relationship between the image display and LCD as "low" today and as “high" by 2008 and “medium" by 2020 because there is the expectation that new technologies, such as SEC, NED and OLED will have replaced LCD.
By looking at the set of relationships of an object and their strength we can get information on the evolution and of the market “interplay”. This is, obviously, a very important information for decision makers having to bet their investment money on research in any given area. The meaning of the grading has to be associated to each type of relationship.

For more in depth description of the web tool and of the database underneath, see the Methodology in Appendix to present report.

As final comment, we remind you that your comments, enrichments, validations and critics are the real aim and value of this part of the Fistera project.
8 Conclusions and next year work

The main focus of the work contained in this present report is the building of a methodology for analyzing the evolution of the technologies relevant for the information society. The methodology has to provide both a useful articulation of the variables relevant for the analysis, and a grid easy to fill with all sorts of updates and enrichments.

The parts on which more work and attention was devoted during the first phase of Fistera are the technologies and the Functionalities and most of all the links and relationships between them. Comments on this work and further discussion – already started during the road shows organized in various European countries, and to be continued also via an interaction on the web – will surely lead to an extension of the present set of Functionalities and Technology Trajectories and will be analyzed in the second deliverable planned in Fall 2004.

Next year work will be also devoted to detail the values associated to the relationships between layers, so that resulting in the “what if” analysis. Relationships are a fundamental aspect of the FISTERA WP2 methodology: they provide the key to move from the trees to the forest and get an understanding of the global picture. The aim is the possibility to relate different ambient scenarios to different choices in technology investment and potential evolution.

The work of the coming year will be largely based on cooperation between Work Packages, especially WP4 for the building of the upper part of the four layers, Services and Ambient, with the development of scenarios aimed at capturing the interest of non technical people. Cooperation and synergy is foreseeing both on the content level and on the tools one. The plan is the sharing of the same data base structure and the same visualization tool for the web. WP1 in the second year of the project will provide relevant inputs for the analysis at the country level, and WP3 will support the enlargement of the Fistera community.

The definition of the Service layer and the Ambient layer, and the study of their relationships will also be a task of the coming year of research. Some preliminary guidelines are presented in the following paragraphs.

The last two paragraphs aim at giving a brief glance on the relations between the WP2 work and the ISTAG Workprogram the first and, the second, on the European countries point of view on emerging technologies.

8.1 The Service layer

A service is an offering by some entity (that in general expects to make money out of its provisioning, either directly or indirectly) to some users. A service aggregates a number of functionalities (one or more) packaging them in a way that makes them useful and usable to a specific target. A service is enabled by the availability of technologies providing the required functionalities, can be delivered if it has a sound economic proposition and will be successful if it meets users’ demand and expectations.

The understanding of service evolution is of interest to enterprises (where is the business going?), to infrastructures and platform builders (what are the future demands infrastructures need to meet?) and to their financing partners.

Gauging market demand is a very difficult task. Even more so as we try to look into future market demands in a time range as long as the one addressed by Fistera.

As it has happened so far there will be a mixture of market pull (demand generated by the market) and enterprise push (enterprises trying to offer new proposition to the market). There will be other factors, beyond technological feasibility and economical sustainability that will have a deep impact on the market and on the type of service offering that will evolve in the next 15 years.

Unpredictable events (from terrorist action like September 11, 2001, to natural disaster, to an increase in summer temperature putting a strain on the electrical grid, to the spread of difficult to control viruses…) are likely to affect significantly the market demand and also the willingness to focus research funds in specific domain (like security, prevention, monitoring…). However on the
longer term one may be confident that these events will just accelerate the evolution, although
twisting it through different paths. The compass in the longer term is likely to point in the direction
of more accessibility to services, more wealth unevenly distributed, more potential to stimulate
market growth.
Technology and infrastructures are likely to automate many activities and the idea of a labour-less
society hypothesized by some may have some fundament. However the decrease of demand for
labour forces will not translate in more free time. Quite the opposite. The market offer and the
cultural push of an even more connected Society is likely to have people engaging in more and
more activity.
WP3 and 4 will provide some elements to create a number of potential scenarios for services.
Some indications will also be derived from the assessment of the national forecasting exercise
done by WP1 and by the discussion of the wider community that we hope will find the WP2
methodological framework a suitable base for reasoning about the future.

8.2 Ambient

An ambient is a physical or virtual location having a certain set of characteristics that singles it out
from the rest, where services are exploited by people, machines, physical/virtual objects to the
benefit of the environment itself and of the environment’s inhabitants.
Any ambient is described in terms of its characteristics, its population, the class of owners and
stakeholders and has links to those services that are most likely to be used. The understanding of
ambient evolution is of interest to sociologists and to enterprises (private and public) whose
service/product portfolio targets it.

8.3 Fistera Layers and the Ambient Intelligent vision

As reported in the IST 2003-2004 Workprogramme the focus of IST in the FP6 is around the
“ambient intelligent” concept which aims at bringing together computers and networks into the
everyday environment to allow the user to easily access a multitude of services and applications.
According to the IST Advisory Group (ISTAG) European research companies should be focussing
their effort in order to ease the creation of AmI through the convergence of technologies such as
networking, computing and intelligent interfaces.

In order to help the above mentioned objectives be satisfied, according to, the main areas to
concentrate effort in the next years are:

- Microelectronic components and micro-systems: it is important to monitor and push the
evolution of micro components. The more they can be miniaturised the better they can be
placed everywhere so allowing the development of new pervasive services
- Mobile, wireless, optical and broadband communications infrastructures and computing
technologies: of course those technologies improve greatly the main concept of Ambient
Intelligent; in fact the possibility to reach the users everywhere, in transparent way from
the user perspective, would be a very useful service for the whole community.
- User friendly interfaces: the access to the ICT services is to be easy for everybody even
and especially to the non-ICT people. The creation and access to information through
semantic-based and context aware DBs help to reduce the digital divide and make
information and services to everybody’s hand.

The issues listed above, are deeply analysed within the four layers of the FISTERA projects
considering impacts and results at each different level (ambient, service, functionality and
technology).
A mapping of the FISTERA layers’ items with the ISTAG areas of interest has been started. The
objective of this exercise is twofold: first of all to make sure that the FISTERA layers include all the
elements that could be possibly needed in designing the path towards the AmI environment;
second, once the mapping has been done, an analysis of all the involved parts would suggest

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14 IST 2003-2004 Workprogramme, European Commission
15 ISTAG in FP6: Working Group 1 IST Research Content, Interim Report June 2003
what the areas to be further explored are, so providing suggestions on new projects and studies to develop the uncovered issues. One of the issues already identified as deserving special attention is the integration issue, which will be focused at in the second year of the project and in close cooperation between WP2, WP3 and WP4.

**Smart materials** – Europe is lagging behind on all of them if compared to both USA and Japan. Smart materials are likely to become crucial in several application fields, on top of which the information displays, the trajectory within which the Smart materials are analysed in FISTERA.

**MEMS tech. & sensor tech.** – MEMS evolution is relevant to three FISTERA trajectories: Communications, Data capture and Printing.

**Ubiquitous communication** – All the cluster of technologies which influence the evolution of Communications is considered central to the development of services and tools for the future. The emphasis on mobility and wireless is also quite strong and it is referred to with the term untethered communications. On top, the wearable computers and the tagging are two research directions particularly promising both for the service evolution and for the market extension through new services.

**I/O device tech. & Natural Interaction & Emotional computing** – Within these technologies, FISTERA WP2 has identified several research directions: voice synthesis/recognition, haptic interface, affective computing, agents, avatar - i.e. all the cluster of behaviour technologies. These impact and enable three of the identified functionality technology trajectories: data capturing, human interfacing, information retrieval. In all these fields the software is the dominant area of research, in which Europe needs to increase its current involvement.

**Adaptive software** – Within the large and diversified set of activities which may be grouped under the Software area, WP2 will have to go more in depth analysing all the aspects and in particular those suggested by ISTAG.

**Media mgmt. & handling** – Semantic database supporting the Information retrieval and Storage, the devices supporting the management and selection autonomy of the user represent the areas of research identified. The lion’s role is played by the coding technology MPEG, which impacts on Bandwidth, Information retrieval and Information visual display, plus data capturing.

**Contextual awareness** - The technologies which enable the pin-pointing and the interaction and recognition of objects, such as sensors, tags, and the interaction and recognition of objects in the environment are two research directions identified as critical ones also in the European arena.

### 8.4 Country specific Overview

In the analysis of the technology trajectories timeline, the role and relative position of the main industrialized countries and within them of the leading companies and research labs represent a critical topic for drawing a picture of the strengths and weaknesses for each technology from the geographical point of view. In the second phase of the FISTERA project, a country specific overview of the technology positioning evolution will come out as a result of several concurring actions:

- the analysis of the geographical location and influence of the main actors identified in each of the elements of the four layers database, combined with
- the national foresight analysis conducted by WP1, and enormously enriched by
- the feedback of the dissemination activity of the Road shows and
- the active participation of the large network of members of the project.

In this way, a systematic collection of information and of views of relevant people – academics, policy makers and business managers participating either to the national workshops or via the web to the FISTERA enrichment and validation – will accompany the completion of the analysis by country.
The effort of mapping the positioning of the companies and the research institutes in the technology research areas is a hard one especially because the national boundaries are not so well defined. Most research programs are transnational, as they involve either international institution funds or the cooperation between research labs and universities of different countries. The largest companies are the more active ones in research funding and research activity and most of them are also multinational enterprises. Nevertheless, the perception of accessibility to the research results by the national economic system, and the perception of the opportunity for young researchers to become part of research teams in their national areas represent a source of strength for the societal progress.
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1 Appendix A – The Methodology

In this chapter we describe the methodology used to represent the technology trajectories and their interplay. A tool has been created to support the input of data and their subsequent display on the Web (http://fistera.telecomitalialab.com).

Screenshots of the various input phases using the tool and the resulting display on the browser are used to illustrate the various steps. Hence this chapter can also be used as a manual to use the tool and to understand the representation on the web site. The documentation of the tool is given in Appendix B; this is intended for developers who may need to expand the tools features or to adapt them to different methodologies.

1.1 Layers

Four layers have been defined:
- Technology Layer
- Functionality Layer
- Service Layer
- Ambient Layer

Any information is placed into a specific layer and it is (may be) connected to other information in the same or contiguous layer(s). The figure shows the home page where layers are listed both on the right hand side as “planes” and in the left hand side as “menu” items. Clicking on the layer names leads to the page dealing with that layer. In the following a detailed description of each layer, its objectives and its structure.

1.1.1 Technology Layer

The technology layer contains the set of technologies that have been identified as relevant to the IST. This is an open set in the sense that more technologies may be added in the future. The tools support addition/updating. Those identified till September 15th are listed in this deliverable in chapter 4 explaining for each of them the reason that have led to the selection. The characteristics associated to each technology are detailed on the web site.

Clicking on the technology layer in the home page, the list of technologies that have been considered are displayed, as shown in the picture on the side.

The list can be scrolled by placing the mouse on the up and down arrows. The space on the side is the area where relationships among technologies and among other layers are displayed (see 1.2). The relationships are visualized by clicking on a specific technology. Clicking in the technology box that is drawn in the relationship area opens the page with the information on that particular technology.

1.1.1.1 What is an IST Technology?

It may seem an idle question: it should be quite clear what a technology is. However as one digs into this concept there are several borderline issues that muddle the water.

Let’s take the microchip. Clearly this is a technology. However the evolution of this technology, as depicted in the figure on the side, is strongly dependent on advances in the lithographic process (the shorter the wavelength used the tinier the details that can be etched on the wafer and the more performing the chip); the manufacturing is of paramount importance, both in determining the cost and in the quality/performance and it ties with it a tremendous amount of technologies; the design of the chip involves many more technologies and it is often a limiting factor in the evolution of the chip.
All these are (set of) technologies that influence, and whose evolution will influence, the evolution of the microprocessor. Going into details in each of these “influencing” technologies would create a huge amount of information that may fuzzy the focus on the microprocessor. Hence the decision, in this case, has been to take them “for granted” and to list them in relation to the microchip as enabling technologies indicating in the “challenges” that these will need to evolve in order to support the stated roadmap for microchip.

Clearly the decision is a subjective one and for different cases one may take a different approach. Also, as more information is gathered, the decision may be reversed and some of these technologies may be isolated and included in the technology list in this layer, hence providing the trajectory for each of them.

The choice has advantages and disadvantages:

- Including an enabling technology within the one that is enabled clearly emphasises the dependency of the latter on the former. At the same time it suggests that the evolution of the enabling technology can be taken as a given.
- Separating an enabling technology from the one it enables emphasises the challenges this enabling technology has to meet and implicitly draw attention on the investment decision. Whenever there is a strong feeling that a technology should be considered for serious investment and research program it is better to isolate it. At the same time its isolation requires the establishment of a specific link with the enabled technology and care should be taken in the synchronisation point (those that need to be achieved in order for the enabled technology to progress).

The evolution of some technology would be moot if there would not be a parallel evolution of other technologies, that, for this reason, we call exploitation technologies. In the case of the microprocessor technologies involved in the packaging and in the assembling are typical exploitation technology.

Again, here we have to decide if we want to include these technologies as stand alone (with appropriate links to the one they are making possible the exploitation) or if we just shroud them under the “main” technology.

In the case of the microprocessor this has been the choice. If these technologies are subject to an evolution that is not a simple adaptation to accommodate the evolution of the main one it is acceptable to disregard them completely. However if there is some significant roadblock ahead that might impede their evolution and therefore the exploitation of the main technology then this potential roadblock should be included in the main technology “challenges”.

In some cases exploitation technology can be considered as enabling technology for other technology or for a functionality. As an example one might consider the assembling technology not as an exploitation technology for the microchip but as an enabling technology for a cell phone or a PDA….since it is at that point that one has to assemble the microchip on a board....

As a general guideline we feel that as long as the technology evolution is uniform independently of the further use in the value chain and its evolution is a direct consequence of the main technology demands it is better to call it an exploitation technology and tie it to the main one. This has been the case for the microchip and the packaging and assembling. A different approach may be chosen, as an example, for tags, where the assembling is more related to the area of application than to the tag technology itself and such assembling impacts the functionality performance (cost and functions).

A further point, related to the identification of the technology and its evolution, is the metrics for measuring the evolution. In the microprocessor example one may elect clock speed as the leading characteristics, or the capacity to perform parallel processing of data and computation (hyperthreading) …We will come back to this point in a short while. So far we have discussed the identification of a technology with respect to others that form along with it a tied set.

Let’s look at this other example.
Quantum Communications is a very interesting technology for its promises to approach the communications in a significantly different way. On one hand it holds the promise to provide a very high parallel communications (thus theoretically expand the bandwidth beyond dreams), on the other hand it seems that any tampering would be impossible (to go unnoticed). Secure communications, hence, is its inherent characteristics. At the same time quantum communications promises new computing paradigms and may prove disruptive for the public key cryptography (since it would provide a means to factorise any number, thus breaking the code used in PKC).

Having said that we should also recognise that unless significant progress is made in a number of enabling technologies quantum communication will remain a theoretical dream. One of the technology that is needed is a theoretical understanding of the quantum field. The present understanding through the Maxwell equations is not satisfactory since they provide a statistical view, and when one is dealing with a single photon the statistics is not useful. If there is little doubt that quantum communications will become part of the IST it is much more debatable if studies on the Maxwell equations are part of IST. It is very likely that unless these are put into a specific perspective most people would say they are not.

Enabling Factors

For the sake of this work a decision has been taken to place these basic technologies outside of the IST (calling them enabling factors). However we are noting when discussing Quantum Communications that evolution coming from outside of the IST area are essential.

Also, as in this case, when there is no consensus on when an enabling factor would become available we have not created any roadmap, rather we have placed the technology in the area of “keep an eye on”. We recognise its potential importance but information is not sufficient to make any prediction.

Possibly, decision makers in the IST area should relate to other research areas within and outside of Europe to establish links that would ensure the activation of work in this field as new information on the enabling factors become available.

1.1.1.2 Describing a technology

We have seen how difficult it may be to identify and select a technology. It is also difficult to “describe” it. A description should serve a purpose, in our case it should convey a meaning and facilitate the understanding to an expected target audience that may not have a technical background.

First a condensed description is provided to let the viewer understand what a (technology) name is about. By placing the mouse on an item in the list of technology a pop up with a yellow background is displayed with a brief text that should be sufficient to understand what it is meant.

This short definition has been provided by the FISTERA team and does not necessarily reflect an (internationally) agreed one. By clicking on the name a box is shown in the relationship area (along with a number of lines connecting it to other boxes, as it will be explained in 1.2). Clicking on this box brings up the information characterising that technology as shown in the picture at the side.

The first information provided is a description of the technology, i.e. “What is it?”. This description is given in plain terms to help people with no specific technical background to understand the feature of that technology, how it can be used, what are the strength and weaknesses.

This description is normally supplemented by a pointer to some places on the web where a more in depth (technical) explanation can be found.

Associated with the description it is possible to include pictures, graphs and in principle whatever file is of interest.

To input the description an appropriate field is provided by the tool created for the FISTERA WP2 data base. Similarly a field is provided to associate pictures and other documents to the description.

The use of the tool is described in detail in Annex E. Here we provide a basic overview so that the screenshots used to describe the methodology can be understood.
1.1.1.3 Using the tool to input data

The input tool is a customisation of the form filling tool “Access” by Microsoft. Upon opening the data base the screen presents the list of elements contained in the data base, Section A, as shown in the picture. Each element is identified within the data base with a unique number (first column in the list). The name of the element is the text that will appear in the list of technologies (or functionalities…) in the layer “home page” and in the box drawn in the relationship space. When the square preceding the identification is clicked a triangle appears to indicate that the record has been selected. If one writes down in any of the fields the triangle changes into a pencil to indicate that updates mode is on. To finalise the update one needs to click on the pencil, the triangle will be shown and the data base updated.

Following the name field is a square to indicate if the record is an actual technology or it is just a way to identify a group of technologies. This is useful from the representation point of view to avoid excessive cluttering of the screen.

The next field is the indication of the layer (tech, funct, serv, ambient). Following this is a set of three numbers indicating the value of that item in the present year, by 2008 and by 2020. More on this in the following parts.

The field above the records contains the brief description of the items, the one that appears in the yellow box when the mouse lingers on an item in the list.

By clicking on the create/modify button the complete form related to that particular item is shown in a separate window. Each of the field will be discussed in the next subchapter.

If one wants to create a new item it is sufficient to click onto any one and once the new window is open click onto Add New as shown in the figure.

The other button contained in the Section A, Connections, brings up another window where it is possible to indicate all the relationship existing from this object to any other object in the data base.

Connections meaning and rules will be explained in 1.2.

1.1.1.4 Evolution in the life cycle

A technology moves through various stages in its evolution and in its relation with the market. The three fields on the top right of the form are used to indicate at what stage the technology is presently and in what stage it will likely be in 2008 and 2020. The stages identified are:

0 = Theory stage
1 = Lab demonstration
2 = Released to market
Not necessarily all technologies enters in stage 0 and inevitably progress to stage 5. It is important to characterise the stage a given technology is in to understand both the implication over time and the where to focus the effort to exploit it (or to move it to a next stage). Not necessarily moving to a next step is advantageous for everybody. As an example moving from 4 to 5 may be good for the end users but it may shrink revenues to manufacturers.

A technology is in the **theory stage** when there have been theoretical results certified by peer to peer review that are not just outlining a possibility but also indicating the path to implement it. A technology is still at a theory stage when some of its fundamental pieces are missing. Quantum computing, as an example, can be considered in this stage although some lab demonstration of operation with few Qbits have been made. A technology is in **Lab demonstration** stage when a full working prototype has been demonstrated. The demonstration may have been achieved through specifically developed components and, more importantly, an industrial development production has not jet been devised (or it is not in place). A technology is in **Release to market** stage when the production process has been set up. It may of course need refinement and it may not be suited yet to scale.

A technology is in the **Applied in niches, high cost** stage when the market segment currently using it, or potentially using it, find a specific high value in the technology, is willing to bear high cost and even unstable performance, is prepared to afford training cost for learning the technology. In general the market addressed is the one of professionals or of geeks. A technology may never leave this stage (e.g. radiographic equipment), or may move to the next stage or even skip the next to land on the last one, embedded in other products. In order to move to the next stage it is not sufficient to have a decrease in price. Other factors play significant roles, such as the scalability of the production and delivery processes, the usability, the culture (fashion...).

A technology is in the **Widespread** stage when the relation between the producers and the end users follows the well established rules of the mass market. A basical independence between user and producer, focus on the product and its feature rather than on the process, basically no adaptation on the user side to make use of the product...Marketing factors are playing a significant role in the success of the technology (product) and the product has a distinctive appeal and is recognised as a stand alone one (e.g. an LCD television).

A technology is in the **Commodity, Embedded** stage when it basically disappears from the focus of the users who may still be interested in having it but as an enhancing feature of a product that is acquired independently of the technology. Advanced screen technology in cellphones and PDA may play a role in the selection of a product over a competing one but it is not the reason why a person buys a cell phone. At the same time anyone buying a cell phone takes for granted that it will have some sort of a screen to present information. Screen technology in cell phone is definitely in stage 5. On the contrary LCD screen technology in computer screen is in stage 4 whilst it was in stage 3 just 3 years ago.

### 1.1.1.5 Performances

It is clearly important to provide information on the performance evolution of a technology since this evolution is likely to play a significant role in what that technology may be used for, in the acceptance of the market and therefore in the impact it will have in the coming years. Understanding the performance trends and how these are likely to progress also provides significant insight on the focus of investment and its effectiveness in terms of impact. As an example if investing in speed evolution for microchip is not increasing the desired performances as a whole (because the currently delivered speed is meeting present and future market request) there is no point in driving for speed. Therefore the most important issue is to understand what performance means for a given technology and how that meaning is going to change over time.

Let's take again as an example the microprocessor. The basic measure of performance in the last 30 years has been the speed (or number of instructions per second). Technologically that meant to look at the clock speed (which progressed in 35 years from 4 MHz to 3 GHz, a 1000 fold increase).
into account other factors leading to the perception of an increased speed, such as the on chip memory, the architecture of the processing (hyperthreading), the bus speed, the specific instruction set to manipulate records or graphic polygons...

More recently the speed factor is becoming less and less important and the expectation is that by the end of this decade it will be a thing of the past. At stage 4 (and obviously at stage 5) speed is no longer to be a distinguishing factor.

In the following decade speed will continue to grow but those applications still interested in speed will no longer look at microprocessors for meeting their needs but rather at distributed architectures like the GRID or custom solutions.

An emerging metric for microprocessors is the power consumption, particularly for laptop and devices on the go. This metric is likely to play a significant role in the coming 10 years. Beyond that, a radical solution to power energy (e.g. through fuel cells or smart materials with a porous nanostructure able to store much greater quantity of energy) can lead to a diminished importance of this metrics.

These examples show how important it is to understand and speculate on the performance aspect of a technology, even before addressing its potential evolution.

In most cases looking at the past performance evolution and for “old technologies” at the change of importance in the performance factors, can provide significant information on the future evolution. Obviously some disruptive innovation may invalidate the assumption of the extrapolation of the past into the future but in 90% of the cases this approach can provide a good forecast.

The forecast can often be based on studies and monitoring within a specific industry, such is the case for the evolution of the semiconductor industry. In other situations it may be inferred from the evolution and roadmapping in “parallel” industries taking into account differences. As an example the evolution of tags can be forecasted from the expected evolution of semiconductors (weighted as a minor contributor), the evolution of packaging (weighted as most important) and the evolution of plastic transistors and smart material (low weight in the next 5 years, medium-high weight in the following decade).

When providing the forecast it is important to state what are the assumptions and how it has been derived. For the purpose of FISTERA, and WP2, it is more important to identify the factors of evolution than forecasting what is going to happen. The point of the exercise, in fact, is to invalidate current forecast by focusing investment to “change” the future.

1.1.1.6 Challenges

The evolution of performance is sketched based on a number of assumptions, involving technical feasibility, parallel evolution and availability of other technologies, a continuity in the investment in research, a market interest in the areas enabled by the technology, the absence or minimal influence form other technologies that may displace the one under consideration...

Additionally, there may be some hurdles lying ahead that one can see but for which there is no off the shelf solution. There is, however, a strong feeling, and consensus, that ways will be found to solve or circumvent the problem. In this sense the need to drastically reduce heat production on the way to increase density in chips is a hurdle and we do not know yet which way to tackle it. But we have a strong conviction that a way will be found. On the contrary the stability of atoms needed to create quantum computers and increase to at least 15 the number of Qbits available is not a hurdle but an unsolved issue that may or may not be solved in the near-distant future.

All of these “ifs and buts” need to be noted down, not to take distance from predictions rather to help in understanding what needs to happen and what needs not to happen and act accordingly to favour it.

This is what needs to be done in the challenges part. A good understanding of challenges will help decision makers in steering research investment, since it is from the addressing of the challenges that evolution will progress. If there are no challenges there is basically no need to invest in research.

Clearly, challenges alone, are not enough to take any decision. One might see a challenge ahead but at the same time there is research work going on in other areas that will result in the solution to the challenge, therefore no action is required.

Addressing a challenge with a research program, on the other hand, may be valuable in itself since it may lead to progress in unrelated areas.
Although this analyses of challenges is not being done as part of WP2 it may be worth doing it based on the information harvested by FISTERA. The methodology defined supports this kind of analyses. The area of supplementary information (pictures, graphs) can be used to indicate timing relationships between challenges and performance, indicating, as an example, up to what point performances may increase until a challenge has to be faced.

1.1.1.7 Costs

Cost is an important factor to consider when observing and charting the evolution of a technology. Statistical considerations deriving from the observation of the past can lead to accurate prediction of the cost trend in the coming years. The more we look into the future the more cost predictions may be uncertain. Technology cost, as it is used in this methodology, relates to the production and availability of the technology at the point of use (as a product or as a component to be integrated into a product). It does not take into consideration the “price” on the market. This varies according to different factors, the cost being just one of them.

Production and availability cost can be calculated as a function of the aggregate cost of the pieces entering into the process, from raw material to production tools….

There are several methods to estimate the cost trends over a certain number of years; they may vary from technology to technology but they are pretty accurate as long as the trend is linear. In FISTERA there has been no attempt in calculating those cost trends for each technology considered. They have been taken from the literature. In a way the determination of the “exact” cost is not a main issue, for the purpose of FISTERA. What is more important is to understand what is making a cost trend evolving in a certain way. The reason is that by understanding it one can stimulate research - and market- in such a way to minimize those factors leading to an increasing cost and maximize those that drive cost down.

In this area the evolution of cost over the last few years should be provided to understand the general trend (usually on a descending slope). Then identification of the factors that are conditioning the trend should be given.

In particular it must be clarified if the cost is:

- Volume related: when up front cost are high (such as developing a new production plant for a new leap in lithographic shrinking) and production cost is low increasing the volume shares the upfront cost thus reducing the cost per item. This is normally the situation in the semiconductor industry. Research should keep this in mind and work to expand the market. Flexibility and scalability are key factors fostering the reuse and thus the increase of volume. At the same time decision makers should evaluate if effort in that area can be sustained by a sufficient market size. Probably there is not too much space for many Intel around the world. Work on specific chips may be hopeless. Work on flexible, software programmable chip may be promising from strategic point of view.

- Process related: the process through which the object is created may have some intrinsic limitation that significantly concur to the trend of cost. As an example the faulty devices in the production of LCD screens or light sensors (for digital camera) play a significant role in their final cost. As the size grows (today over 15” for a LCD screen, 1” for a digital camera sensor) the number of faulty pieces that have to be discarded grows exponentially with a strong impact on cost. This is the reason why 42” LCD screen are so expensive. Research should focus on the production process to increase its effectiveness.

- Packaging related: a significant portion of the cost may be related to packaging the technology in such a way that it can be used. Research stimulating integration at the production level, SoC, chip flexibility, to name but a few, may greatly contribute to address this issue. Since packaging has historically had a very low decreasing cost trend competitive advantage in objects derives from the integration of as many functions as possible on the single chip. Cell phones have been so extraordinarily effective and kept increasing their functionality at a decreasing price because companies have found ways to integrate everything (or almost everything) onto a chip. This integration requires stable interfaces and sound standards (one of the issue with UMTS) and simulator tools that can solve any problem before the integration takes place into a single chip. This integration phase, in fact, is tremendously expensive and an error would be paid dearly by the company making it. Understandable, then, the cautions approach of the big companies in deploying
innovation, when this requires integrating on a chip everything. This is a major competitive issue since those companies who dare most, and get it right, buy themselves an important leading edge. Whenever the cost is strongly affected by packaging research efforts should be focused on the simulation aspects, fast prototyping. Software driven chip may, as well, play an important role in this area.

1.1.1.8 Application areas

The information on the application areas is intended to provide support for guessing the potential volume of that technology and hence derive information on trends. It is also a way to emphasize the importance of a certain technology from a social viewpoint. These application areas are bottom up view and may not find a correspondence in the top down view derived from the ambient-service-functionality view. Discrepancies may be used by decision makers to promote usage of a certain technology in newer domain. Conversely the gap should make researchers reflect on why a potential field of application enabled by the technology is not using it. Gaps tend to outline alternatives and a study on the forces favouring one technology vs another in a given area is very interesting for decision makers.

The methodology then requires that in this information field the view taken is the one of the “technologist” who in principle should be more emphatic and optimistic in broadening the opportunity of applications.

1.1.1.9 Main Actors

In this field main actors in the evolution of the technology should be listed. These are the ones that today are investing money, are recognised as the leading edge in the evolution of the technology. It comprises both private companies and institutions government and for each one information should be provided on the role it is playing (e.g. stimulating a general growth in know how – likely for public organisations; pursuing a competitive advantage through patenting – likely for a private company; fostering convergence on a standard – likely for consortia).

The listing of present main actors is also of interest since it is providing further reference on the research endeavour and on the ways this is carried out. It should also include those actors that are likely to become main players in the coming years as result of their own strategy or as a consequence of their country’s policy in the area.

Listing the main actors that will play a major role in the future does not need to be interpreted as an immutable fate. On the contrary European policies may focus on altering this situation and research program to stimulate competition in certain area may have this as objective. Ensuring that by 2008, or later, Europe can take the upper hand in certain sectors that are considered strategic.

1.1.1.10 News Monitoring

There are several sources of information that FISTERA is considering. However they are seen at a certain time and “frozen” in order to allow for a comparison and identification of technology trajectories. Clearly the evolution is “all in the future” and as such people reading the FISTERA results may be confronted with “oldies” in a very short time, given the fast pace of evolution. This is why the News Monitoring field has been inserted to provide links to places that independently of the work being done in FISTERA are following the evolution of a specific technology. In many cases it is possible to subscribe to the information so tha updates can be received as they become available.

By inserting this link we intend on one hand to provide a service to user of FISTERA and on the other hand to let further studies to benefit from up-to-date information.
1.1.1.11 IST Relations

The tremendous effort going on at the European level should be considered in all analyses of FISTERA and in relating these results to the ongoing activities. This is why the methodology requires filling in of information of programs and projects part of the IST that are connected (even loosely) in the technology being examined.

At the end of the FISTERA project the intention is to provide tools usable by any European project to update the view on activities in any specific field, providing further information for considering what new research should be founded.

1.1.1.12 Country projects

In addition to European programs and policies individual countries, in Europe and outside Europe, have their own research program. Information on this programs, their objectives, efforts and timelines is an important material for a better understanding of the technology evolution scenario.

Information is derived from the work of FISTERA WP1 and includes in addition to the European countries main activities in the USA and Japan.

1.1.1.13 Geography

Information on Country programs and projects is summarized and integrated with a view on the positioning of some leading Countries (leading with respect to this technology) that takes into account their production capacity, the market available to absorb innovation locally...as it today, as it may be by 2008 and by 2020 assuming the condition we are seeing today in terms of policy and research efforts remain unchanged.

This information may be quite useful for assessing strategy at European level and also, in perspective, to play what if simulation to study the impact of focusing resources in certain areas.

To include this kind of information one should click on the Geography button at the top right of the form and the form shown at the side will pop up. In the first column one should select the name of the country (pull down menu), in the second one the year the estimate refers to (selected by a pull down window) and in the third the grading.

The following grading is available:

0 = Not interested in the area
1 = At the window. No action is being taken nor considered but the topic is kept under scrutiny and situation may change in the coming years.
2 = Applying. The technology is being used as is, it is acquired by other countries and there is no effort on being autonomous in the area.
3 = Researching. The country is investing in research at various levels (university, country programs, industry).
4 = Leading the pack. The set of researches and the structures of the endeavour makes the country a main player in the area and one that is likely to reap most benefit from its exploitation.
5 = Out of reach. The present state of achievement in the area plus the amount and quality of the research effort and the industrial fabric for result exploitation makes the country out of range for followers. It is very difficult to pursue the follow and catch game in this case. Alternative strategies,
such as pursuing different technologies that may disrupt the present one are probably a better way to wage one’s investment.

Note: the information on relationship among technologies and between these and the functionalities are explained in 1.2.

To insert a new country in the list one should click on the Geography button in the opening screen and add the country name to the list of countries as shown in the screenshot below.

1.1.2 Functionality Layer

The functionality layer contains the set of functionalities that have been identified as a means to capture the features of technologies meeting specific needs. As an example, broadband is a functionality, the possibility to obtain large amount of information. In order to deliver functionality one or several technologies need to be exploited. In the case of broadband it may be through ADSL, VDSL, Optical Fibre, 3G connectivity. It is exactly the variety of possible alternatives that make functionality an essential step in the “where to invest” decision process. Furthermore the existence of alternative technologies, each one with a certain evolution trajectory, requires a global view to decide when research investment is appropriate and till when it makes sense. Investing in display technology may be important since there is a high request for a display functionality. Investing on CRT, LCD, SED, NED…is a decision that needs to take into consideration the respective technology trajectories mapping them onto the trajectory of the functionality, that is what and when it is needed.

The list of functionality identified is given in part 4.2, and on the FISTERA web site.

1.1.2.1 Describing functionality

Some of the considerations made for technologies apply to functionalities as well. Is broadband a Service, a Functionality or a Technology? There is a thin line separating one from the other, and this has been emphasised on the representation by the fading hues connecting one layer with the next (functionality is located just above the technology in the azure area).

A functionality defines some features that are of interest, such as transporting, visualizing, capturing, processing information. Technologies are “hard tools” to provide a feature, services are ways to offer features in exchange for money (or other valuable) and are characterised by the relation of someone willing to offer the service (and sustain cost in order to be able to offer it) and someone willing to use it (and pay for it). Functionals are somewhere in between. They represent needs and as needs their evolution is somewhat slow. On the contrary technologies may have a rapid or slow pace of evolution and services usually have a brief life span (with the exception of those addressing basic needs, such as POTS, Plain Old Telephone Services).

As done with technologies any functionality is described with a few words (Glossary) as an help to understand the name given.

The actual description can be seen by clicking on the functionality box in the relationship space.

The description of a functionality, then, should emphasise what is required and to a certain extent “why” it is required and who may require it. Actually it is the mixture of these three aspects, what-why-who, that singles
out the type of features needed and the perceived “quality”. Broadband on the network side, where it is the
expression of a technology providing data at high speed, can be measured in bit per seconds, with the
thresholds somewhere between 100 to 500 kbps (depending on how much “strain” is put on the technology:
if you are using cellular communications technicians would classify 100 kbps as broadband, if on the
contrary you are dealing with fixed line technicians are likely to require at least 300 kbps to call that
broadband). Broadband on the human user side is classified as the feeling to get rapidly, within few seconds
(less than 3-5) images and text and possibly video. Users do not measure broadband in kbps, they measure
it in perceived delay (if it is perceived it is not broadband).
As the mix of what-why-who changes so change the demand on the features required to a technology (or
their mix).

1.1.2.2 Evolution in the life cycle

A functionality moves (although at a slow pace, usually) through various stages in evolution with respect to
the market demand (and technology available).

The stages identified are:
0 = Not available
1 = Experimental
2 = Niche application
3 = Broad Market
4 = Commodity
5 = Embedded

The stage is marked in the upper right corner of the form, one for each of the year taken as reference. This
information is shown in the functionality box displayed in the relationship area as a number in brackets after
the name as shown in the screenshot on the side where the functionality Data Capture is considered to be in
stage 3 (Broad Market). The representation of the connections to the technologies (lower part of the
screenshot) is explained in 1.2.

1.1.2.3 Performances

Assessing and predicting the performances of functionality require, as
for the technology, the identification of a metrics. Explanation
of what is important from the user side leads to the identification of parameters and for each of them a quantitative or qualitative metrics should be
defined.

Based on this metrics one can assess current performances and future ones. In assessing the future ones
one should try to analyse the importance of one factors versus the others as time goes by. As an example
for 3D imaging cost, usability of the capturing device, resolution, size of the rendered image are identified as
factors one can measure the performance on. Today the main factor is cost. Evolution should diminish the
importance of this factor hence emphasising other aspects like resolution and ease of use for the capturing
device. Each of these factors, additionally, has a different “weight” depending on the service where the
functionality is used.

Since functionality is made possible by the exploitation of a (mix of) technology and there are normally alternatives it is
important to make association between a performance trend and the underlying technology trend.
From this understanding it is possible to reason on the relative importance (drive and adoption likelihood) of
technologies. If detailed resolution is of key importance in delivering a certain service the 3D imaging functionality is
likely to be using the technology that at that particular time provides most resolution...
In a way, then, it is service that guides the evolution of functionality, although this evolution is made possible by the technology.
1.1.2.4 **Challenges**

How can functionality be used effectively? This is the basic question to answer in the Challenges area. As an example, in the case of 3D imaging challenges may be providing the ability to create larger images, interacting with the displayed image, creating moving images. Responding to these challenges may require more than a simple evolution of technologies. It may require new approaches, a different mix of technologies. For functionality challenges derive from market expectation and its understanding can provide elements to steer research in a certain direction. As an example, holographic imaging severely limits the size of the image produced because of the need to keep light “coherent” over the full span of the image. Pushing hard on the evolution of holography (to get better colour or/and resolution) would not be adequate if the drive from the market is towards bigger images since standard holography cannot deliver. Better to invest in research on different technologies.

1.1.2.5 **Costs**

The point to clarify on cost is mostly about the expectation of cost change to deliver a certain functionality. This may be difficult to estimate so possibly one could indicate the range of cost expected and the alternative options. As an example in 3D imaging there is an expectation of decreasing cost on the visualization part but marginal decrease in the production part. This may significantly restrict the production volume and 2D can remain the main form of visualization for a long time.

1.1.2.6 **Application areas**

The application areas should provide clues on the impact at the upper layer and therefore help in assessing the market potential. In 3D, as an example, the potential applications are in niche markets, like medical diagnostics and in mass market like gaming. By crossing this potential application areas with the challenges and costs one can infer what flavour of functionality is more likely to take hold and using what type of technology. The high cost of 3D production is unlikely to favour 3D gaming environment set up by gamers themselves but it may lead gamers to play in 3D environment produced by some major player given the cost of 3D imaging “reproduction” on the decrease. In the case of medical diagnostics, on the contrary, the high value of 3D imaging may push towards data capturing equipment embedding 3D capture capability since the cost factor is not playing a major role. However the adoption of this kind of data capturing in medical equipment will do very little to improve the adoption in gaming since the technologies at the core of the two will be significantly different so it the former is unlikely to play a leading role on the latter. A research program in this area should either focus on the reproduction part or look into ways to create a technology whose cost can be strongly volume dependent so that after its niche application (as an example in the medical diagnoses) it can be exported at high volumelow cost in the mass market.

1.1.3 **Service Layer**

The service layer contains the set of services that have been identified. First of all let’s note that it will be impossible to “name” specific services that will be available next year, forget about those that will be available in ten years time. The services are representative of classes of potential offerings aiming at identifying who is interested in providing a certain (class of) service (and to what market segment). Information should be given on
the actors (and their potential evolution over the time frame considered);
the market segment (size – quality in terms of expenditure capacity) as it is now and how it is likely to evolve.
From decision makers at the European Community information on who is expected to derive a direct
commercial benefit from offering a service is important since it is a factor in deciding to support research with
public money or rather let private companies to invest their own money, with the EU working to provide the
environment to make such investment productive.
The offering of a service bundles, in general, a number of functionalities in an
attractive package. The “attractive” has two faces: the offer and the demand side. At the
service layer the focus is mostly on the offer side, although the estimate of the market
size involves an understanding of the demand side as well. The offer side has to
take into account the cost of the components, of the packaging, of the delivery and of the operation
(customer care, upkeeping, maintenance). These various aspects cannot be addressed into details, nor it
would be possible to do that for a 2008/2020 scenario. The qualitative factors that influence those aspects
are however important because they provide more ground on the evolution assumptions being made.
The functionality bundling into a service can be expressed into a set of relationship. Technology has been a
strong enabler for bundling functionalities in a single product/service. The marketing drive may often push in
the direction of bundling several functionalities to have a better market proposition. This is not necessarily
what the users need (although it may be what they have the perception of “wanting”). The evolution of
production may drive the evolution in an opposite direction: that of product and services with a much more
limited set of functionalities. This can also be the drive of the market where producer will tend to differentate
their offering hence proposing specific products rather then omni-comprehensive ones. The interplay of
functionality and service is expressed in terms of relations and the purpose of these is to connect what
technology makes possible to what the market makes sensible (and pursuable in sustainable terms). This is
described in 1.2.
This layer is not the focus of WP2 and will not be filled in in this first deliverable. However it is very important
from a methodological point of view and it is included as an open container that will be progressively
populated by other FISTERA WPs and through interactions with users of the results provided by FISTERA.

1.1.3.1 Describing a service

For the purpose of FISTERA, services should be described in a way to identify an area where there may be
enterprises (individuals) willing to offer functionality (bundle of) and a potential market willing to pay for it (in
a variety of ways, hence including the case of indirect revenue generation and service cost sustained by a
party different from the user, as it may be the case for social services that are paid for by the community).
The relationship between provider and user is the fundamental one. In order to make it working in the real
world a relation should also exist between the cost of providing a service and those providing remuneration
for that cost. It is not the purpose of FISTERA, nor it is supported by the methodology, the development of
business plan.

1.1.3.2 Evolution in the life cycle

A given service, with few exceptions, moves quickly, from
the conception to the activation and after a while fades
away leaving the market space to a new one. This will be a
general trend for most services in the future: they will evolve
rapidly to capture customers’ attentions and revamp
business. However a class of service is likely to have longer
life span and may evolve differently in different areas,
because of local culture, economics…
This information is important, to understand the volume of
business and its time span. Business volume and time span
(window of opportunity) are important to evaluate research opportunity and likelihood of companies picking
up the tab (and conversely the need for the EU to invest and stimulate the market). When a service class is
estimated to become mass market only in a certain country reason should be given to support and explain
the estimate. This is important because actions may be taken to change the situation and make the service
successful in broader environment (if so desired). As an example, recognising that gaming on line is a mass market in South Korea but it is not likely to become ubiquitous is probably not an issue from a European standpoint (companies selling games or providing connection services may think differently but it will be up to them to invest money to change the situation).

On the contrary, recognising that in the USA e-learning is growing significantly and may become a mass market by 2008 whilst in Europe this is not so may be an issue the European Community wants to take actions to modify the current trend, providing policy in school education, investing in research in areas like knowledge management, process management, education…fostering on the job training….and so on.

The stages identified are:

0 = Non existing
1 = Trial
2 = Niche Market
3 = Widespread
4 = Mass Market in selected countries
5 = Mass Market ubiquitous

As for technologies, functionality and ambient the stage is marked in the upper right corner of the form, one for each of the year taken as reference. This information is shown in the service box displayed in the relationship area as a number in brackets after the name.

1.1.3.3 Performances

The performance of a (class of) service should define the metrics and its evolution and then the estimated trend with snapshot at 2008 and 2020, also providing figure on the present situation.

The evaluation on the change of metrics in the service area is quite important, possibly the most important information that can be provided since it identifies a consumer trend and the evolution of the perception of what is important.

As an example, Storage-on-demand presently has “capacity” as an important performance factor, by 2008 the reliability may be the leading factor, since the continuous increase in capacity and decrease in price may diminish the importance of capacity as motivation to get storage-on-demand services. In the longer term other factors such as durability of information, correlation, packaging may take the upper hand. Each of this evolution “in the market” leads to different requirements on technology and possibly to different players winning the market.

1.1.3.4 Challenges

For services the challenges comes from the market and goes under the name of ROI, window of opportunity, competition among providers, mainstreaming and network effect, value chain, issues fostering/hampering diffusion (the S curve), usability, concerns (social/ethical/cultural), competition on money and competition on time.

The ROI, Revenue over investment, is obviously difficult to estimate and is dependent on a variety of factors. What is important is to provide a feeling of the ratio between cost in providing (creating/delivering/operating) a service and the market availability to pay for it (how much, over what period of time).

Technology evolution (in terms of cost to support functionality) is an important beacon to consider and the relationship established with the lower layers should help in providing information. At the service layer in the challenge it is important to outline what are the crucial factors for making a success on the market and the extent to which technology is an enabler (in many cases technology has very little to do with success on the market and there are several examples of better technologies failing against lesser ones because of the importance of other factors).

The window of opportunity is important in the context of fast evolving technologies with several potential alternatives. The time span to exploit anyone of these tends to shrink. It is important to provide information from a service point of view on what expectations there are on the acceptance of a given technology from the market viewpoint (e.g. for how long time a communication technology may hope to be the only one on the market to satisfy a given market demand?).
Competition among providers is another factor that is significant when making decisions on where to invest. As a rule of thumb, the more competition exists in a given area, the more likely it is that inner forces can guide the evolution without any need from the outside. On the other hand, any technology that shows little promise to bring significant money from the market in a short time is unlikely to find sponsors in the private industry and some prodding may be beneficial. A service may have mainstreaming characteristics, in the sense that it is important to acquire from the very beginning many customers since the value of the service, for any single customers, derives from the presence of the other customers (the so-called network effect). Examples abound, like the fax (useless unless there are other people having fax machines), videotelephony (requiring my correspondents to have a videophone...). The slow uptake of a service resulting from a lack of mainstreaming may kill the service (other services, other technologies will displace the currently unsuccessful one). The identification of mainstreaming characteristics in a service (class) is important in guiding the investment strategy.

A service is always part of a value chain, including at least the provider and the consumer. However, some services may displace existing value chains, disrupting the market. E-commerce is a typical example. Providing information on the evolution of the value chains is therefore important to gauge the challenges in front of the service and its potential larger impact on the market structure.

Issues fostering/hampering diffusion are important beyond the service itself. In particular, for the goal of FISTERA these issues should be outlined to better understand what technology should deliver and hence where research money should be spent best. These issues include Usability (particularly for mass market services) and they may need focused research efforts on interface, terminal, cognitive areas. Sometimes a service may generate concerns, such as the case for identification services where privacy immediately becomes an issue.

Any service is competing on the money a customer has available. Money is not infinite and whenever a decision is made to spend money on something an implicit decision is taken not to spend money on something else. It is very important to understand where a given service is going to compete for money, both to estimate the availability (quantity) and to gauge what other service in that environment will suffer. Over short span of time money only flows among services within the same environment (you buy a dress from a company you buy less from another one) but over longer time span environment capacity tend to be displaced (people spend more money on entertainment today than they used to do 30 years ago...). These kinds of considerations are important in understanding service dynamics and the implications on technology.

A different sort of competition, competition on time, has even more binding rules. We only have 24 hours a day to play with: any service is likely to need (and consume) our time and this is against the time we are currently dedicating to other things. Understanding how much time a certain service is going to chew (or in some cases to free for us!) is very important to gauge the potential appeal, use and the type of technology that best fit the service. Technologies supporting mobility, as an example, tend to free time (they use an otherwise wasted time and free time we would have need to spend later).

1.1.3.5 Costs

In services with cost we actually mean “price”. Although it would be foolish to attempt a cost definition for services that do not even exist it may be interesting to provide information, speculation, on cost models and how these may evolve over time. Possible cost model to consider include:

- pay per use
- flat subscription rate
- subsidised
- bundled

The evolution of the pricing model provides information on the type of use and therefore also on technology requirements.

1.1.3.6 Application areas

The application areas should outline “where is the market” possibly quantifying it and providing an estimate of its evolution over time. Secondly it should provide indication on the business relation with the market: are
direct business models leading the producer customer relationship (the customers pay the producer, or retailer directly) or there are indirect business model (as is the case for many services provided by government, municipalities…that are not directly paid for by the customer).

This information helps in understanding who are the stakeholders and the shareholders and therefore who as a directed vested interest in providing a service (and hence potentially to bear research cost).

1.1.3.7 Main Actors

Information should be provided on who is likely to offer the service, a private company, a public one, an institution, the government. This helps identifying possible shareholders and suggests entities to be involved in the trial of a research program.

1.1.3.8 Geography

Information on market size in different countries and the expected evolution.

The information is based on current situation with projection deriving from single country forecast analysed by WP1, WP3 and WP4 plus discussion during the road shows. They are not available at the time this deliverable is printed and will form part of the information of next year deliverable.

The following grading is available:

0 = No market foreseen (no present market) for this class of services
1 = Niche market. Adoption of services in specific business oriented areas.
2 = Well to do market. Services used by affluent people.
3 = Widespread. Service adoption is widespread across different social classes, possibly with different reason. However the service is not widely adopted (less than 20% of the target market)
4 = Pervasive. Service adoption has reached or is about to reach maturity with over 50% of the target population using it.
5 = Commodity. Service is no longer seen as a competitive advantage by providers and it is no longer perceived as something to look for by users since they take it for granted (like tap water in the house).

1.1.4 Ambient Layer

The ambient layer describes the evolving environment of everyday life in its various aspects.

An ambient is important since it provides an understanding on how our life may change as result of policies, investment, progress, culture evolution. From the FISTERA point of view the attempt is to provide a mechanism to show how technology evolution, through its various relations with the market, may affect the way of life.

Ultimately, decision on where to invest should be based on the effect that such an investment is like to have on our citizen life.

Clearly technology is but a little piece in the complex puzzle shaping the environment in which we live, the way we live into it and the values according to which we measure the progress of our society.

Hence the view of the various ambient do not have the purpose of describing the complete story but just to emphasize, through relationship, the importance, for better and for worse, of the technological evolution. Having a dynamic broadband service is something that would make our life any better? The answer cannot be found here, they are obviously subjective. However by looking at specific ambient, like the one for
education or the home environment, we may see that dynamic broadband can provide (for a limited time window, lets say between 2008 and 2015) the access to information in any form (including video) thus easing communication, providing better learning environment, better feeling of community with our friends and relatives and can provide that at a lower cost than the one that would be required if the networks had to provide top bandwidth at any time to every one. Beyond that timeframe probably the network capacity would have evolved to such a level that pick bandwidth can actually be provided cheaper than the dynamic one (you no longer have the cost associated in controlling it).

An ambient can represent:
- a physical environment, like our home,
- a condition we are in, like being on the move,
- a virtual space, like when we form a community of interest,
- a function oriented status, like when we study.

The interest of FISTERA is to outline a few of them and connect them to the lower layers to help understanding the implication. The scheme provided, and part of the information, may well serve as a base for developing scenarios that may embed many more factors into them to help policy makers, social researchers and others to investigate and speculate on the future.

1.1.4.1 Describing a Ambient

The description of an ambient serve the purpose of providing a view of the way life is being lived, the actors involved, the resources (physical and logical like bricks and information) used, the interaction among actors and resources, who is responsible for what. It is not the representation of a static situation but rather of a dynamic one. Values are not in what is sitting there (like a television in the living room) but what is being done with what is there (how dwellers are using the television, as a radio?, as a gateway to information?, as a videophone to cluster distant friend in the living room by seeing their images, and chatting with them as if they were here?...).

Associated information may provide scenarios of life, like virtual videoclip of life in the future helping people to think about it and answer the question: is it for me? Would I like to live at such a time in such a place?

1.1.4.2 Evolution in the life cycle

A given ambient, as described, represent a snapshot into the future (or on the present) but it may refer to a marginal part of the people or to the vast majority. Clearly one could decide to write a description that fits only niches (early adopters) to emphasise how much changes are possible, or on the other hand could trim the vision to fit the vast majority of people to emphasises culture – society evolution. The decision from a methodological viewpoint, and considering the goal of FISTERA, that is to provide an understanding on the implication of technological evolution to steer investment decision, has been to let forecasters free to choose their yardstick, as long as they declare “how long” it is.

For this reason 6 penetration levels are provided. They have to be understood in reference to the description of the ambient and the assumption on the “location” of that ambient. As an example one may elect to describe the home of the future by looking at the cutting edge technology available in rich countries and there inhabited by technology geeks to bring to the edge the vision of what can be done from a technological point of view. Hence the need to understand the number in the context of the ambient proposed. These are the 6 levels of penetration:

0 = <5% of target population
1 = <20% of target population
2 = <40% of target population
3 = <60% of target population
4 = <80% of target population
5 = Ubiquitous

Note the fact that percentage points refer to a target population for that specific ambient not to the whole population in a country or throughout Europe.

1.1.4.3 Performances

As in all other layer the first issue is to define a metrics. There are however some differences. Here the metrics is not likely to change over time (being healthy is an absolute goal, it is no likely to become a second level objective because it has been reached) and it is more a way to understand how certain parameters may change over time. Referring to the home ambient, as an example, one can say that the future home will deliver “purified” water (this is a given in Western Society but a long sought objective in many parts of the world) and that such purity should be guaranteed through local monitoring able to intercept pollutant that may adversely affect the well being of the specific dwellers. This is going much further beyond were we are today. People suffering from some ailments that make them sensitive to chlorine simple do not drink tap water to avoid the risk. In the future their house, or even their glass, will be able to detect dangerous level (for them) of chlorine and provide a warning.

Once the metrics is defined (basically after having identified all parameters that are relevant in a given ambient, that may be used to gauge its status and estimated evolution) the point is to provide a substantiated description indicating how the perceived quality of life (perceived both/either by the individual and by the society) is progressing, and because of what (relation to services being used).

The appreciation of the quality of life provided by an ambient depends to a certain extent on our habits and mostly on our expectation. This may be reflected by a positioning as indicated in the Maslow pyramids of needs:

- Self actualisation
- Ego needs
- Social needs
- Security needs
- Body needs

It may be appropriate to introduce this rating when discussing performance in ambient observing the current positioning of the target population and the delta introduced by the evolution. It is interesting to note that if the positioning is above the performance evolution that evolution is unlikely to result in high income (people tend to value less the satisfaction of needs below their present position – you are less willing to be charged for bread then for diamonds, the former satisfy a body need, the latter a Ego need; clearly if you are at the body need position, i.e. starving, you value bread much more than diamonds).

1.1.4.4 Challenges

In Ambient evolution challenges come from the Social, Ethical and Political context. Additionally there are economic conditions that need to be present otherwise evolution may occur only in limited areas and the effect on the global society may be nil. As an example it is not sufficient that a minority can afford laptop, and ubiquitous connectivity to stimulate investment in infrastructure to make it possible, nor would such a physical infrastructure be sufficient, in absence of a significant market, to activate new way of living, such as cooperative education. These aspects are of fundamental importance to a policy maker and to decision maker asked to foster evolution by focusing investment. If there is no market stimulating a private industry to create an infrastructure then the government may take the burden on itself but this may prove to be useless unless a parallel investment is made in cultural change. Minitel happened because both the infrastructure, the distribution of terminals in every home and the clustering of information provider was orchestrated.
1.1.4.5 *Costs*

Evolution of ambient is a lengthy and costly endeavour. In the cost area information, and expectation, on who will bear the cost to stimulate the evolution (including research investment), the deployment and the operation/up-keeping have to be provided.

1.1.4.6 *Application areas*

Application areas is mostly used to represent the segmentation of the population. This may happen because of cultural reason, of wealth and spending capacity, of location.

1.1.4.7 *Main Actors*

The main actors area serve the goal to identify who are:

- the shareholders, those willing to invest money for the evolution of the ambient;
- the stakeholders, those who will benefit from the evolution of an ambient, i.e. many companies will benefit from the availability of a broadband connection in every house. Although they are not willing to invest in research for creating affordable broadband connections, nor to bear any cost for the deployment of connections they will reap the benefit from the possibility of delivering information and content in a much more flexible way. As such they may also be willing to share part of their revenues with the infrastructures’ providers once the system is up and running;
- the users, that is the “inhabitants” of the ambient, who may pay directly or indirectly for the services used and who is the one that will perceive the increase in the quality of life.

1.1.4.8 *Geography*

Geography serves the purpose to indicate the countries position, who is leading.

1.2 *Infra-Inter Layer(s) relationships*

Relationships are a fundamental aspect of the FISTERA WP2 methodology. They provide the key to move from the trees to the forest and get an understanding of the global picture. Furthermore, relationships offer the fabric to perform simulations and what if analyses, something that will be looked into in the next WP2 activity, scheduled in the next year with deliverable in September 2004.

In this section we explain the way to create relationships and the way these are represented in the browsing tool.

1.2.1 *What is a relationship?*
Objects sharing some sort of dependencies are connected together by a relationship. There are several types of relationships. First of all relationships can be passive, in the sense that the object does not influence the evolution of the other it is related to (like “use”) or active in the sense that the object influences the evolution of the other (like “enhances”), the former are represented in yellow, the latter in red, as shown in the screenshot below.

In any layer objects can be related one another and relations with other layers can be established. In general relations across layers occur only between contiguous layers.

An object in the technology layer may have connections with objects in the functionality layer, not with objects in the service layer. An object at the functionality layer can establish relations with objects at the technology layer and with objects at the service layer.

Some exceptions can be made and will be explained in the following.

If object “A” at layer “x” establishes a relation with object “B” at layer “x+1” a symmetrical relation is implicitly established. As an example if Bluetooth technology “enables” the broadband functionality, as shown in the screenshot above, the broadband functionality is “enabled” by Bluetooth. However not necessarily, when representing the relationships of the Broadband functionality, the one with Bluetooth will be listed unless it is deemed to be a fundamental one. The purpose of establishing an explicit relationship is to draw the attention of the reader to that particular relationship from a certain point of view.

Now from the point of view of Bluetooth the fact that this technology can provide a 1Mbps bandwidth is important since it can support video communications, but when one is considering the Broadband functionality the micro grained view of a communication channel based on Bluetooth can be disregarded. However, in the data base the relationship established from Bluetooth to Broadband exists and it can be considered by a tool mapping the objects into a relationship tree.

Clearly there can be several relationships between two objects. So far WP2 has identified and used the following relationships (black are active, red are passive):

**ACTIVE:**

- **Impacts on:** The object evolution has an impact on the evolution of the other object. A comment can be associated to the relationship to clarify what kind of impact it can have (increase usability, performances, reliability, size…);
- **Increases processing power:** The object increases the processing power of the other object. This is not necessarily related to the evolution of the object itself, it may derive from the fact that the object is used by the other, as it is the case of a graphic card that is improving the processing power of a PC.
- **Enhances the functionality:** The object enhances the functionality of the other one. The latter can operate independently of the former although it will not be able to do certain thing at all. An example is the adoption of haptic interfaces to provide tactile sensation. Interface can exist without this feature but its use would provide an additional (sometimes highly valued) functionality.
• Enables: The object is a fundamental component of the other in order for the latter “to exist”. An example is the storage capacity which is essential for any PC. However there may exist alternative solutions to enable that “existence”. Storage capacity, as an example, can be provided by hard disk, CD ROM, DRAM, Compact Flash…and so on. Clearly each enabler has its own characteristics and advantages. Every time the Enables relation is used there should be some other relations explaining the alternatives. If that is not the case the latter object cannot exist independently of the former and there would be just one. Enabling dependencies are very important from the point of view of decision makers since they create value chain and alternative options for investment. Enabling dependencies change over time, they may become stronger or weaker as it will be explained later on.

• Easies the use of/ the access to: The object does not play a fundamental role in the existence of the latter but its presence would contribute to the success of the latter.

PASSIVE

• Is Influenced by: The object evolution is influenced by the evolution of the other object. This relationship is symmetric to the active one “Impacts on”.

• Is Enabled by: The object existence depends on the other component which is fundamental for its functioning. This relationship is symmetric to the active one “Enablers”. There may be alternative enablers, that is one may be absent provided an alternative one exists.

• Uses: The object is using the features and functionality of the latter. It has no influence on the latter, apart from creating market pressure in terms of requirements. The evolution of the object may benefit from the evolution of the latter but not the other way round. Often it is quite the opposite, the evolution of the object “kills” the need to use the latter (and when this is the case a comment should be inserted to point it out).

• Enhanced by: The object functionality is enhanced by using the latter object. Such a use is not crucial (as it is the case in the “use” relationship). In a way it is the symmetrical of “Enhances the functionality”. The decision to use one or the other depends on where one wants to put the focus. It does not make sense to duplicate the relationship (i.e. attributing to object A the relationship “enhanced by” object B and attribute to object B the relationship “enhances” object A).

• Its use/access is eased by: The object is not fundamentally depending on the evolution of the latter but its presence would contribute to the success of the former.

• Part of: The object is a component of the latter.

More relationships may be added as required.

Relationship strength A relationship can be assigned a “strength” to define how much it binds the two objects. The weights that have been defined, shown in the screenshot on the side are:

- 1 Very low
- 2 Low
- 3 Medium
- 4 High
- 5 Very High

The strength is useful both to indicate the degree of binding and to express how it is likely to change over the years. As an example the image display functionality “uses” the CRT today as standard, hence we can associate “very high” as strength but by 2008 that use would have been declining significantly, probably to “medium” and by 2020 the grading may be “very low” (possibly nil, in which case there will no longer be a relationship between the two objects. At the same time we can grade the “uses” relationship between the image display and LCD as “low” today and as “high” by 2008 and “medium” by 2020 because there is the expectation that new technologies, such as SEC, NED and OLED will have replaced LCD.

By looking at the set of relationships of an object and their strength we can get information on the evolution and of the market “interplay”. This is, obviously, a very important information for decision makers having to bet their investment money on research in any given area.

The meaning of the grading has to be associated to each type of relationship. Additionally, when creating a relationship between two objects an explanatory comment may be needed (as an example one may decide to grade the use of CRT as “very high” if we consider the whole spectrum of use, television and computers, we can downgrade it to “high” if we consider 15” screen as a whole and to “low” if the focus is just computer screens 15” and less).
These are the metrics adopted for the grading of the identified relationships:

**Impacts on:**

- **1:** The object evolution impact on the evolution of the other object is marginal. It may affect some of its minor features, e.g. the evolution of OLED contributes to the evolution of digital camera providing them with a better electronic viewfinder but that does not result in an increase in performance for the digital camera.

- **2:** The object evolution impact on the evolution of the other object is felt but it is not significant. It does not change the evolution path nor the perception of the user, e.g. the increase in storage capacity in the car provides better features but it is not steering the evolution in any particular direction nor it is felt by the end user since the features provided are marginal with respect to the core functions expected from the car.

- **3:** The object evolution impact on the evolution of the other object is felt. It provides new possibilities that are changing the perception of the evolution, e.g. the increase in storage capacity of compact flash for digital camera affects the way people are using and appreciating the digital camera. However it does not change the evolution path of the digital cameras that will continue to evolve knowing that more storage capacity will become available and therefore higher resolution (pixel numbers) can be managed.

- **4:** The object evolution impact on the evolution of the other object is strong. It affects the evolution of the object, e.g. the presence of Bluetooth in PDA changes the way people use the PDA and affect the design and evolution plan of the product.

- **5:** The object evolution impact on the evolution of the other object is essential. The evolution of the latter is a precondition for the evolution of the former, e.g. digital sensors are, today, a key component in digital cameras whose evolution is basically steering the evolution of the camera.

**Increases processing power:**

- **1:** marginal contribution to the evolution, mostly due to architectural solutions, such as the evolution of bus technology and faster storage devices.

- **2:** low contribution to the evolution, like the extension of processing power through higher capacity batteries.

- **3:** contribution in specific processing activities, such as through the use of graphic accelerators.

- **4:** radically influence the evolution, like parallel processing architectures, improvements in the lithographic processing.

- **5:** bring in processing power in the evolution of a technology (object), like inclusion of silicon into optical, digital into analogue, quantum processing…

**Enhances the functionality:**

- **1:** marginal contribution to the enhancement of the functionality (including technology, functionality, service or ambient), such as the present application of voice syntheses to speed dialling. The low contribution may be a consequence of the marginal importance of that object on the other or it may be due to the stage of evolution (of one or the other). In both cases a comments should be inserted to clarify the point. If the contribution is marginal and neither of the case is true (hence it will not increase in the future) it does not make sense to establish the relationship.

- **2:** low contribution, such as the GRID to on line gaming today. Same considerations as above apply.

- **3:** medium contribution, such as the WiFi on broadband access in the general market today. Even if no increase is expected in the future the relation is worth noting.

- **4:** high level of enhancement of functionality, such as the case of digital camera applied to the cellular phone. Comments to explain in what regard the contribution has to be considered high should be made. In the example the contribution is mostly on the market side (push to buy), not on the technical side. Furthermore it enables new services and communications paradigms.

- **5:** very high level of enhancement. The object (technology, functionality, service) provides a radical improvement in the functionality perceived that can motivate, “per se”, adoption of the object being enhanced. As an example, radio communications included in biosensors can radically transform the set of applications and significantly extend their use.

**Enables:**

- **1:** marginal contribution quite often as a lower interest alternative. The low profile may be due to a immaturity of either of the two objects in the relationship. Comments should provide a clarification. If the contribution is marginal and it will not increase in the future it does not make sense to establish the relationship.
2: low level of contribution. The low "grading" may derive from the enabling of a marginal part of the object to which the relationship is directed.

3: Average support. The object is not the main enabling factor although it is playing an important role for the success of the enabled object.

4: The object plays a crucial role in making it possible the evolution of the enabled object. An example is the progress in the lithographic process to enable the evolution of the microprocessor. If the lithographic process progress the microchip evolves. However there may exist other approaches resulting in the evolution of the microchip that are independent of the evolution of the lithographic process (such as nanotechnology and self assembling processes that may result in better microchips). In other words the enabling factor is very important since it results in an ipso facto evolution but it is not blocking.

5: The use of the object and its evolution are crucial to the evolution of the enabled one. They are having a blocking effect. There is no way to progress the enabled object "without" the enabling one. As an example unless one can improve the reading heads of the disk drive there is no way to increase the performance of the drive. A progress in the magnetoresistive surface that in principle provides higher storage density cannot be exploited unless a parallel progress takes place in the reading heads.

**Easies the use of/ the access to:**

1: the increase in usability or in the access is marginal. There is the expectation that the evolution of any of the factors involved will augment the capacity to increase usability/access. If the increase is marginal and it is not expected to increase in the future it does not make sense to establish the relationship. As an example, gesture capturing plays a minimal role in easing the interaction with a computer but it is expected that evolution in technology will provide more sophisticated capability and that will increase significantly the use of several computer applications.

2: the increase is minimal although it can be appreciated right now and it will increase in the future.

3: the adoption is "standard" in a variety of applications. An example is the windows interface.

4: the increase in use/access is such that it makes the object a most important part for the success of the target one. There are, however a number of possible alternative to achieve similar result.

5: the increase of usability or access is reaching such an important level that it makes it the most fundamental factor in the success of the target one. There are no practical alternative.

**Is influenced by:**

1: The object evolution is marginally influenced by the evolution of the other object. It may be affected in some of its minor features, e.g. the evolution of “human interfacing” might be slightly influenced by the evolution of “Information appliances” which could provide it with new interfacing capabilities but that does not result in an increase in performance for the “human interfacing” functionality.

2: The object evolution is slightly touched by the evolution of the other object. It does not change the evolution path nor the perception of the user, e.g. the increase in storage capacity in the car provides better features but it is not steering the evolution in any particular direction nor it is felt by the end user since the features provided are marginal with respect to the core functions expected from the car.

3: The object evolution feels the effect of the evolution of the other object. It is provided with new possibilities that are changing the perception of the evolution, e.g. the increase of MPEG diffusion enriches the information visual display functionality however it does not change the evolution path of the Information Visual Display.

4: The object evolution is strongly influenced by the evolution of the other object. e.g. PDA is influenced by Bluetooth means that the presence of Bluetooth in PDA changes the way people use the PDA and affect the design and evolution plan of the product.

5: The object evolution is changed by the evolution of the other object. The evolution of the latter is a precondition for the evolution of the former, e.g. digital sensors are, today, a key component in digital cameras whose evolution is basically steering the evolution of the camera.

**Is enabled by:**

1: marginal contribution, quite often as a lower interest alternative. The low profile may be due to an immaturity of either the two objects in the relationship. Comments should provide a clarification. If the contribution is marginal and it will not increase in the future it does not make sense to establish the relationship.
- low level of contribution. The low “grading” may derive from the enabling of a marginal part of the object to which the relationship is directed.

- Average support. The object to which the relation is pointing is not the main factor although it is playing an important role for the success of the enabled object.

- The enabler object plays a crucial role in making it possible the evolution of the enabled object: the enabling factor is very important since it results in an ipso facto evolution but it is not blocking.

- The use of the object and its evolution are crucial to the evolution of the enabled one. They are having a blocking effect. There is no way to progress the enabled object “without” the enabling one.

**Uses:**

- the object makes a minimal use of the features of the other object. The limited use can be related to a sub-functionality or to a limited amount of the whole object. More use can be expected in the future as one of the two (both) evolves. Would that not be the case the relationship should not be present.

- the object makes low use of the features of the other object. However this usage is somewhat important for the performance of the object and cannot be disregarded even in the case no particular increase is expected in the future.

- the object is using the other one as a standard feature. Whenever that object is present there is a high probability that also the second one is involved.

- the object used provides some specific contribution that makes it an important part of the whole. An un-availability would require a substitution (and that would be possible).

- the object used provides some essential contributions that make it a fundamental part of the whole. Its availability must be ensured.

**Enhanced by:**

- the object is marginally enhanced by the other object features. The low contribution may be a consequence of the marginal importance of that object on the other or it may be due to the stage of evolution (of one or the other). In both cases a comments should be inserted to clarify the point. If the contribution is marginal and neither of the case is true (hence it will not increase in the future) it does not make sense to establish the relationship.

- low contribution with the same comments of 1 applying.

- medium contribution. Even in case no increase is expected in the future the relation is worth noting.

- high level of enhancement derived. This enhancement by itself is a reason to associate the two objects and investment in the one that provides the enhancement is justified by the part of the owner of the enhanced one.

- very high level of enhancement. The object (technology, functionality, service) obtain a radical improvement in the functionality perceived that can motivate, “per se”, investment on the enhancing object.

**Its use/access is eased by:**

- the increase in usability or in the access is marginal. There is the expectation that the evolution of any of the factors involved will augment the capacity to increase usability/access. If the increase is marginal and it is not expected to increase in the future it does not make sense to establish the relationship.

- the increase is minimal although it can be appreciated right now and it will increase in the future.

- the adoption is “standard” in a variety of applications. An example is the “Windows” interface.

- the increase in ease of use/access of one object is such that it makes the object addressed by the relationship a most important part for the success of the former. There are, however a number of possible alternative to achieve a similar result.

- the increase in ease of use/access of one object by a second one is reaching such an important level that it makes the second the most fundamental factor in the success of the first one. There is no practical alternative.

**Part of:**

- the object is occasionally part of the other (software applet, hardware component...). It is not a significant component though, nor in terms of features provided nor in terms of cost. However this situation is bound to change in time. This is the reason to define the relationship.

- the object has a low importance in the overall package but its presence is important, such as a WiFi PCMCIA card in a laptop computer. From a packaging point of view the inclusion has very
limited impact but the features delivered are important. That may be a driver to extend this type of packaging to other devices, such as PDA, digital cameras…

- 3: the object is normally part of the other. Its role is not essential.
- 4: the object is an important part of the other and its presence is very important. Its absence should be addressed by the inclusion of some alternative.
- 5: the object is always part of the other whose features would not be possible in the absence of this.

1.2.2 Creating relationships

Creating a connection is very easy. Deciding what connection to create and the value to associate to it is quite complex.

There are a number of pre-defined connections, as described in 1.2. Their list can be seen by clicking in the opening page on the Connection Create/Modify button as shown on the right. This results in the opening of the window shown on the left. The first column list the names of each available connection, the second one indicates if the connection is active or passive (active: the object influence the evolution of the other; passive: the object does not influence the evolution of the other).

If the available connections are not appropriate to describe a relationship a new one can be added by clicking on the asterisk and providing a name and the type (active or passive). If one adds to the list a definition of the relationship and of the values it can assume should be given. Additionally the new relationship type should be inserted in a hierarchy of relationship.

What does this mean?

When considering the relationship between two objects it is often the case than more than one may apply. This from the point of view of the methodology is not a problem (we can have as many relationships among objects as needed) but it is a problem from a representation point of view since there is only the possibility to draw one line between two objects and several relationships would coalesce into a single line.

The guideline is to refer to the hierarchy of relationship as shown on the side and indicate the relationship that is at a higher hierarchical level. If we have two objects that may be linked by relationship of Enables and Easies the use of we will only indicate the Enables relationship. The other may be included as a comment in the explanation of the Enables relationship.

To create a relationship between two objects one has to click on the object that is the “origin” of the relationship (in the Enables it will be the object that “enables” the other) and then click on the Connection button above the list of items.

This will cause the opening of the relationship window (as shown on the side) where the existing connections are listed. One can modify an existing one by clicking onto it or can create a new one by clicking on the asterisk that is present on the last line (that is, the empty one).
Using the pull down menu associated to the first field we can associate the desired connection type, e.g. enables the functionality. The pull down on the second field contains a list of all the objects that have been defined. To “point” the relationship one just need to select the desired object. The pull down leaves complete freedom in the selection of the object. From a methodology point of view it is advisable to establish relationship only between objects define in the same layer (e.g. both are technology) or between objects that are defined in contiguous layers (e.g. an object in the technology layer may have a connection with one defined in the functionality layer but not with one at the service layer, one at the service layer may connect to one defined in an ambient or in a functionality but not with a technology). There is an exception to this guideline and that is the possibility to connect an object defined at the technology layer with one defined in the ambient layer.

The reason is that in the technology layer, as described in 1.1. there is the possibility to include “complex” object, such as a television or a PDA, in order to emphasize some packaging characteristics that play a significant role in the evolution. These are typically technological issue. However the device as such, the PDA, finds its existence in an ambient (e.g. on the move). Because of this double role it is admissible to set up a relationship between technology and ambient layer (but only for this type of objects).

There can be as many relationships as needed associated to an object. However it is better to keep them at a minimum. This would ensure that the attention of the reader is focused on the ones that really matter. In case of FISTERA the importance of a relationship should be gauged on the relevance of that relationship to decision makers having to decide where to focus investment and when.

Because of this objective one of the most important information that can be provided on a relationship is the existence of alternative. Alternatives are identified by inserting a number into the column “Alternatives”. Different numbers denote different alternatives. A same number attributed to more relationship indicates that all those relationship are forming a single alternative that needs to be compared to the others (denoted by different numbers).

In the screenshot 3D imaging can use either Flat screen LCD or Holographic technology. In this case both are becoming a “niche” reality in year 2008 and can be considered as standard by year 2020 (this information is provided by the last column where the relationship strength is quantified). It is up to strategic consideration to focus investment in such a way to promote one over the other and clearly this decision should take into account the other market for the two technologies because these markets may provide by themselves a clear direction of evolution. In particular looking at those market applications one may see that the LCD technology will evolve and become a de facto standard for image representation by 2008 (therefore achieving economy of scale and cost reduction) with industries that will invest their own money (particularly Korean and Japanese ones having the upper hand in steering the evolution and the lion’s share of the
market). In this sense it may be more appropriate for the European Community to invest in holographic technologies to become the leader in some areas and some applications, possibly trying to create some disruption in the market by achieving a technological breakthrough. More in depth analyses is given in analyzing technology trajectories.

Here the point was made for the sake of helping in understanding the methodology and the representation tools developed.

The comment space is provided to key in any supplementary information on the grading associated to a relationship and to point out other relationships between the objects that are of potential interest, although of lower importance than the one defined.

1.2.3 Representing relationships

Relationships are represented in the relationship window of the browser as shown in the screenshot on the side.

The relationship window is activated by clicking on an object, in this case 3D imaging. The relationships shown are the result of a processing of the relationships defined in the data base (as described in 1.2.1).

The object is drawn in the middle of the layer it belongs to, in this case the functionality layer, and is connected to all objects it has relation to. These objects are drawn in the layers they belong. In this case there is a relationship with the Wearable functionality, three relationships with objects at the service layer (bandwidth on demand, education and healthcare) and two relationships with objects at the technology layer (Flat screen display and Holograpy).

Each object is identified by its name and a number in parentheses indicating the stage of the object in the life cycle.

Each relationship is represented by a line, a red one to denote an active relationship (the evolution of the object affects the evolution of the other), a yellow one to denote a passive relationship (the evolution of the object does not affect the evolution of the other).

The thickness of the line provides a first glance information on the “strength” of the relationship.

By passing the mouse on the dot over the line (approximately half way between the connected objects) a pop up is displayed to provide information on the type of relationship, on its strength and the comment associated to it as shown in the screenshot on the side.

Because of this representation it is important to structure the comment in a synthetic way so that in just a sentence or two the viewer can get the understanding of the role such a relationship plays between the two objects.

The relationship map shown relates to a specific year, in this case 2008 (highlighted in red by the hourglass).
Moving the mouse over the years cause the change in the relationship and this is a powerful help to perceive, at a glance, how an object can evolve its relationship over time, as shown in the screenshot at the side.

In the first screenshot, related to year 2003, the functionality 3D imaging shows relation with another functionality in the same layer and another one in the upper layer.

There is no relation with the technology layer since 3D imaging today is still in its infancy and it uses a number of technologies (some special software to render images in 3D, some special display in niche application…) none of which can be connected to 3D in a significant way.

By 2008 two technologies are likely to be used for 3D imaging, LCD and holography. Both of them will contribute just a bit to the functionality, the 3D software is still playing a major role and in several niches special equipment will still be used. More applications area (services) will make use of 3D imaging.

By 2020 3D imaging will become much more common in association with the same areas identified as application in 2008. The stronger relations hip is shown by the thicker lines connecting the boxes. Also the support from the LCD and holography will be stronger and this is reflected by the thicker yellow lines.

1.3 Information Capturing

The information included in the data base is derived from a number of sources:
- published studies
- internet sources
- IST
- WP1
- Universities
- IEEE
- Research Centres
- News Monitoring

There are many published studies available and several have been and will be considered by FISTERA WP2. Most of these results from analyses that had a different goal from FISTERA. WP2 takes the information “as is” (and provide the appropriate reference) but also digest the information in a global assessment.

Quite often different sources provide different analyses of the same information. Very few anyhow consider the evolution trends for market and technology in terms of assessing where it would be best to invest.

WP2 is not doing that either but tries to present the information in such a way to make it easier for decision maker to answer that question.

Internet sources are both used to get global trends and for specific information. When used specifically reference to the URL is given and a cashing of the page is done on the FISTERA WP2 web site to keep the source available (there is no guarantee that the original source will stay available on the original web site). Internet sources are also referred to as pointers to keep an eye on a given area (technology, market). There are a number of associations and companies that are monitoring evolution in very specific fields and it is best to refer to them, rather than duplicate effort.

IST provides important sources of information, both through specific studies and projects (like FISTERA) and through its funded projects. The hope is to establish a cooperation with as many IST projects as possible to feed in information deriving from research in the various areas. That would be an invaluable way to extend the services and increase the value of FISTERA beyond the project timeline.
WP1 analyses the situation and plans in European countries and it is therefore a primary source of information to understand what are the investment trends in Europe and what is the competitive advantage in the various area of each European Country. Additionally the strategic plans in many cases are ongoing activities that can be usefully connected to FISTERA to feed and retrieve information.

Several relations have been established with European and USA universities. These are important since Universities often provide cutting edge research and moreover some of their research is at the edges of IST. These are not in the focus of IST but their progress and results may affect, particularly over the long time span that is addressed by FISTERA, the investment decision and the technology trajectories. It is out of these groundbreaking researches that disruptions are most likely to come.

IEEE COMSOC is another interesting source of information through its various publications. Its many members spread all over the world constitute a tremendous “information base” that we hope will be interested in challenging FISTERA results and provide information.

Research Centres through direct contacts and through publications are another important source for analysing and challenging the wealth of available information. Clearly TI Lab has been a main source for discussing and challenges ideas.

An interesting, although not principal source of information, has been the process leading to intercept announcements of new ideas, research results, products innovation that is the News Monitoring. News have been published on the FISTERA WP2 website since March 2003 and by the date of the release of this deliverable there have been over 300 of them.

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1 We would like to acknowledge in particular the contributions received from the University of Florence and the discussions with professors at MIT and Media Lab.
Appendix B – The web representation tool

2.1 Preliminary remarks

Requirements for the reading and use of the handbook.
It is assumed that one has knowledge of the following software platforms:
- HTML language
- Javascript language
- Php language
- Tools for Visual Studio language, in particular Visual Fox Pro.
- Microsoft Access.

2.2 Introduction

The objective of the program is to build a web site in which, appropriately using text and graphs, the network of relationships among ICT technologies is represented. Highlighted are the influences, opportunities and bonds among the ICT technologies and their consequent link to functionalities they satisfy, services they activate, and ambients from which they emerge.

With this approach in mind, the elements that are part of the scenario have been placed on four different levels that are blended into one another, referring to three different timespans.

Starting from the bottom one has the technologies, which represent the most basic elements and are the closest to scientific research (such as RAM, CPU, Hard-Disk...). Given the fact that each technology tends to satisfy a generic need (to store, to explain, to process...), the latter can be aggregated, at a higher level, in functionalities. Each functionality can make use of different technologies. When a functionality is offered, either alone or in combination with other functionalities, through a commercial offering, there is a move to a superior level: services. The ambient in which the different services are used is the highest level, and represents the context in which we carry out our activities, the one in which we live.

In the model built, each element is placed in its appropriate level, and the links - to the other elements it is in relation with - are represented.

The display of the page also shows the weight (in terms of relevance, per, degree of attention, degree of influence on other elements, etc.) of both the elements that appear in the page and of the relationship that links the elements together.

2.3 The project

First of all the project requires the possibility to catalogue and store, in a simple and guided manner, a series of information relative to a specific technology. In practice the filling out of Forms that allow to highlight, when
appropriate, structured information for each element, in addition to the relationships that, in different moments, can exist among the already listed elements.

On the other hand the project needs to represent the information relative to a technology on a web space that allows to navigate among the elements requested and eventual to study in depth the subject, with the possibility of consulting the appropriate “file”.

The two interfaces are necessary because of different types of users. On the one hand those that gather, interpret and put the information in a controlled space (internet), on the other hand the “public” user that accesses the data in a hypertext manner (WorldWideWeb). In between a deferred processing, but sufficiently rapid and frequent to guarantee a constant updating of the data published.

In detail:

1. the relations page presents itself with 3 information sensible areas
   a. to the left an area that defines the time span (2003 / 2008 / 2020)
   b. to the left (under) a list of objects classified as technologies, functionalities, services and ambients
   c. in the center, on a colored background (4 shaded strips), the objects that are eventually requested

2. each object is briefly described by a glossary definition that is found in a window, opened by passing over the mouse on the object (javascript function onmouseover())

3. With a mouseclick on an object listed on the left, one obtains a recall to the central area of the object, and to all the other objects that are linked to the original object by a stated relationship. The object (specifically the letters of the word) is bordered if the object represents an aggregation of objects. The linked objects take on the same color if they can be put together in cohesive groups. (same color, same group).

4. Each relationship is represented by a line tying together the two objects, with the color of the line defining the type of relationship (active/passive), and the thickness of the line defining the strength of the link. A red dot (activated when passing on it) defines what type of relationship and with which characteristics.

5. A click on linked objects produces the same effects described in point 3

6. A click on the main objects allows one to access to the detailed page (of information) on that element

2.4 The tools

For the realization of the model the following tools have been used:
- a Database developed on a Microsoft Access (Windows) platform that permits the guided introduction of data, and the definition of the existing links.
- a software developed on a Visual Studio (in particular Visual Fox Pro) platform that allows the reading of the data taken from the DB and the automatic generation of the HTML pages.
- The Javascript language for the use of the graphic libraries and to create certain effects in the HTML pages
- The php language in order to create dynamic HTML pages
2.5 The Database

The objects that constitute the model and all of the information relative to each element are stored in a database developed on a Microsoft Access platform. The information is gathered in three types of tables:
- Those containing the data and the description of the objects
- Those containing the relationships that link together the objects.
- Other support tables

The input of the data, the maintenance, and the signaling of eventual errors are governed by a menu and by interactive files that guide the user and allow, with specific reports, to visualize all of the content.

What follows is a list of the tables used, and of the fields and relationships that exist.

Table Voci_2
This table contains all of the objects that make the model work. Each voice (a record) is identified by a progressing number (ID_Voce). The information contained in the field refers to the paragraphs that appear in the detailed pages of the site. In particular one should note the “Layer” that defines the level to which the object belongs to.

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID_Voce</td>
<td>Interlo lungo</td>
<td>4</td>
<td>Identification of the record</td>
</tr>
<tr>
<td>Titolo</td>
<td>Testo</td>
<td>250</td>
<td>Name given to object</td>
</tr>
<tr>
<td>Flag1</td>
<td>Si/No</td>
<td>1</td>
<td>Flag service</td>
</tr>
<tr>
<td>Gloss</td>
<td>Memo</td>
<td></td>
<td>Glossary: synthetic description of the object</td>
</tr>
<tr>
<td>Descr</td>
<td>Memo</td>
<td></td>
<td>Contents relative to the voice “what is it?”</td>
</tr>
<tr>
<td>De1ima</td>
<td>Memo</td>
<td></td>
<td>Eventual description 1’ image/graph</td>
</tr>
<tr>
<td>De2ima</td>
<td>Memo</td>
<td></td>
<td>Eventual description 2’ image/graph</td>
</tr>
<tr>
<td>De3ima</td>
<td>Memo</td>
<td></td>
<td>Eventual description 3’ image/graph</td>
</tr>
<tr>
<td>De4ima</td>
<td>Memo</td>
<td></td>
<td>Eventual description 4’ image/graph</td>
</tr>
<tr>
<td>PerfFut</td>
<td>Memo</td>
<td></td>
<td>Contents relative to the voice “Performance trends”</td>
</tr>
<tr>
<td>PF1ima</td>
<td>Memo</td>
<td></td>
<td>Eventual description 1’ image/graph</td>
</tr>
<tr>
<td>PF2ima</td>
<td>Memo</td>
<td></td>
<td>Eventual description 2’ image/graph</td>
</tr>
<tr>
<td>PF3ima</td>
<td>Memo</td>
<td></td>
<td>Eventual description 3’ image/graph</td>
</tr>
<tr>
<td>PF4ima</td>
<td>Memo</td>
<td></td>
<td>Eventual description 4’ image/graph</td>
</tr>
<tr>
<td>Challenge</td>
<td>Memo</td>
<td></td>
<td>Contents relative to the voice “Challenge ahead”</td>
</tr>
<tr>
<td>Ch1ima</td>
<td>Memo</td>
<td></td>
<td>Eventual description 1’ image/graph</td>
</tr>
<tr>
<td>Ch2ima</td>
<td>Memo</td>
<td></td>
<td>Eventual description 2’ image/graph</td>
</tr>
<tr>
<td>Ch3ima</td>
<td>Memo</td>
<td></td>
<td>Eventual description 3’ image/graph</td>
</tr>
<tr>
<td>Ch4ima</td>
<td>Memo</td>
<td></td>
<td>Eventual description 4’ image/graph</td>
</tr>
<tr>
<td>Cost</td>
<td>Memo</td>
<td></td>
<td>Contents relative to the voice “Costs trends”</td>
</tr>
<tr>
<td>Co1ima</td>
<td>Memo</td>
<td></td>
<td>Eventual description 1’ image/graph</td>
</tr>
<tr>
<td>Co2ima</td>
<td>Memo</td>
<td></td>
<td>Eventual description 2’ image/graph</td>
</tr>
<tr>
<td>Co3ima</td>
<td>Memo</td>
<td></td>
<td>Eventual description 3’ image/graph</td>
</tr>
<tr>
<td>Co4ima</td>
<td>Memo</td>
<td></td>
<td>Eventual description 4’ image/graph</td>
</tr>
<tr>
<td>Applic</td>
<td>Memo</td>
<td></td>
<td>Contents relative to the voice “Application areas”</td>
</tr>
<tr>
<td>Ap1ima</td>
<td>Memo</td>
<td></td>
<td>Eventual description 1’ image/graph</td>
</tr>
<tr>
<td>Ap2ima</td>
<td>Memo</td>
<td></td>
<td>Eventual description 2’ image/graph</td>
</tr>
<tr>
<td>Ap3ima</td>
<td>Memo</td>
<td></td>
<td>Eventual description 3’ image/graph</td>
</tr>
<tr>
<td>Ap4ima</td>
<td>Memo</td>
<td></td>
<td>Eventual description 4’ image/graph</td>
</tr>
<tr>
<td>Actor</td>
<td>Memo</td>
<td></td>
<td>Contents relative to the voice “Main Actors”</td>
</tr>
</tbody>
</table>
The table describes the relationship with which two objects represented in the model are linked together: Given that a link has a direction\(^2\), there will be a subject, an object and a link that ties the two, in addition to a series of attributes that define other characteristics. Amongst these the possibility to pool together certain objects (Alter), in such a way that they can appear as an alternative to another grouping.

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID_reg</td>
<td>Interolungo</td>
<td>4</td>
<td>Identification of the record</td>
</tr>
<tr>
<td>ID_Voce</td>
<td>Interolungo</td>
<td>4</td>
<td>Identification of the subject of the relationship</td>
</tr>
<tr>
<td>ID_Voce2</td>
<td>Interolungo</td>
<td>4</td>
<td>Identification of the object of the relationship</td>
</tr>
<tr>
<td>ID_Legame</td>
<td>Interolungo</td>
<td>4</td>
<td>Identification of the relationship</td>
</tr>
<tr>
<td>Alter</td>
<td>Testo</td>
<td>50</td>
<td>Code for the aggregation of the alternatives</td>
</tr>
<tr>
<td>ID_Anno</td>
<td>Interolungo</td>
<td>4</td>
<td>Identification of the year</td>
</tr>
<tr>
<td>ID_Peso</td>
<td>Interolungo</td>
<td>4</td>
<td>Identification of the weight</td>
</tr>
<tr>
<td>Notes</td>
<td>Memo</td>
<td>-</td>
<td>Comment of the relationship defined</td>
</tr>
</tbody>
</table>

\(^2\) In the sense that an object has an influence on another object or it receives an influence from the other, and in fact the relationship itself is defined as ACTIVE or PASSIVE.
Name | Type | Size | Description
-----|------|------|------------------
ID_reg | Intero lungo | 4 | Identification del record
ID_Voce | Intero lungo | 4 | Identification of the subject of the relationship
Voci_2_Titolo | Testo | 250 | Name of the subject
Voci_2_Layer | Intero lungo | 4 | Identification of the layer assigned to the subject
ID_Voce2 | Intero lungo | 4 | Identification of the object of the relationship
Voci_2_1_Titolo | Testo | 250 | Name of the object
Voci_2_1_Layer | Intero lungo | 4 | Identification of the type of relationship
Legame | Testo | 50 | Description of the relationship
Tipo | Testo | 50 | Type of relationship (Active / Passive)
ID_Anno | Intero lungo | 4 | Identification of the year assigned
ID_Peso | Intero lungo | 4 | Identification of the weight assigned
Note | Memo | - | Comment to the relationship defined
Alter | Testo | 50 | Code for the aggregation of the alternatives
Aggr_1 | Si/No | 1 | Defines if the object is an aggregation of objects
Vol2003 | Intero lungo | 4 | Weight given to the year 2003
Vol2008 | Intero lungo | 4 | Weight given to the year 2008
Vol2020 | Intero lungo | 4 | Weight given to the year 2020

The Query that generates the table is the following:

```sql
SELECT Legami.ID_reg, Legami.ID_Voce, Voci_2.Titolo, Voci_2.Layer, Legami.ID_Voce2,
Voci_2_1.Titolo, Voci_2_1.Layer, Legami.ID_Anno, Legami.ID_Peso, Legami.Note, Legami.Alter,
FROM (((Legami LEFT JOIN Voci_2 ON Legami.ID_Voce = Voci_2.ID_Voce) LEFT JOIN Voci_2
AS Voci_2_1 ON Legami.ID_Voce2 = Voci_2_1.ID_Voce) LEFT JOIN DescrizioneLegami ON
Legami.ID_Legame = DescrizioneLegami.ID_Legame) LEFT JOIN Layer ON Voci_2.Layer =
Layer.ID_concetto) LEFT JOIN Layer AS Layer_1 ON Voci_2_1.Layer =
Layer_1.ID_concetto;
```

Some tables contain reference data valid for many of the objects described in the DB. Referring to
the identification of the record allows the retrieval of the correlated information.
The tables referred to are listed below.

**Table DescrizioneLegami**

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID_Legame</td>
<td>Intero lungo</td>
<td>4</td>
<td>Identification of the record</td>
</tr>
<tr>
<td>Legame</td>
<td>Testo</td>
<td>50</td>
<td>Description of the relationship</td>
</tr>
<tr>
<td>Tipo</td>
<td>Testo</td>
<td>50</td>
<td>Type of relationship (Active / Passive) defines the color of the link joining the objects involved.</td>
</tr>
</tbody>
</table>

**Table Geografia**

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID_Geo</td>
<td>Intero lungo</td>
<td>4</td>
<td>Identification of the record</td>
</tr>
<tr>
<td>Descrizione</td>
<td>Testo</td>
<td>50</td>
<td>Description of the geographic location</td>
</tr>
<tr>
<td>Coord_X</td>
<td>Intero lungo</td>
<td>4</td>
<td>Coordinate X of the position of the location in the area</td>
</tr>
<tr>
<td>Coord_Y</td>
<td>Intero lungo</td>
<td>4</td>
<td>Coordinate Y of the position of the location in the area</td>
</tr>
<tr>
<td>Flag</td>
<td>Si/No</td>
<td>1</td>
<td>Flag service</td>
</tr>
<tr>
<td>Mappa</td>
<td>Testo</td>
<td>50</td>
<td>Name of the .jpg file representing the geographic area</td>
</tr>
</tbody>
</table>

**Table Layer**

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID_concetto</td>
<td>Intero lungo</td>
<td>4</td>
<td>Identification of the record</td>
</tr>
</tbody>
</table>

29/01/04
Table Pesi

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID_Peso</td>
<td>Intero lungo</td>
<td>4</td>
<td>Identification of the record</td>
</tr>
<tr>
<td>Descrizione</td>
<td>Testo</td>
<td>50</td>
<td>Description of the weight in a textual format</td>
</tr>
<tr>
<td>Valore</td>
<td>Intero lungo</td>
<td>4</td>
<td>Value of the weight</td>
</tr>
</tbody>
</table>

Table Tempo

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID_Anno</td>
<td>Intero lungo</td>
<td>4</td>
<td>Identification of the record</td>
</tr>
<tr>
<td>Anno</td>
<td>Intero lungo</td>
<td>4</td>
<td>Year in a numeric format</td>
</tr>
<tr>
<td>Descr</td>
<td>Testo</td>
<td>50</td>
<td>Description of the year in a textual format</td>
</tr>
</tbody>
</table>

2.7 The Software

The passage of the data from the database to the Web site is guaranteed by a program\(^3\), (tecnologie6.prg) developed in Visual Fox Pro language, which enables the production of dynamic HTML pages.

Access, in fact, allows to extract the tables in dbf format. The program reads the information in this format, processes it and transforms it into HTML code “lines” (or eventually in javascript code “lines”), and saves it in text files, assigning a coded name based on the contents. The files are then stored in an area assigned by the Web server.

Two appropriately prepackaged\(^4\) HTML pages, using within themselves the PHP language, are able to read the files and englobe the text files.

The moment there is a request to access a given page, in fact, the server proceeds to execute the PHP commands described in the HTML pages. The commands give the order to utilize, on the basis of the given parameters, certain text files related to the specific subject being requested, in this way providing an “personalized” HTML page. When the browser receives the page, it in turn processes the functions in javascript, which in part refer to certain graphic libraries downloaded without cost from the network, providing in this way the requested effects.

The tables involved in the extraction process, sufficient for the processing, are:

- Voci_2
- Exp_Legami

\(^3\) The program code is shown in Appendix A.

\(^4\) The codes of these pages are shown in Appendix B.
2.8 Codes for the program Tecnologie8.prg

CLEAR
SET PATH TO C:\Dallamura2003\Lavoro\Fistera\DataBaseAccess\Tab
*SET PATH TO C:\_ArchivioDati\_Ufficio\news
*SET SAFETY OFF
SET DATE TO italian
mDataUltime=CTOD("20-05-03")
* Array in order to check multiple relationships

DO Cpzero WITH 'voci_2.DBF',850
If !file("Oggetti.dbf")
   CREATE TABLE C:\Dallamura2003\Lavoro\Fistera\DataBaseAccess\Tab\Oggetti
   (Oggetto C(15),Num n(10),XB n(10),YB n(10),X n(10),Y n(10))
   USE
endif
Select 4
Use NewsLega
Index on
right('00000'+Alltrim(Str(Id_voce)),5)+right('00000'+Alltrim(Str(Id_voce2)),5)+Alltrim(str(Id_Legame ))+Alltrim(str(Id_Anno)) to NewsLega
Set index to NewsLega
Select 3
Use Oggetti
index on Oggetto to oggetto
set index to oggetto
SELECT 2
USE Exp_Lega
index on right('00000'+Alltrim(Str(Id_voce)),5) TO Voce
SET INDEX TO Voce

* In this phase one must prepare the list of technologies, functionalities, etc.
* ... and for each one plans at least its position on the background

SELECT 1
USE Voci_2
index on Upper(left(Titolo,20)) TO Titolo
SET INDEX TO Titolo

mKost=167

* use the same variables because just need to create and then close the file that will be used
* Creation of the lists of objects for each level: the text is incorporated by functions
* in the page "techno03.php"
indirizz.tecn
mFndx='C:\Dallamura2003\Lavoro\Fistera\website\php\ambi.txt' && file di
indirizz.tecn

29/01/04
boh=FCLOSE(gnErrFile)

mFndx='C:\Dallamura2003\_Lavoro\Fistera\website\php\serv.txt' &&
  gnErrFile = FCREATE(mFndx,0) && If not, create it
  boh=FCLOSE(gnErrFile)

mFndx='C:\Dallamura2003\_Lavoro\Fistera\website\php\funct.txt' &&
  gnErrFile = FCREATE(mFndx,0) && If not, create it
  boh=FCLOSE(gnErrFile)

mFndx='C:\Dallamura2003\_Lavoro\Fistera\website\php\tech.txt' &&
  gnErrFile = FCREATE(mFndx,0) && If not, create it
  boh=FCLOSE(gnErrFile)

mFTip='C:\Dallamura2003\_Lavoro\Fistera\website\php\tip.txt' &&
  gnErrFile = FCREATE(mFTip,0) && If not, create it
  boh=FCLOSE(gnErrFile)

*mm=0
DO WHILE !EOF()
  *DO WHILE mm<5
    * mm=mm+1
    if layer!=0
      Select 3
      zap
      select 1
      * reads the Technology in alphabetical order and defines the name of the files
      * that must be registered
      mID=right('00000'+Alltrim(Str(Id_voce)),5)
      mLLayer=alltrim(str(Layer))
      mld_voce='C:\Dallamura2003\_Lavoro\Fistera\website\php\tech_'+mID
      mldT=mld_voce+"T.txt"
      mldA=mld_voce+"A.txt"
      mldA1=mld_voce+"A1.txt"
      mldA2=mld_voce+"A2.txt"
      mldA3=mld_voce+"A3.txt"
      mldA4=mld_voce+"A4.txt"
      mldC=mld_voce+"C.txt"
      mldC1=mld_voce+"C1.txt"
      mldC2=mld_voce+"C2.txt"
      mldC3=mld_voce+"C3.txt"
      mldC4=mld_voce+"C4.txt"
      mldD=mld_voce+"D.txt"
      mldD1=mld_voce+"D1.txt"
      mldD2=mld_voce+"D2.txt"
      mldD3=mld_voce+"D3.txt"
      mldD4=mld_voce+"D4.txt"
      mldE=mld_voce+"E.txt"
      mldE1=mld_voce+"E1.txt"
      mldE2=mld_voce+"E2.txt"
      mldE3=mld_voce+"E3.txt"
      mldE4=mld_voce+"E4.txt"
      mldF=mld_voce+"F.txt"
      mldF1=mld_voce+"F1.txt"
      mldF2=mld_voce+"F2.txt"
      mldF3=mld_voce+"F3.txt"
      mldF4=mld_voce+"F4.txt"
      mldG=mld_voce+"G.txt"
mLi4=Alltrim(Li4_ima)
mIST=Alltrim(ISt)
mIs1=Alltrim(Is1_ima)
mIs2=Alltrim(Is2_ima)
mIs3=Alltrim(Is3_ima)
mIs4=Alltrim(Is4_ima)
mCountries=Alltrim(Countries)
mCn1=Alltrim(Cn1_ima)
mCn2=Alltrim(Cn2_ima)
mCn3=Alltrim(Cn3_ima)
mCn4=Alltrim(Cn4_ima)

mVol2003=Alltrim(str(Vol2003))
mVol2008=Alltrim(str(Vol2008))
mVol2020=Alltrim(str(Vol2020))

* defines the link of the list on the left
* building of the HTML codes to reload the page with different parameters
* mRigaLink=<a href="dram.htm" onMouseover="(showTip('tip2');
  showTech('sph6,502,781'))" ONMOUSEOUT="hideTip('tip2')">Dram<br></a>
  mRiga1='a href="techno03.php?id=' + mID + '&ly=' + mLayer + '.."
  onMousover="showTip("' +
  mRiga2="tip" + mID
  mRiga3="")'+"" ONMOUSEOUT="hideTip('"
  mRiga4="tip" + mID + ")" + "')">mTitol + 'br></a>'
  mRigaLink = mRiga1 + mRiga2 + mRiga3 + mRiga4

* defines the comment (tip) on the link
* builds the HTML code
  mTip1='div id="tip' + mID + '" class="tip"><table bgcolor="yellow" width="150"
  border="1"<tr><td><font face="Verdana, Arial, Helvetica, sans-serif" size="1"><b>
  mTip2=mGloss
  mTip3='</b></font></td></tr></table></div>
  mTip = mTip1 + mTip2 + mTip3

mFTip='C:\Dallamura2003\_Lavoro\Fistera\website\php\tip.txt' & file di
  glossario.tecn
* creates different lists based on the layer to which they belong

mBCooX=612
do case
  case layer=1
    mFndx='C:\Dallamura2003\_Lavoro\Fistera\website\php\ambi.txt' & file di
  case layer=2
    mFndx='C:\Dallamura2003\_Lavoro\Fistera\website\php\serv.txt' & file di
  case layer=3
    mFndx='C:\Dallamura2003\_Lavoro\Fistera\website\php\funct.txt' & file di
  case layer=4
    mFndx='C:\Dallamura2003\_Lavoro\Fistera\website\php\tech.txt' & file di
endcase

m_BCooX=alltrim(str(mBCooX))
m_BCooY=alltrim(str(mBCooY))

* creates the base of the Ttl object in the background
* creation of the HTML code

* <div id="ttl_a00068" class="ttl" style="left: 603px; top: 952px;">
<table width="100%" border="0" height="20" bgcolor="#FFFFFF">
<tr><td align="center" valign="middle">
</td></tr></table>
* <a href="tech_ndx.php?id=00068&ly=4" onClick="javascript:void(0)
onMouseOver="showTip('tip00068')" onMouseOut="hideTip('tip00068')">
* <font face="Verdana, Arial, Helvetica, sans-serif" size="2">
* <b>Personal Computer</b></font></a>
</div>

* Anno 2003
mBorder=if(Aggr_1,",","")
mRiga1="<div id="ttl_a"+mID+"" class="ttb" style="left: '+m_BCooX+ 'px; top: '+
+m_BCooY+ 'px;">"+table width="100%" border=""+mBorder+"" height="20"
bgcolor="#FFFFFF">"+tr><td align="center" valign="middle">

mRiga6="<font face="Verdana, Arial, Helvetica, sans-serif" size="2">"+b> + mTitol + 
(' +mVol2003+ ')"+"</font></a></td></tr></table>
* Anno 2008
mRiga1="<div id="ttl_b"+mID+"" class="ttb" style="left: '+m_BCooX+ 'px; top: '+
+m_BCooY+ 'px;">"+table width="100%" border=""+mBorder+"" height="20"
bgcolor="#FFFFFF">"+tr><td align="center" valign="middle">

mRiga6="<font face="Verdana, Arial, Helvetica, sans-serif" size="2">"+b> + mTitol + 
(' +mVol2008+ ')"+"</font></a></td></tr></table>
* Anno 2020
mRiga1="<div id="ttl_c"+mID+"" class="ttb" style="left: '+m_BCooX+ 'px; top: '+
+m_BCooY+ 'px;">"+table width="100%" border=""+mBorder+"" height="20"
bgcolor="#FFFFFF">"+tr><td align="center" valign="middle">

* _____________ _______________________________________
* writes Tip
 IF !FILE(mFTip) && Does file exist?
 gnErrFile = FCREATE(mFTip,0) && If not, create it
 @ 1,1 say "crea file "+str(gnErrFile)
 boh=FCLOSE(gnErrFile)
 IF boh
 @ 2,1 say "chiuso "
 ELSE
 @ 2,1 say "no chiuso "
 ENDIF
ENDIF
 gnErrFile = FOPEN(mFTip,2) && If so, open read-write
 IF gnErrFile < 0 && Check for error opening file
 @ 3,1 say 'Cannot open file '+str(gnErrFile)
 ELSE && If no error, write to file
@ 3,1 say "apre "+str(gnErrFile)
@ 4,1 say "Titolo: "+Alltrim(mTitol)
mSize=FSEEK(gnErrFile, 0, 2)
boh=FPUTS(gnErrFile, mTip)
@ 5,1 say "scrive "+str(boh)+str(gnErrFile)
ENDIF
boh=FCLOSE(gnErrFile) && Close file
IF boh
  @ 6,1 say "chiuso 
ELSE
  @ 6,1 say "no chiuso 
ENDIF
* =======================================================
* ____________________________________________________
* write file list on the left
IF !FILE(mFndx) && Does file exist?
gnErrFile = FCREATE(mFndx,0) && If not, create it
  @ 1,1 say "crea file "+str(gnErrFile)
boh=FCLOSE(gnErrFile)
IF boh
  @ 2,1 say "chiuso 
ELSE
  @ 2,1 say "no chiuso 
ENDIF
ENDIF
gnErrFile = FOPEN(mFndx,2) && If so, open read-write
IF gnErrFile < 0 && Check for error opening file
  @ 3,1 say 'Cannot open file '+str(gnErrFile)
ELSE && If no error, write to file
  @ 3,1 say "apre "+str(gnErrFile)
  @ 4,1 say "Titolo: "+Alltrim(mTitol)
mSize=FSEEK(gnErrFile, 0, 2)
boh=FPUTS(gnErrFile, mRigaLink)
  @ 5,1 say "scrive "+str(boh)+str(gnErrFile)
ENDIF
boh=FCLOSE(gnErrFile) && Close file
IF boh
  @ 6,1 say "chiuso 
ELSE
  @ 6,1 say "no chiuso 
ENDIF
* =======================================================
* ____________________________________________________
* writes Titoli file for each file
* IF !FILE(mIdT) && Does file exist?
gnErrFile = FCREATE(mIdT,0) && If not, create it
  @ 1,1 say "crea file "+str(gnErrFile)
boh=FCLOSE(gnErrFile)
IF boh
  @ 2,1 say "chiuso 
ELSE
  @ 2,1 say "no chiuso 
ENDIF
* ENDIF
gnErrFile = FOPEN(mIdT,2) && If so, open read-write
IF gnErrFile < 0 && Check for error opening file

@ 3.1 say 'Cannot open file '+str(gnErrFile)
ELSE  & If no error, write to file
   @ 3.1 say "apre "+str(gnErrFile)
   @ 4.1 say "Titolo: "+Alltrim(mTitol)+space(50)
   boh=FPUTS(gnErrFile, mTitol)
   @ 5.1 say "scrive "+str(boh)+str(gnErrFile)+space(50)
ENDIF
boh=FCLOSE(gnErrFile)  && Close file
IF boh
   @ 6.1 say "chiuso 
ELSE
   @ 6.1 say "no chiuso 
ENDIF

* writes the other information for each file: write (where, what)
niente=scrivi(mIDA,mDescr)
niente=scrivi(mIDA1,mDe1)
niente=scrivi(mIDA2,mDe2)
niente=scrivi(mIDA3,mDe3)
niente=scrivi(mIDA4,mDe4)
niente=scrivi(mIDC,mPerfFut)
niente=scrivi(mIDC1,mPF1)
niente=scrivi(mIDC2,mPF2)
niente=scrivi(mIDC3,mPF3)
niente=scrivi(mIDC4,mPF4)
niente=scrivi(mIDD,mChall)
niente=scrivi(mIDD1,mCh1)
niente=scrivi(mIDD2,mCh2)
niente=scrivi(mIDD3,mCh3)
niente=scrivi(mIDD4,mCh4)
niente=scrivi(mIDE,mCost)
niente=scrivi(mIDE1,mCo1)
niente=scrivi(mIDE2,mCo2)
niente=scrivi(mIDE3,mCo3)
niente=scrivi(mIDE4,mCo4)
niente=scrivi(mIDF,mAppi)
niente=scrivi(mIDF1,mDAp1)
niente=scrivi(mIDF2,mDAp2)
niente=scrivi(mIDF3,mDAp3)
niente=scrivi(mIDF4,mDAp4)
niente=scrivi(mIDG,mActor)
niente=scrivi(mIDG1,mAc1)
niente=scrivi(mIDG2,mAc2)
niente=scrivi(mIDG3,mAc3)
niente=scrivi(mIDG4,mAc4)
niente=scrivi(mIDH,mLink)
niente=scrivi(mIDH1,mLi1)
niente=scrivi(mIDH2,mLi2)
niente=scrivi(mIDH3,mLi3)
niente=scrivi(mIDH4,mLi4)
niente=scrivi(mIDI,mIST)
niente=scrivi(mIDI1,mIs1)
niente=scrivi(mIDI2,mIS2)
niente=scrivi(mIDI3,mIs3)
niente=scrivi(mIDI4,mIs4)
niente=scrivi(mIDJ,mCountries)
niente=scrivi(mIDJ1,mCn1)
niente=scrivi(mIDJ2,mCn2)
niente=scrivi(mIDJ3,mCn3)
niente=scrivi(mIDJ4,mCn4)

* Creates the files that will hold the Array in order to check the time layers
* use the same variables because just need to create and then close the
file that will be used

mFArr_a=’C:\Dallamura2003\_Lavoro\Fistera\website\php\A_aTtl’+mID+.txt’ &&

TTL e ICO 2003

  gnErrFile = FCREATE(mFArr_a,0)
  boh=FCLOSE(gnErrFile)

mFArr_b=’C:\Dallamura2003\_Lavoro\Fistera\website\php\A_bTtl’+mID+.txt’ &&

TTL e ICO 2008

  gnErrFile = FCREATE(mFArr_b,0)
  boh=FCLOSE(gnErrFile)

mFArr_c=’C:\Dallamura2003\_Lavoro\Fistera\website\php\A_cTtl’+mID+.txt’ &&

TTL e ICO 2020

  gnErrFile = FCREATE(mFArr_c,0)
  boh=FCLOSE(gnErrFile)

* ____________________________________________________
* Name the TTL objects for the years that will appear in the Array

mTtl_a=’”ttl_a’ +mId+ ‘”’

mTtl_b=’”ttl_b’ +mId+ ‘”’

mTtl_c=’”ttl_c’ +mId+ ‘”’

* ____________________________________________________
* create the names of the files:  Ttl - Lin - Ico - Reg (mID is the one used for the
caller item)

mFTtl=’C:\Dallamura2003\_Lavoro\Fistera\website\php\Ttl’ +mID+.txt’

  gnErrFile = FCREATE(mFTtl,0)  && If not, create it
  boh=FCLOSE(gnErrFile)

mFLin=’C:\Dallamura2003\_Lavoro\Fistera\website\php\Lin’ +mID+.txt’

  gnErrFile = FCREATE(mFLin,0)  && If not, create it
  boh=FCLOSE(gnErrFile)

mFIco=’C:\Dallamura2003\_Lavoro\Fistera\website\php\Ico’ +mID+.txt’

  gnErrFile = FCREATE(mFIco,0)  && If not, create it
  boh=FCLOSE(gnErrFile)

mFReg=’C:\Dallamura2003\_Lavoro\Fistera\website\php\Reg’ +mID+.txt’

  gnErrFile = FCREATE(mFReg,0)  && If not, create it
  boh=FCLOSE(gnErrFile)

* ____________________________________________________
* write Ttl bas efile (corresponding to the left)
* IF !FILE(mFTip)  && Does file exist?
  gnErrFile = FCREATE(mFTtl,0)  && If not, create it
  @ 1,1  say "crea file “+str(gnErrFile)
  boh=FCLOSE(gnErrFile)
IF boh
@ 2,1 say "chiuso"
ELSE
   @ 2,1 say "no chiuso"
ENDIF

* ENDIF

gnErrFile = FOPEN(mFTtl,2) && If so, open read-write
IF gnErrFile < 0 && Check for error opening file
   @ 3,1 say 'Cannot open file '+str(gnErrFile)
ELSE && If no error, write to file
   @ 3,1 say "apre"+str(gnErrFile)
   @ 4,1 say "Titolo:"+Alltrim(mTitol)
   mSize=FSEEK(gnErrFile,0,2)
   boh=FPUTS(gnErrFile,mRigaTtl_a)
   boh=FPUTS(gnErrFile,mRigaTtl_b)
   boh=FPUTS(gnErrFile,mRigaTtl_c)
   @ 5,1 say "scrive"+str(boh)+str(gnErrFile)
ENDIF

boh=FCLOSE(gnErrFile) && Close file
IF boh
   @ 6,1 say "chiuso"
ELSE
   @ 6,1 say "no chiuso"
ENDIF

* =======================================================
* write in the Array the name of TTL Base objects
ScriviArray(mFArr_a,mTtl_a)
ScriviArray(mFArr_b,mTtl_b)
ScriviArray(mFArr_c,mTtl_c)
* =======================================================

select 2
* search for the relationships
* If at least one relationship is found
seek mID
if leof() 
   * remembers how many relationships there are and in which layers
      mQti_Aa=0
      mQti_Sa=0
      mQti_Fa=0
      mQti_Ta=0
      mQti_Ab=0
      mQti_Sb=0
      mQti_Fb=0
      mQti_Tb=0
      mQti_Ac=0
      mQti_Sc=0
      mQti_Fc=0
      mQti_Tc=0
      mNum_Aa=0
      mNum_Sa=0
      mNum_Fa=0
      mNum_Ta=0
      mNum_Ab=0
      mNum_Sb=0
      mNum_Fb=0
      mNum_Tb=0
mNum_Ac=0
mNum_Sc=0
mNum_Fc=0
mNum_Tc=0

do while mID=right('00000'+Alltrim(Str(Id_voce)),5)
do case
  case Voci_2_1_l=1 and (Id_anno=1 or Id_anno=0)
    mQti_Aa=mQti_Aa+1
  case Voci_2_1_l=1 and Id_anno=2
    mQti_Ab=mQti_Ab+1
  case Voci_2_1_l=1 and Id_anno=3
    mQti_Ac=mQti_Ac+1
  case Voci_2_1_l=2 and (Id_anno=1 or Id_anno=0)
    mQti_Sa=mQti_Sa+1
  case Voci_2_1_l=2 and Id_anno=2
    mQti_Sb=mQti_Sb+1
  case Voci_2_1_l=2 and Id_anno=3
    mQti_Sc=mQti_Sc+1
  case Voci_2_1_l=3 and (Id_anno=1 or Id_anno=0)
    mQti_Fa=mQti_Fa+1
  case Voci_2_1_l=3 and Id_anno=2
    mQti_Fb=mQti_Fb+1
  case Voci_2_1_l=3 and Id_anno=3
    mQti_Fc=mQti_Fc+1
  case Voci_2_1_l=4 and (Id_anno=1 or Id_anno=0)
    mQti_Ta=mQti_Ta+1
  case Voci_2_1_l=4 and Id_anno=2
    mQti_Tb=mQti_Tb+1
  case Voci_2_1_l=4 and Id_anno=3
    mQti_Tc=mQti_Tc+1
endcase
skip
do while mID=right('00000'+Alltrim(Str(Id_voce)),5)
do case
  case Voci_2_1_l=1 and (Id_anno=1 or Id_anno=0)
    mQti_Aa=mQti_Aa+1
  case Voci_2_1_l=1 and Id_anno=2
    mQti_Ab=mQti_Ab+1
  case Voci_2_1_l=1 and Id_anno=3
    mQti_Ac=mQti_Ac+1
  case Voci_2_1_l=2 and (Id_anno=1 or Id_anno=0)
    mQti_Sa=mQti_Sa+1
  case Voci_2_1_l=2 and Id_anno=2
    mQti_Sb=mQti_Sb+1
  case Voci_2_1_l=2 and Id_anno=3
    mQti_Sc=mQti_Sc+1
  case Voci_2_1_l=3 and (Id_anno=1 or Id_anno=0)
    mQti_Fa=mQti_Fa+1
  case Voci_2_1_l=3 and Id_anno=2
    mQti_Fb=mQti_Fb+1
  case Voci_2_1_l=3 and Id_anno=3
    mQti_Fc=mQti_Fc+1
  case Voci_2_1_l=4 and (Id_anno=1 or Id_anno=0)
    mQti_Ta=mQti_Ta+1
  case Voci_2_1_l=4 and Id_anno=2
    mQti_Tb=mQti_Tb+1
  case Voci_2_1_l=4 and Id_anno=3
    mQti_Tc=mQti_Tc+1
endcase
skip
seek mID

della regola
mID_reg=right('00000'+Alltrim(Str(Id_reg)),5) && ID
della voce chiamata
mTitol2=alltrim(Voci_2_1_t)
&& Titolo
mLayer2=alltrim(str(Voci_2_1_l))
&& Layer
mldLega=alltrim(str(Id_legame)) && Id_legame
mLega =alltrim(legame)
&& Legame
mTipo =alltrim(Tipo)
&& Tipo (attivo,passivo)
mNote =alltrim(note)
&& Note
mSpes =alltrim(str(Id_peso))
&& Spessore linea di collegamento
if mSpes="0"

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mSpes="1"
endif
mAnno =alltrim(str(Id_anno))
&& Anno di riferimento
if mAnno="0"
   mAnno="1"
endif
mVol2003=Alltrim(str(Vol2003))
mVol2008=Alltrim(str(Vol2008))
mVol2020=Alltrim(str(Vol2020))
mAlter=Alltrim(Alter)
mBorder=iif(Aggr_1,"1","0")
mTtlCol="#FFFFFF"
Do case
   case mAlter="1"
      mTtlCol="#FFCCFF"
   case mAlter="2"
      mTtlCol="#CCCCFF"
   case mAlter="3"
      mTtlCol="#00FFFF"
   case mAlter="4"
      mTtlCol="#66FFCC"
   case mAlter="5"
      mTtlCol="#CCFF00"
   case mAlter="6"
      mTtlCol="#CCFF99"
Endcase

* defines the coordinates of the position of the object in the
* on the basis of the layer to which it belongs and the num.progr
given
mXsx=339
mXdx=888
do case
* ---- LAYER AMBIENTS ------
case mLayer2="1" and mAnno="1"
   mNum_Aa=mNum_Aa+1
   mCooX=((mXdx-
mXsx)/(mQti_Aa+1)+1)*mNum_Aa)+mXsx
   mCooY=335-mKost
   If mod(mNum_Aa,2)=0
      mCooY=mCooY+35
   endif
case mLayer2="1" and mAnno="2"
   mNum_Ab=mNum_Ab+1
   mCooX=((mXdx-
mXsx)/(mQti_Ab+1)+1)*mNum_Ab)+mXsx
   mCooY=335-mKost
   If mod(mNum_Ab,2)=0
      mCooY=mCooY+35
   endif
case mLayer2="1" and mAnno="3"
   mNum_Ac=mNum_Ac+1
   mCooX=((mXdx-
mXsx)/(mQti_Ac+1)+1)*mNum_Ac)+mXsx
   mCooY=335-mKost
   If mod(mNum_Ac,2)=0
      mCooY=mCooY+35
   endif
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mCooY=mCooY+35
endif

* ---- LAYER SERVICES ------
case mLayer2="2" and mAnno="1"
mNum_Sa=mNum_Sa+1
mCooX=((mXdx-
mXsx)/(mQti_Sa+1)+1)*mNum_Sa)+mXsx
mCooY=420-mKost
if mod(mNum_Sa,2)=0
  mCooY=mCooY+35
endif
case mLayer2="2" and mAnno="2"
mNum_Sb=mNum_Sb+1
mCooX=((mXdx-
mXsx)/(mQti_Sb+1)+1)*mNum_Sb)+mXsx
mCooY=420-mKost
if mod(mNum_Sb,2)=0
  mCooY=mCooY+35
endif
case mLayer2="2" and mAnno="3"
mNum_Sc=mNum_Sc+1
mCooX=((mXdx-
mXsx)/(mQti_Sc+1)+1)*mNum_Sc)+mXsx
mCooY=420-mKost
if mod(mNum_Sc,2)=0
  mCooY=mCooY+35
endif

* ---- LAYER FUNCTIONALITIES ------
case mLayer2="3" and mAnno="1"
mNum_Fa=mNum_Fa+1
mCooX=((mXdx-
mXsx)/(mQti_Fa+1)+1)*mNum_Fa)+mXsx
mCooY=680-mKost
if mod(mNum_Fa,2)=0
  mCooY=mCooY+35
endif
case mLayer2="3" and mAnno="2"
mNum_FB=mNum_FB+1
mCooX=((mXdx-
mXsx)/(mQti_FB+1)+1)*mNum_FB)+mXsx
mCooY=680-mKost
if mod(mNum_FB,2)=0
  mCooY=mCooY+35
endif
case mLayer2="3" and mAnno="3"
mNum_Fc=mNum_Fc+1
mCooX=((mXdx-
mXsx)/(mQti_Fc+1)+1)*mNum_Fc)+mXsx
mCooY=680-mKost
if mod(mNum_Fc,2)=0
  mCooY=mCooY+35
endif

* ---- LAYER TECHNOLOGIES ------
case mLayer2="4" and mAnno="1"
mNum_Ta=mNum_Ta+1
mCooX=((mXdx-
mXsx)/(mQti_Ta+1)+1)*mNum_Ta)+mXsx
mCooY=850-mKost
if mod(mNum_Ta,2)=0

mCooY=mCooY+35
endif

case mLayer2="4" and mAnno="2"
mNum_Tb=mNum_Tb+1
mCooX=((mXdx-
mXsx)/(mQti_Tb+1)+1)*mNum_Tb)+mXsx
mCooY=850-mKost
if mod(mNum_Tb,2)=0
mCooY=mCooY+35
endif

case mLayer2="4" and mAnno="3"
mNum_Tc=mNum_Tc+1
mCooX=((mXdx-
mXsx)/(mQti_Tc+1)+1)*mNum_Tc)+mXsx
mCooY=850-mKost
if mod(mNum_Tc,2)=0
mCooY=mCooY+35
endif

case mLayer2="4" and mAnno="4"
mNum_Tb=mNum_Tb+1
mCooX=((mXdx-
mXsx)/(mQti_Tb+1)+1)*mNum_Tb)+mXsx
mCooY=850-mKost
if mod(mNum_Tb,2)=0
mCooY=mCooY+35
endif

case mLayer2="4" and mAnno="5"
mNum_Tc=mNum_Tc+1
mCooX=((mXdx-
mXsx)/(mQti_Tc+1)+1)*mNum_Tc)+mXsx
mCooY=850-mKost
if mod(mNum_Tc,2)=0
mCooY=mCooY+35
endif

case mLayer2="4" and mAnno="6"
mNum_Tb=mNum_Tb+1
mCooX=((mXdx-
mXsx)/(mQti_Tb+1)+1)*mNum_Tb)+mXsx
mCooY=850-mKost
if mod(mNum_Tb,2)=0
mCooY=mCooY+35
endif

case mLayer2="4" and mAnno="7"
mNum_Tc=mNum_Tc+1
mCooX=((mXdx-
mXsx)/(mQti_Tc+1)+1)*mNum_Tc)+mXsx
mCooY=850-mKost
if mod(mNum_Tc,2)=0
mCooY=mCooY+35
endif

case mLayer2="4" and mAnno="8"
mNum_Tb=mNum_Tb+1
mCooX=((mXdx-
mXsx)/(mQti_Tb+1)+1)*mNum_Tb)+mXsx
mCooY=850-mKost
if mod(mNum_Tb,2)=0
mCooY=mCooY+35
endif

case mLayer2="4" and mAnno="9"
mNum_Tc=mNum_Tc+1
mCooX=((mXdx-
mXsx)/(mQti_Tc+1)+1)*mNum_Tc)+mXsx
mCooY=850-mKost
if mod(mNum_Tc,2)=0
mCooY=mCooY+35
endif

case mLayer2="4" and mAnno="10"
mNum_Tb=mNum_Tb+1
mCooX=((mXdx-
mXsx)/(mQti_Tb+1)+1)*mNum_Tb)+mXsx
mCooY=850-mKost
if mod(mNum_Tb,2)=0
mCooY=mCooY+35
endif

case mLayer2="4" and mAnno="11"
mNum_Tc=mNum_Tc+1
mCooX=((mXdx-
mXsx)/(mQti_Tc+1)+1)*mNum_Tc)+mXsx
mCooY=850-mKost
if mod(mNum_Tc,2)=0
mCooY=mCooY+35
endif

endcase

m_CooX=alltrim(str(mCooX))
m_CooY=alltrim(str(mCooY))

* creates the levels of the objects (Ttl) link to the temporal layers *

=================================================================================================

mRiga1="

mRiga2="<a href="techno03.php?id=' + mID2 + '&ly=' + mLayer2 + " onMouseover="showTip('mRiga3="tip" + mID2"
mRiga4=""+" ONMOUSEOUT="hideTip('"
mRiga5=""+mID2 + "")" + "'>"
mRiga6=""
mTtl_a=""" mTtl_b=""" mTtl_c=""" S_riga=1
Do case

" onmouseover="showTip"

mRiga1='"<div id="ttl_a' +mID2+ " class="ttl" style="left: ' +m_CooX+ 'px; top: ' + m_CooY+ 'px;"'><table width="100%" border=""+mBorder+"" height="20"
bcolor=""+mTtlCol+"">"<tr><td align="center" valign="middle">

mRiga6='"<font face="Verdana, Arial, Helvetica, sans-serif" size="1" >' + mTitol2 + ' (b) +mVol2003+ '</b>')</font></a></td><tr></table></div>'
mTtl_a='"' mTtl_b='" select 3

seek mTtl_a
if !found()
append blank
replace Oggetto with mTtl_a
replace Num with S_riga
replace XB with mBCooX
replace YB with mBCooY
replace X with mCooX
replace Y with mCooY
else
replace Num with Num+1
mTtl_a='"
S_riga=0
endif
select 2
case mAnno=“2"
  mRiga1 = '<div id="ttl_b" +mID2+ " class="ttl" style="left: ' +m_CooX+ 'px; top: ' + m_CooY+ 'px;">\t<table width="100%" border=""+mBorder+" height="20"
  bgcolor=""+mTtlCol+"">\tr><td align="center" valign="middle">" +mTitol2 + ' (<b>' +mVol2008+ '</b>)</td></tr></table></div>'
  mRiga6 = '<font face="Verdana, Arial, Helvetica, sans-serif" size="1">' + mTitol2 + '<b>' +mVol2008+ '</b></font>'
  select 3
  seek mTtl_b
  if ffound()
    mTtl_b = "" +mTitol2 + '<b>' +mVol2008+ '</b></font>
  else
    replace Num with Num+1
    mTtl_b = ""
  endif
endcase
mRigaTtl = mRiga1 + mRiga2 + mRiga3 + mRiga4 + mRiga5 + mRiga6

* creates the relationship links

* drawLine(‘lin_a’,702+50,768,363+50,897,’#cc0033’,4);
if Tipo
  mColore = iif(mTipo=“ACTIVE”,”#cc0033”,”#FFFF00”)
endif
mRiga1=""
do case
case mAnno="1"
mRiga1="drawLine('lin_a'," +alltrim(str(mCooX+50))+ "," +m_CooY+ "," +alltrim(str(mCooX+50))+ "," +m_BCooY+ ")+" +mColore+ "," +mSpes+ ";");"
case mAnno="2"
mRiga1="drawLine('lin_b'," +alltrim(str(mCooX+50))+ "," +m_CooY+ "," +alltrim(str(mCooX+50))+ "," +m_BCooY+ ")+" +mColore+ "," +mSpes+ ";");"
case mAnno="3"
mRiga1="drawLine('lin_c'," +alltrim(str(mCooX+50))+ "," +m_CooY+ "," +alltrim(str(mCooX+50))+ "," +m_BCooY+ ")+" +mColore+ "," +mSpes+ ";");"
endcase
mRigaLin=mRiga1

* defines the position coordinates of the rule (ico)
*
==========================================================
* <div id="ico_a00001" class="ico" style="left: 580px; top: 830px;">*
* <a href="javascript:void(0)"
onMouseover="(showTip('reg00001'))" ONMOUSEOUT="hideTip('reg00001')">
* <img name="regola" src="ima/regola.gif" border="0" width="15"></a></div>

mFact=7 && correzione: shift del centro dell'icona
m_ZCooX=alltrim(str(((mBCooX-mCooX)/2+mCooX)+50 -mFact))
m_ZCooY=alltrim(str(((mBCooY -mCooY)/2+mCooY)-mFact))
mDe=0
Xa=0
Ya=0
select 3
set exact off
do case
case mAnno="1"
seek ',”ttl_a' +mId2+ ""
case mAnno="2"
seek ',”ttl_b' +mId2+ ""
case mAnno="3"
seek ',”ttl_c' +mId2+ ""
endcase
if found()
if Num >1
mDe=(XB -X)/(YB-Y)
Xa=16*(Num -1)*mDe
Ya=16*(Num -1)
m_ZCooX=alltrim(str( ((XB -X)/2+X)+50 -mFact+Xa) )
m_ZCooY=alltrim(str( ((YB -Y)/2+Y)-mFact+Ya) )
endif
endif
set exact on

select 4
&& Index on
right('00000'+Alltrim(Str(Id_voce)),5)+right('00000'+Alltrim(Str(Id_voce2)),5)+Alltrim(str(Id_Legame ))+Alltrim(str(Id_Anno)) to NewsLega
seek mId+mID2+mIdLega+mAnno
if !eof()
mNews="javascript:MM_openBrWindow('newslist.php?id="+right('00000'+Alltrim(Str(Id_rg))
),5)"

mNews=mNews+","Internet","scrollbars=yes,resizable=yes,width=400,height=400"+')"
else
  mNews='javascript:void(0)'
endif

select 2
mRiga1="" 
mlco_a="" 
mlco_b="" 
mlco_c=""
Do case
  case mAnno="1"
    mRiga1=<div id="ico_a" +mID_reg+ "" class="ico"
    mlco_a=","ico_a" +mID_reg+ ""
  case mAnno="2"
    mRiga1=<div id="ico_b" +mID_reg+ "" class="ico"
    mlco_b=",ico_b" +mID_reg+ ""
  case mAnno="3"
    mRiga1=<div id="ico_c" +mID_reg+ "" class="ico"
  endcase

mRiga2=</a></div>

mRigaIco= mRiga1 + mRiga2 + mRiga3

* defines the contents of the rule (ico)

========================================================================
* <div id="reg00001" class="reg"><table bgcolor="#00FF99"
width="200" border="1"><tr><td><font face="Verdana, Arial, Helvetica, sans-serif" size="1"><b>
* Titolo del legame: Enhances the functionality...
* </b></td></tr></table></div>

mRiga1=</a></div>

mRiga2=</a></div>

mRiga4=</font></td></tr></table></div>"
mRigaReg = mRiga1 + mRiga2 + mRiga3 + mRiga4

* writes in the File-Array the name of the derived TTL objects
* the variable is empty only if the object is multiple (already present)

if !empty(mTtl_a)
    ScriviArray(mFArr_a,mTtl_a)
endif
if !empty(mTtl_b)
    ScriviArray(mFArr_b,mTtl_b)
endif
if !empty(mTtl_c)
    ScriviArray(mFArr_c,mTtl_c)
endif

* writes the TTL file of the linked objects

if S_riga=1
    gnErrFile = FOPEN(mFTtl,2) &
    IF gnErrFile < 0 &
        @ 3,1 say 'Cannot open file ' +str(gnErrFile)
    ELSE &
        @ 3,1 say 'apre ' +str(gnErrFile)
        @ 4,1 say 'Titolo: ' +Alltrim(mTitol)
        mSize=FSEEK(gnErrFile, 0, 2)
        boh=FPUTS(gnErrFile, mRigaTtl)
        @ 5,1 say 'scrive ' +str(boh)+str(gnErrFile)
    ENDIF

    boh=FCLOSE(gnErrFile) &
    IF boh
        @ 6,1 say "chiuso 
    ELSE
        @ 6,1 say "no chiuso 
   ENDIF
* writes the relationship links file of the linked objects

if S_riga=1
    gnErrFile = FOPEN(mFLin,2) &
    IF gnErrFile < 0 &
        @ 3,1 say 'Cannot open file ' +str(gnErrFile)
    ELSE &
        @ 3,1 say 'apre ' +str(gnErrFile)
        @ 4,1 say 'Titolo: ' +Alltrim(mTitol)
        mSize=FSEEK(gnErrFile, 0, 2)
        boh=FPUTS(gnErrFile, mRigaLin)
        @ 5,1 say 'scrive ' +str(boh)+str(gnErrFile)
    ENDIF

    boh=FCLOSE(gnErrFile) &
    IF boh
        @ 6,1 say "chiuso 
    ELSE
        @ 6,1 say "no chiuso 
   ENDIF
*
IF boh
  @ 6,1  say "chiuso ":
ELSE
  @ 6,1  say "no chiuso ":
ENDIF

* writes in the File-Array the name of the derived ICO objects
if !empty(mlco_a)
  ScriviArray(mFArr_a,mlco_a)
endif
if !empty(mlco_b)
  ScriviArray(mFArr_b,mlco_b)
endif
if !empty(mlco_c)
  ScriviArray(mFArr_c,mlco_c)
endif

* writes the Ico file on the lines
gnErrFile = FOPEN(mFlco,2) && If so, open read-write
IF gnErrFile < 0 && Check for error opening file
  @ 3,1  say 'Cannot open file '+str(gnErrFile)
ELSE && If no error, write to file
  @ 3,1  say "apre "+str(gnErrFile)
  @ 4,1  say "Titolo: "+Alltrim(mTitolo)
  mSize=FSEEK(gnErrFile, 0, 2)
  boh=FPUTS(gnErrFile, mRigaIco)
  @ 5,1  say "scrive "+str(boh)+str(gnErrFile)
ENDIF
boh=FCLOSE(gnErrFile) && Close file
IF boh
  @ 6,1  say "chiuso ":
ELSE
  @ 6,1  say "no chiuso ":
ENDIF

* writes the Reg file on the lines
gnErrFile = FOPEN(mFReg,2) && If so, open read-write
IF gnErrFile < 0 && Check for error opening file
  @ 3,1  say 'Cannot open file '+str(gnErrFile)
ELSE && If no error, write to file
  @ 3,1  say "apre "+str(gnErrFile)
  @ 4,1  say "Titolo: "+Alltrim(mTitolo)
  mSize=FSEEK(gnErrFile, 0, 2)
  boh=FPUTS(gnErrFile, mRigaReg)
  @ 5,1  say "scrive "+str(boh)+str(gnErrFile)
ENDIF
boh=FCLOSE(gnErrFile) && Close file
IF boh
   @ 6,1  say "chiuso 
ELSE
   @ 6,1  say "no chiuso 
ENDIF
*
=================================================================

skip
enddo
endif
SELECT 1
* reads another Technology
   @ 10,1  say "rec: "+str(recno())
endif
*
* cancels the empty files
* --------------------------
mDim=FSIZE2(mIdT )
   if mDim<=2
      Delete file &mIdT
   endif

mDim=FSIZE2(mIdA )
   if mDim<=2
      Delete file &mIdA
   endif

mDim=FSIZE2(mIdA1)
   if mDim<=2
      Delete file &mIdA1
   endif

mDim=FSIZE2(mIdA2)
   if mDim<=2
      Delete file &mIdA2
   endif

mDim=FSIZE2(mIdA3)
   if mDim<=2
      Delete file &mIdA3
   endif

mDim=FSIZE2(mIdA4)
   if mDim<=2
      Delete file &mIdA4
   endif

mDim=FSIZE2(mIdC )
   if mDim<=2
      Delete file &mIdC
   endif

mDim=FSIZE2(mIdC1)
   if mDim<=2
      Delete file &mIdC1
   endif

mDim=FSIZE2(mIdC2)
   if mDim<=2
      Delete file &mIdC2
   endif

mDim=FSIZE2(mIdC3)
   if mDim<=2
Delete file &mIdC3
endif
mDim=FSIZE2(mIdC4)
if mDim<=2
    Delete file &mIdC4
endif
mDim=FSIZE2(mIdD)
if mDim<=2
    Delete file &mIdD
endif
mDim=FSIZE2(mIdD1)
if mDim<=2
    Delete file &mIdD1
endif
mDim=FSIZE2(mIdD2)
if mDim<=2
    Delete file &mIdD2
endif
mDim=FSIZE2(mIdD3)
if mDim<=2
    Delete file &mIdD3
endif
mDim=FSIZE2(mIdD4)
if mDim<=2
    Delete file &mIdD4
endif
mDim=FSIZE2(mIdE)
if mDim<=2
    Delete file &mIdE
endif
mDim=FSIZE2(mIdE1)
if mDim<=2
    Delete file &mIdE1
endif
mDim=FSIZE2(mIdE2)
if mDim<=2
    Delete file &mIdE2
endif
mDim=FSIZE2(mIdE3)
if mDim<=2
    Delete file &mIdE3
endif
mDim=FSIZE2(mIdE4)
if mDim<=2
    Delete file &mIdE4
endif
mDim=FSIZE2(mIdF)
if mDim<=2
    Delete file &mIdF
endif
mDim=FSIZE2(mIdF1)
if mDim<=2
    Delete file &mIdF1
endif
mDim=FSIZE2(mIdF2)
if mDim<=2
    Delete file &mIdF2
endif
mDim=FSIZE2(mIdF3)
if mDim<=2
  Delete file &mIdF3
endif
mDim=FSIZE2(mIdF4)
if mDim<=2
  Delete file &mIdF4
endif
mDim=FSIZE2(mIdG )
if mDim<=2
  Delete file &mIdG
endif
mDim=FSIZE2(mIdG1)
if mDim<=2
  Delete file &mIdG1
endif
mDim=FSIZE2(mIdG2)
if mDim<=2
  Delete file &mIdG2
endif
mDim=FSIZE2(mIdG3)
if mDim<=2
  Delete file &mIdG3
endif
mDim=FSIZE2(mIdG4)
if mDim<=2
  Delete file &mIdG4
endif
mDim=FSIZE2(mIdH )
if mDim<=2
  Delete file &mIdH
endif
mDim=FSIZE2(mIdH1)
if mDim<=2
  Delete file &mIdH1
endif
mDim=FSIZE2(mIdH2)
if mDim<=2
  Delete file &mIdH2
endif
mDim=FSIZE2(mIdH3)
if mDim<=2
  Delete file &mIdH3
endif
mDim=FSIZE2(mIdH4)
if mDim<=2
  Delete file &mIdH4
endif
mDim=FSIZE2(mIdI )
if mDim<=2
  Delete file &mIdI
endif
mDim=FSIZE2(mIdI1)
if mDim<=2
  Delete file &mIdI1
endif
mDim=FSIZE2(mIdI2)
if mDim<=2
  Delete file &mIdI2
endif
mDim=FSIZE2(mIdI3)
if mDim<=2
    Delete file &mIdI3
endif
mDim=FSIZE2(mIdI4)
if mDim<=2
    Delete file &mIdI4
endif
mDim=FSIZE2(mIdJ)
if mDim<=2
    Delete file &mIdJ
endif
mDim=FSIZE2(mIdJ1)
if mDim<=2
    Delete file &mIdJ1
endif
mDim=FSIZE2(mIdJ2)
if mDim<=2
    Delete file &mIdJ2
endif
mDim=FSIZE2(mIdJ3)
if mDim<=2
    Delete file &mIdJ3
endif
mDim=FSIZE2(mIdJ4)
if mDim<=2
    Delete file &mIdJ4
endif
* -----------------------------
mDim=FSIZE2(mFTtl)
if mDim<=2
    Delete file &mFTtl
endif
mDim=FSIZE2(mFLin)
if mDim<=2
    Delete file &mFLin
endif
mDim=FSIZE2(mFlco)
if mDim<=2
    Delete file &mFlco
endif
mDim=FSIZE2(mFReg)
if mDim<=2
    Delete file &mFReg
endif
* -----------------------------
skip
ENDDO
CLOSE DATABASES
Close All

* -------------- treatment of the strings and text
Function Testo(mTesto)
    mDescr=mTesto
    mLDescr=""
    mKey=""

mKQd=""
mW=1
conta=1
mDescr=strtran(mDescr,chr(13)+chr(10),"<br>")
do while mW>=1
  *inkey(1)

  **** cerca la posizione della prima parentesi [
  mQdr=at("[",mDescr,1)
  **** cerca la posizione della prima parentesi ]
  mFiQd=at("]",mDescr,1)
  if mQdr>0
    **** se esiste la parentesi ] è corretto
    **** allora estrae la stringa che supporta l'url
    mKQd=substr(mDescr,mQdr+1,mFiQd-mQdr-1)
    **** ricompone la Descr togliendo [...] 
    mDescr=strtran(mDescr,[''+mKQd+']","")
  else
    **** se non esiste lo segnala
    mKQd="*******"
  endif
  *
  mDescr=left(mDescr,mQdr-1)+right(mDescr,len(mDescr)-mFiQd)

  * searches for the position of the umpteenth (mW) http
  mHttp=at("http",mDescr,mW)
  if mHttp=0
    * finished the search of all the http, concludes the Descr
    mLDescr=mLDescr+right(mDescr,len(mDescr)-len(mKey))
    Return mLDescr
    exit
  endif
  *
  * forgets about everything that precedes the umpteenth http found
  mLDescr=mLDescr+right(left(mDescr,mHttp-1),len(left(mDescr,mHttp-1))-len(mKey))
  mDescr=right(mDescr,len(mDescr)-mHttp+1)

  * searches for the position of the first occurrence of “parenthesis closed”
  mFine=at(")",mDescr,1)
  * extracts the word
  if mFine>0
    * if it exists it is correct
    * extracts the "url" string
    mKey=substr(mDescr,1,mFine-1)
    if at("http",mKey,2)>0
      * checks if the url has a sub-address and signals it
      mKey="--- "++mKey
    endif
  else
    * if it does not exist it signals it
    mKey="*******"
  endif
  *
  * updates which is the next available space
  if mW=1
    mW=mW+1
  endif
  conta=conta+1
  if mKQd="*******"
    mKQd=mKey
  endif
sostituto='<a href=""+mKey+"">'+mKQd+'</a>
" if(mKQd<>',mKQd,"link")
mLDescr=mLDescr+sostituto
enddo
* ----------------- End treatment of the strings and text

Function scrivi(Qfile,cosa)
* ------------- writes Descr file
* IF !FILE(Qfile) && Does file exist?
gnErrFile = FCREATE(Qfile,0) && If not, create it
  @ 1,1 say "crea file "+str(gnErrFile)
  boh=FCLOSE(gnErrFile)
  IF boh
    ELSE say "chiuso "
  ENDIF
* ENDIF
gnErrFile = FOPEN(Qfile,2) && If so, open read-write
  IF gnErrFile < 0 && Check for error opening file
    ELSE say "Cannot open file "+str(gnErrFile)
    boh=FPUTS(gnErrFile, Testo(cosa))
      ELSE say "scrive "+str(boh)+str(gnErrFile)
  ENDIF
boh=FCLOSE(gnErrFile) && Close file
  ELSE say "Chiuso 
  ENDIF
* ---------------- end, writes Descr

Function scriviArray(Qfile,Cosa)
  gnErrFile = FOPEN(Qfile,2) && If so, open read-write
  IF gnErrFile < 0 && Check for error opening file
    ELSE say "Cannot open file "+str(gnErrFile)
    ENDIF
boh=FCLOSE(gnErrFile) && Close file
  ELSE say "Chiuso 
  ENDIF
* ***************************************************************
FUNCTION fsize2
PARAMETERS gcFileName && File to be checked
PRIVATE pnHandle,pnSize
IF PARAMETERS( ) = 0
   RETURN -2  && Return -2 if no parameter passed
ELSE
   IF !FILE(gcFileName)
      RETURN -1  && Return -1 if file does not exist
   ENDIF
ENDIF
pnHandle = FOPEN(gcFileName)   && Open file
pnSize = FSEEK(pnHandle,0,2)   && Determine file size, assign to pnSize
=FCLOSE(pnHandle)  && Close file
RETURN pnSize  && Return value
Appendice B

HTML code / PHP / Javascript used in the web pages

Page: techno03.php

```html
<html>
<head>
<title>Fistera: Work Package 2</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
<style type="text/css">
.tip {position: absolute; visibility: hidden; z-index: 100;}
.ttl {position: absolute; visibility: hidden; z-index: 20; width:100px; height:20px;}
.ttb {position: absolute; visibility: hidden; z-index: 20; width:130px; height:20px;}
.reg {position: absolute; visibility: hidden; z-index: 100;}
.lin {position: absolute; visibility: hidden; z-index: 10; width:100px; height:100px;}
.ico {position: absolute; visibility: hidden; z-index:90; width:15px; height:15px;}
</style>
<script language="JavaScript">
<!--
function MM_reloadPage(init) { //reloads the window if Nav4 resized
  if (init==true) with (navigator) {if ((appName=="Netscape")&&(parseInt(appVersion)==4)) {
document.MM_pgW=innerWidth; document.MM_pgH=innerHeight; onresize=MM_reloadPage;
}
else if (innerWidth! = document.MM_pgW || innerHeight! = document.MM_pgH) location.reload();
}
MM_reloadPage(true);
// -->
</script>
<script language="JavaScript" src="overlib.js"></script>
<script language="JavaScript" src="js/JSFX_Layer.js"></script>
<script language="JavaScript" src="js/JSFX_Browser.js"></script>
<script language="JavaScript" src="js/wz_jsgraphics.js"></script>
<script language="JavaScript">
var myLayer;

function create()
{
    bgLayer = new JSFX.Layer("<IMG SRC='images/fx1.gif'>");
    bgLayer.setBgColor('#0000FF');
    bgLayer.setzIndex(2);
    bgLayer.show();
}
</script>
</head>
</html>
```
bgLayer.moveTo(80,100);
myLayer = new JSFX.Layer("<IMG SRC='images/fx1.gif'>");
myLayer.setzIndex(1);
myLayer.show();
myLayer.moveTo(100,100);
}
var theEvent = "onmouseover";

function addMouseDown()
{
    myLayer.addEventListener(theEvent, myHandler);
    // alert("Mouse Event Handler Added\nClick mouse over layer\nThis handler will be deleted in 10 seconds!!!");
    // setTimeout("removeMouseDown()", 5000);
}
function removeMouseDown()
{
    alert("The mouseDown event handler\nhas been removed");
    myLayer.removeEventListener(theEvent);
}
function myHandler(xl, ev)
{
    var str = "Event Object\n------------\n";
    str += "ev.type   = " + ev.type + "\n";
    str += "ev.button   = " + ev.button + "\n";
    str += "ev.layerX   = " + ev.layerX + "\n";
    str += "ev.layerY   = " + ev.layerY + "\n";
    str += "ev.clientX   = " + ev.clientX + "\n";
    str += "ev.clientY   = " + ev.clientY + "\n";
    str += "ev.screenX  = " + ev.screenX + "\n";
    str += "ev.screenY  = " + ev.screenY + "\n";
    str += "ev.keyCode  = " + ev.keyCode + "\n";
    str += "ev.altKey   = " + ev.altKey + "\n";
    str += "ev.ctrlKey   = " + ev.ctrlKey + "\n";
    str += "ev.shiftKey  = " + ev.shiftKey + "\n";
    alert(str);
}

var Anno_a = new Array;
<?php
if (file_exists("php/A_aTtl".$id.".txt"))
    {include("php/A_aTtl".$id.".txt");}?
);
var Anno_b = new Array;
<?php
if (file_exists("php/A_bTtl".$id.".txt"))
    {include("php/A_bTtl".$id.".txt");}?
);
var Anno_c = new Array;
<?php
if (file_exists("php/A_cTtl".$id.".txt"))
    {include("php/A_cTtl".$id.".txt");}?
);
function showTip(obj)
    {   if  (document.layers)
        {   if (document.layers[obj] != null) {document.layers[obj].visibility = 'visible';
            }
        }
    else
        if (document.all) {document.all[obj].style.left=JSFX.Browser.mouseX+20;
                    document.all[obj].style.top=JSFX.Browser.mouseY;
                    document.all[obj].style.visibility = 'visible';
        }
    function hideTip(obj)
    {   if  (document.layers)
        {   if (document.layers[obj] != null) document.layers[obj].visibility = 'hidden';
        }
    else
        if (document.all)
            document.all[obj].style.visibility = 'hidden';
    }  //--------------------------------------
function showTtl_a()
    {for (var i=1; i<document.all.length; i++)
        {if (document.all[i].id.substr(0,5)=='ttl_a')
            {document.all[i].style.visibility='visible';
            }
        }
    }
function showTtl_b()
    {for (var i=1; i<document.all.length; i++)
        {if (document.all[i].id.substr(0,5)=='ttl_b')
            {document.all[i].style.visibility='visible';
            }
        }
    }
function showTtl_c()
    {for (var i=1; i<document.all.length; i++)
        {if (document.all[i].id.substr(0,5)=='ttl_c')
            {document.all[i].style.visibility='visible';
            }
        }
    }
function hideTtl_a()
    {for (var i=1; i<document.all.length; i++)
        {if (document.all[i].id.substr(0,5)=='ttl_a')
            {document.all[i].style.visibility='hidden';
            }
        }
    }
function hideTtl_b()
    {for (var i=1; i<document.all.length; i++)
        {if (document.all[i].id.substr(0,5)=='ttl_b')
            {document.all[i].style.visibility='hidden';
            }
        }
    }
function hideTtl_c()
    {for (var i=1; i<document.all.length; i++)
        {if (document.all[i].id.substr(0,5)=='ttl_c')
            {document.all[i].style.visibility='hidden';
            }
        }
    }  }
function Show_a()
{
    for (var i=0; i<Anno_a.length; i++)
    {
        document.all[Anno_a[i]].style.visibility='visible';
    }
}

function Show_b()
{
    for (var i=0; i<Anno_b.length; i++)
    {
        document.all[Anno_b[i]].style.visibility='visible';
    }
}

function Show_c()
{
    for (var i=0; i<Anno_c.length; i++)
    {
        document.all[Anno_c[i]].style.visibility='visible';
    }
}

function Hide_a()
{
    for (var i=0; i<Anno_a.length; i++)
    {
        document.all[Anno_a[i]].style.visibility='hidden';
    }
}

function Hide_b()
{
    for (var i=0; i<Anno_b.length; i++)
    {
        document.all[Anno_b[i]].style.visibility='hidden';
    }
}

function Hide_c()
{
    for (var i=0; i<Anno_c.length; i++)
    {
        document.all[Anno_c[i]].style.visibility='hidden';
    }
}

function showIco_a()
{
    for (var i=1; i<document.all.length; i++)
    {
        if (document.all[i].id.substr(0,5)=='ico_a')
        {
            document.all[i].style.visibility='visible';
        }
    }
}

function showIco_b()
{
    for (var i=1; i<document.all.length; i++)
    {
        if (document.all[i].id.substr(0,5)=='ico_b')
        {
            document.all[i].style.visibility='visible';
        }
    }
}

function showIco_c()
{
    for (var i=1; i<document.all.length; i++)
    {
        if (document.all[i].id.substr(0,5)=='ico_c')
        {
            document.all[i].style.visibility='visible';
        }
    }
}

function hideIco_a()
turi.clip.left = cl + dx;
turi.clip.top = ct + dy;
turi.clip.right = cr + dx;
turi.clip.bottom = cb + dy;
turi.top = t - dy;
turi.left = l - dx;
}
else {
    if (document.all) {
        turi = eval("document.all." + bersaglio + ".style");
        if (turi.clip) {
            var clipv = turi.clip.split("rect(")[1].split("\"\")[0].split("px")
            var ct = Number(clipv[0]);
            var cr = Number(clipv[1]);
            var cb = Number(clipv[2]);
            var cl = Number(clipv[3]);
            var l = turi.pixelLeft;
            var t = turi.pixelTop;
            }
        ncl = cl + dx;
        nct = ct + dy;
        ncr = cr + dx;
        ncb = cb + dy;
        turi.pixelTop = t - dy;
        turi.pixelLeft = l - dx;
        eval("turi.clip = 'rect(' + nct + \" \" + ncr + \" \" + ncb + \" \" + ncl +\")\")
    }
}
tmt_scrollalo = setTimeout("tmt_scrollLayerBy" + bersaglio + \"\", + dx + \",\" + dy + ",\" + vel + \")", vel);
}
function tmt_stopScroll() {
    if (tmt_scrollalo) {
        clearTimeout(tmt_scrollalo);
    }
}

if (document.layers) {
    origWidth = innerWidth;
    origHeight = innerHeight;
    function reDo() {
        if (innerWidth != origWidth || innerHeight != origHeight)
            location.reload();
    }
    if (document.layers) onresize = reDo;
</SCRIPT>

<script>
/* Rollover effect on different image script -
By Website Abstraction (http://wsabstract.com)
Over 200+ free scripts here! */

function changeimage(towhat,url)

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if (document.images)
    document.images.targetimage.src=towhat.src
    gotolink=url

function warp()
    window.location=gotolink

</script>
<script language="JavaScript1.1">
    var myimages=new Array()
    var gotolink="#"

    function preloadimages()
        for (i=0;i<preloadimages.arguments.length;i++)
            myimages[i]=new Image()
            myimages[i].src=preloadimages.arguments[i]
    }

    preloadimages("ima/clessidra0.jpg","ima/clessidra1.jpg","ima/clessidra2.jpg","ima/clessidra3.jpg")
</script>

<script>
    <!--
        n = (document.layers) ? 1:0
        ie = (document.all) ? 1:0

        function drawLine(layer,x1,y1,x2,y2,color,stroke)
            { 
                var jg = new jsGraphics(layer);
                jg.setColor(color);
                jg.setStroke (stroke);
                jg.drawLine(x1, y1, x2, y2);
                jg.paint()
            }

        function spostCircolare(layer,raggio,incremento,init_angle, end_angle,speed) {
            var mylayer = new dynLayer(layer)
            mylayer.circle(raggio,incremento,init_angle, end_angle,speed)
        }

        function spostLineare(layer,newx,newy,inc,speed) {
            var mylayer = new dynLayer(layer)
            mylayer.linear(newx,newy,inc,speed)
        }

        // Dynamic Layer with Circle Method
        function dynLayer(id,nestref) {

```
if (n) {
    if (nestref) {
        this.css = eval("document." + nestref + ".document." + id)
        this.ref = eval("document." + nestref + ".document." + id + ".document")
    } else {
        this.css = document.layers[id]
        this.ref = document.layers[id].document
    }
    this.x = this.css.left
    this.y = this.css.top
} else if (ie) {
    this.css = document.all[id].style
    this.ref = document
    this.x = this.css.pixelLeft
    this.y = this.css.pixelTop
} this.obj = id + "Object"
eval(this.obj + "=" + this"")
this.moveBy = dynLayerMoveBy
this.moveTo = dynLayerMoveTo
this.show = dynLayerShow
this.hide = dynLayerHide
this.circle = dynLayerCircle
this.circleSlide = dynLayerCircleSlide
this.linear = moveSlow
this.linearSlide = moveSlowSlide
}
function dynLayerMoveBy(x,y) {
    this.x += x
    this.css.left = this.x
    this.y += y
    this.css.top = this.y
}
function dynLayerMoveTo(x,y) {
    // alert(x+" +y)
    this.x = x
    this.css.left = this.x
    this.y = y
    this.css.top = this.y
}
function moveSlow(x,y,inc,speed) {
    //alert(this.x +'-----' + this.y)

    if (!this.moveActive) {
        var sposty = y - this.y
        var spostx = x - this.x

        this.moveActive = 1

        this.linearSlide(x,y,inc,speed, spostx,sposty)
FISTERA – THEMATIC NETWORK – IST-2001 -37627

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}
}
function moveSlowSlide(x,y,inc,speed,spostx,sposty) {
var newy = this.y
var newx = this.x
if (spostx==0)
{
if (sposty>0)
newy = this.y+inc
else if (sposty<0)
newy = this.y-inc
}
else
{
if (spostx>0)
var newx = this.x+inc
else
var newx = this.x-inc
var coeff_angle = (sposty/spostx)
var coeff_zero = y - x*coeff_angle
var newy = newx*coeff_angle + coeff_zero
}

//alert('Moving from:\nx:'+this.x+'--- >'+newx+'\ ny:'+this.y+'--- >'+newy+'\nDestination: x'+x+' y'+y)

if (this.moveActive && ((sposty>0 && newy<=y) || (sposty<0 && newy>=y) || (sposty==0 &&
spostx>0 && newx <=x) || (sposty==0 && spostx<0 && newx >=x))) {
this.moveTo(newx,newy)

setTimeout(this.obj+".linearSlide("+x+","+y+","+inc+","+speed+","+spostx+","+sposty+")",s
peed)
}
else {
//

alert ('shutdown')
this.moveActive = 0

}
}

function dynLayerShow() {
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if (n) this.css.visibility = "show"
else if (ie) this.css.visibility = "visible"
}

function dynLayerHide() {
  if (n) this.css.visibility = "hide"
else if (ie) this.css.visibility = "hidden"
}

function dynLayerCircle(radius,angleinc,angle,endangle,speed,vertical,horizontal,fn) {
  if (!vertical) vertical = 1
  if (!horizontal) horizontal = 1
  if (!fn) fn = null
  if (!this.circleActive) {
    var centerX = this.x - horizontal*radius*Math.cos(angle*Math.PI/180)
    var centerY = this.y + vertical*radius*Math.sin(angle*Math.PI/180)
    if (endangle != null) {
      angleinc = Math.abs(angleinc)
      if (endangle < angle) angleinc *= -1
    }
    this.circleActive = 1
    this.circleSlide(radius,angleinc,angle,endangle,speed,vertical,horizontal,fn,centerX,centerY)
  }
  this.circleActive = 1
}

function dynLayerCircleSlide(radius,angleinc,angle,endangle,speed,vertical,horizontal,fn,centerX,centerY) {
  if (this.circleActive && (endangle == null || Math.abs(angleinc) < Math.abs(endangle - angle))) {
    angle += angleinc
    var x = centerX + horizontal*radius*Math.cos(angle*Math.PI/180)
    var y = centerY - vertical*radius*Math.sin(angle*Math.PI/180)
    this.moveTo(x,y)
    setTimeout(this.obj + ".circleSlide(\"+radius\",\"+angleinc\",\"+angle\",\"+endangle\",\"+speed\",\"+vertical\",\"+horizontal\",\"+fn\",\"+centerX\",\"+centerY\")\",speed)
  } else {
    this.circleActive = 0
    if (endangle != null) {
      var x = Math.round(centerX + horizontal*radius*Math.cos(endangle*Math.PI/180))
      var y = Math.round(centerY - vertical*radius*Math.sin(endangle*Math.PI/180))
      this.moveTo(x,y)
    }
    eval(fn)
  }
}

-->
</script>

<script>
<!--
n = (document.layers) ? 1:0
ie = (document.all) ? 1:0

function showLin(obj)
{
    if (n)
    {
        document.layers[obj].visibility = 'visible';
    }
    else if (ie)
    {
        document.all[obj].style.visibility = 'visible';
    }
}

function hideLin(obj)
{
    if (n)
    {
        document.layers[obj].visibility = 'hidden';
    }
    else if (ie)
    {
        document.all[obj].style.visibility = 'hidden';
    }
}

function prepare()
{
    <?php
    if (file_exists("php/Lin$Id$.txt"))
    {
        include("php/Lin$Id$.txt");
        echo "showLin('lin_a');";
    }
    echo "Show_a();";
    ?>

}

</script>


<LINK REL="stylesheet" HREF="overlib.css" TYPE="text/css">

</head>

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<table>
<thead>
<tr>
<th>Ambients:</th>
<th>Services:</th>
<th>Functionalities:</th>
<th>Technologies:</th>
</tr>
</thead>
</table>

Please, send us your comments on any of the listed aspects or on other topics.

What is it?:
Performance trends:
Challenges ahead:
Cost trends:
Application areas:
Main actors:

Keep an eye on... Disruptions... Ambients... Services... Functionalities... Technologies...
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Please, send us your comments on any of the listed aspects or on other topics.

- What is it?: ...
- Performance trends: ...
- Challenges ahead: ...
- Cost trends: ...
- Application areas: ...
- Main actors: ...

> Comments</a></b></font></div>
</td>
</tr>
</table>
</div>

<?php
switch ($ly)
{
    case 1:
        echo "Ambients: ";
        break;
    case 2:
        echo "Services: ";
        break;
    case 3:
        echo "Functionalities: ";
        break;
    case 4:
        echo "Technologies: ";
        break;
    default:
        echo "Unidentified layer ";
}
?>
<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ambients</td>
</tr>
<tr>
<td>2</td>
<td>Services</td>
</tr>
<tr>
<td>3</td>
<td>Functionalities</td>
</tr>
<tr>
<td>4</td>
<td>Technologies</td>
</tr>
<tr>
<td>5</td>
<td>Unidentified layer</td>
</tr>
</tbody>
</table>

(Low 1 2 3 4 5 High)
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Please, send us your comments on any of the listed aspects or on other topics.

What is it?
Performance trends:
Challenges ahead:
Cost trends:
Application areas:
Main actors:

">

Please, send us any comments or your opinion" border="0"></a></td></tr>
</table>
<p>
</p>
<p>&lt;font size="2" face="Verdana, Arial, Helvetica, sans-serif"&gt;&lt;a href="techno03.php?id=00000&ly=2"&gt;Services&lt;/a&gt;&lt;/font&gt;&lt;/p&gt;
<p>&lt;font size="2" face="Verdana, Arial, Helvetica, sans-serif"&gt;&lt;a href="techno03.php?id=00000&ly=3"&gt;Functionalities&lt;/a&gt;&lt;/font&gt;&lt;/p&gt;
<p>&lt;font size="2" face="Verdana, Arial, Helvetica, sans-serif"&gt;&lt;a href="techno03.php?id=00000&ly=4"&gt;Technologies&lt;/a&gt;&lt;/font&gt;&lt;/p&gt;
</p>
</div>
<div id="Layer2" style="position:absolute; width:95px; height:28px; z-index:2; left: 45px; top: 255px"><font face="Verdana, Arial, Helvetica, sans-serif" size="2"><a href="mailto:fistera@tilab.com?subject=Please%20send%20us%20your%20comments%20on%20any%20of%20the%20listed%20aspects%20or%20on%20other%20topics.">
</a>&lt;?php
switch ($ly)
{
case 1:
    $riga="Ambients > ";
    break;
case 2:
    echo "Services > ";
    break;
case 3:
    echo "Functionalities > ";
    break;
case 4:
    echo "Technologies > ";
    break;
default:
    echo "Unidentified layer > ";
}
if (file_exists("php/tech_".$id."T.txt"))
{
    $fp=fopen("php/tech_".$id."T.txt","r");
    $techno=fgets($fp,filesize("php/tech_".$id."T.txt"));
    fclose($fp);
}
echo $riga.$techno;
?>
&body=

Please, send us your comments on any of the listed aspects or on other topics.

What is it?:
Performance trends:
Challenges ahead:
Cost trends:
Application areas:
Main actors:

News monitoring:

Comments

<?php
switch ($ly)
{
case 1:
    echo "Ambients: ";
    break;

case 2:
    echo "Services: ";
    break;

case 3:
    echo "Functionalities: ";
    break;

case 4:
    echo "Technologies: ";
    break;

default:
    echo "Unidentified layer ";
}
if (file_exists("php/tech_".$id.".T.txt"))
    include("php/tech_".$id.".T.txt");
?>

<table width="100%" border="0">
<tr>
<td width="50%">
<ul>
<li><div align="left"><font size="2"><i><font face="Verdana, Arial, Helvetica, sans-serif" color="#666666">
<?php
    $stringa='<A href="tech_ndx.php?id='.$id.'&ly='.$ly.'#A">What is it?</a>';
    echo $stringa;
    ?>
</font></i></font></div></li>
<li><div align="left"><font size="2"><i><font face="Verdana, Arial, Helvetica, sans-serif" color="#666666">
<?php
    $stringa='<A href="tech_ndx.php?id='.$id.'&ly='.$ly.'#A">Performance trends</a>';
    echo $stringa;
    ?>
</font></i></font></div></li>
<li><div align="left"><font size="2"><i><font face="Verdana, Arial, Helvetica, sans-serif" color="#666666">
<?php
    $stringa='<A href="tech_ndx.php?id='.$id.'&ly='.$ly.'#A">Challenges ahead</a>';
    echo $stringa;
    ?></font></i></font></div></li>
</ul>
</td>
</tr>
</table>
echo $stringa;
?>
</font></i></font></div>
</li>
<li>
<div align="left"><font size="2"><i><font face="Verdana, Arial, Helvetica, sans-serif"
color="#666666">
<?php $stringa='<A href="tech_ndx.php?id='.$id.'&ly='.$ly.'#E">Cost trends</a>'; echo $stringa; ?>
</font></i></font></div>
</li>
<li>
<div align="left"><font size="2"><i><font face="Verdana, Arial, Helvetica, sans-serif"
color="#666666">
<?php $stringa='<A href="tech_ndx.php?id='.$id.'&ly='.$ly.'#F">Application areas</a>'; echo $stringa; ?>
</font></i></font></div>
</li>
<li>
<div align="left"><font size="2"><i><font face="Verdana, Arial, Helvetica, sans-serif"
color="#666666">
<?php $stringa='<A href="tech_ndx.php?id='.$id.'&ly='.$ly.'#G">Main actors</a>'; echo $stringa; ?>
</font></i></font></div>
</li>
<li>
<div align="left"><font size="2"><i><font face="Verdana, Arial, Helvetica, sans-serif"
color="#666666">
<?php $stringa='<A href="tech_ndx.php?id='.$id.'&ly='.$ly.'#I">IST relations</a>'; echo $stringa; ?>
</font></i></font></div>
</li>
<li>
<div align="left"><font size="2"><i><font face="Verdana, Arial, Helvetica, sans-serif"
color="#666666">
<?php $stringa='<A href="tech_ndx.php?id='.$id.'&ly='.$ly.'#J">Countries projects</a>'; echo $stringa; ?>
</font></i></font></div>
</li>

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What is it?

<?php
if (file_exists("php/tech_.".$id."A.txt"))
{include("php/tech_.".$id."A.txt");}
?>

<?php
if (file_exists("ima/_".$id."A1.jpg"))
{
    $stringa='<img src="ima/_".$id."A1.jpg"><br>';
    echo $stringa;
    if (file_exists("php/tech_.".$id."A1.txt"))
    {echo '<br>'; echo '<i>include("php/tech_.".$id."A1.txt"); echo '</i>';}
}
if (file_exists("ima/_".$id."A2.jpg"))
{
    $stringa='<img src="ima/_".$id."A2.jpg"><br>';
    echo $stringa;
    if (file_exists("php/tech_.".$id."A2.txt"))
    {echo '<br>'; echo '<i>include("php/tech_.".$id."A2.txt"); echo '</i>';}
}
if (file_exists("ima/_".$id."A3.jpg"))
{
    $stringa='<img src="ima/_".$id."A3.jpg"><br>';
    echo $stringa;
    if (file_exists("php/tech_.".$id."A3.txt"))
    {echo '<br>'; echo '<i>include("php/tech_.".$id."A3.txt"); echo '</i>';}
}
if (file_exists("ima/_".$id."A4.jpg"))
{
    $stringa='<img src="ima/_".$id."A4.jpg"><br>';
    echo $stringa;
    if (file_exists("php/tech_.".$id."A4.txt"))
    {echo '<br>'; echo '<i>include("php/tech_.".$id."A4.txt"); echo '</i>';}
}?>

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Performance trends

<?php
if (file_exists("php/tech_\$id.C.txt"))
{
include("php/tech_\$id.C.txt");
}

if (file_exists("ima/_\$id.C1.jpg"))
{
$stringa='<img src="ima/_\$id.C1.jpg">';
echo $stringa;
if (file_exists("php/tech_\$id.C1.txt"))
{
echo '<br>'; echo '<i>';
include("php/tech_\$id.C1.txt"); echo '</i>';}
}

if (file_exists("ima/_\$id.C2.jpg"))
{
$stringa='<img src="ima/_\$id.C2.jpg">';
echo $stringa;
if (file_exists("php/tech_\$id.C2.txt"))
{
echo '<br>'; echo '<i>';
include("php/tech_\$id.C2.txt"); echo '</i>';}
}

if (file_exists("ima/_\$id.C3.jpg"))
{
$stringa='<img src="ima/_\$id.C3.jpg">';
echo $stringa;
if (file_exists("php/tech_\$id.C3.txt"))
{
echo '<br>'; echo '<i>';
include("php/tech_\$id.C3.txt"); echo '</i>';}
}

if (file_exists("ima/_\$id.C4.jpg"))
{
$stringa='<img src="ima/_\$id.C4.jpg">';
echo $stringa;
if (file_exists("php/tech_\$id.C4.txt"))
{
echo '<br>'; echo '<i>';
include("php/tech_\$id.C4.txt"); echo '</i>';}
}
?>

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<table width="100%" border="0">
<tr>
<td width="92%" align="left" valign="middle">
<div align="left">
<p align="left">
<?php
if (file_exists("ima/_".$id."D1.jpg"))
{
    $stringa='<img src="ima/_".$id.'D1.jpg'><br>';
    echo $stringa;
    if (file_exists("php/tech_".$id."D1.txt"))
    {
        echo '<br>'; echo '<i'>
        include("php/tech_".$id."D1.txt"); echo '</i>';}
}
if (file_exists("ima/_".$id."D2.jpg"))
{
    $stringa='<img src="ima/_".$id.'D2.jpg'><br>';
    echo $stringa;
    if (file_exists("php/tech_".$id."D2.txt"))
    {
        echo '<br>'; echo '<i'>
        include("php/tech_".$id."D2.txt"); echo '</i>';}
}
if (file_exists("ima/_".$id."D3.jpg"))
{
    $stringa='<img src="ima/_".$id.'D3.jpg'><br>';
    echo $stringa;
    if (file_exists("php/tech_".$id."D3.txt"))
    {
        echo '<br>'; echo '<i'>
        include("php/tech_".$id."D3.txt"); echo '</i>';}
}
if (file_exists("ima/_".$id."D4.jpg"))
{
    $stringa='<img src="ima/_".$id.'D4.jpg'><br>';
    echo $stringa;
    if (file_exists("php/tech_".$id."D4.txt"))
    {
        echo '<br>'; echo '<i'>
        include("php/tech_".$id."D4.txt"); echo '</i>';}
}
<?php

</p></div>
</td>
</tr>
</table>
<table width="100%" border="0">
<tr><td width="92%" align="left" valign="middle">
<div align="left">
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</td><td width="8%" align="right">&nbsp;</td></tr></table>

29/01/04
Main actors

<?php
if (file_exists("php/tech_..\$id."G.txt"))
    {include("php/tech_..\$id."G.txt");}
?>

<?php
if (file_exists("ima/_..\$id."G1.jpg"))
    {
        $stringa='<img src="ima/_..\$id."G1.jpg"><br>';
        echo $stringa;
        if (file_exists("php/tech_..\$id."G1.txt"))
            {echo '<br>'; echo '<i>'; include("php/tech_..\$id."G1.txt"); echo '</i>';}
    }

if (file_exists("ima/_..\$id."G2.jpg"))
    {
        $stringa='<img src="ima/_..\$id."G2.jpg"><br>';
        echo $stringa;
        if (file_exists("php/tech_..\$id."G2.txt"))
            {echo '<br>'; echo '<i>'; include("php/tech_..\$id."G2.txt"); echo '</i>';}
    }

if (file_exists("ima/_..\$id."G3.jpg"))
    {
        $stringa='<img src="ima/_..\$id."G3.jpg"><br>';
        echo $stringa;
        if (file_exists("php/tech_..\$id."G3.txt"))
            {echo '<br>'; echo '<i>'; include("php/tech_..\$id."G3.txt"); echo '</i>';}
    }

if (file_exists("ima/_..\$id."G4.jpg"))
    {
        $stringa='<img src="ima/_..\$id."G4.jpg"><br>';
        echo $stringa;
        if (file_exists("php/tech_..\$id."G4.txt"))
            {echo '<br>'; echo '<i>'; include("php/tech_..\$id."G4.txt"); echo '</i>';}
    }
?>

</font></font></font></p>
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<font face="Verdana, Arial, Helvetica, sans-serif" size="2" color="#666666">IST relations</font><br>
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    <p align="left"><font face="Verdana, Arial, Helvetica, sans-serif" size="5"><font size="2" color="#666666">
<?php
if (file_exists("php/tech_'.$id.'1.txt"))
    {include("php/tech_'.$id.'1.txt");}
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<thead>
<tr>
<th>Countries projects</th>
</tr>
</thead>
</table>

```php
if (file_exists("php/tech_'.$id.'J.txt"))
    {include("php/tech_'.$id.'J.txt");}
</br>
</p>

if (file_exists("ima/_'.$id.'J1.jpg"))
{
    $stringa='<img src="ima/_'.$id.'J1.jpg"><br'>
    echo $stringa;
    if (file_exists("php/tech_'.$id.'J1.txt"))
        {echo '<br>'; echo '<i>include("php/tech_'.$id.'J1.txt"); echo '</i>';} } if (file_exists("ima/_'.$id.'J2.jpg"))
{
    $stringa='<img src="ima/_'.$id.'J2.jpg"><br'>
    echo $stringa;
    if (file_exists("php/tech_'.$id.'J2.txt"))
        {echo '<br>'; echo '<i>include("php/tech_'.$id.'J2.txt"); echo '</i>';} } if (file_exists("ima/_'.$id.'J3.jpg"))
{
    $stringa='<img src="ima/_'.$id.'J3.jpg"><br'>
    echo $stringa;
    if (file_exists("php/tech_'.$id.'J3.txt"))
        {echo '<br>'; echo '<i>include("php/tech_'.$id.'J3.txt"); echo '</i>';} } if (file_exists("ima/_'.$id.'J4.jpg"))
{
    $stringa='<img src="ima/_'.$id.'J4.jpg"><br'>
    echo $stringa;
    if (file_exists("php/tech_'.$id.'J4.txt"))
        {echo '<br>'; echo '<i>include("php/tech_'.$id.'J4.txt"); echo '</i>';} }
```
monitoring</br>
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<div align="left"><font face="Verdana, Arial, Helvetica, sans-serif" size="2" color="#666666"></font></div>
<p align="left"><font face="Verdana, Arial, Helvetica, sans-serif" size="5"><font size="2" color="#666666">
<?php
if (file_exists("php/tech_'.$id.'H.txt"))
 {include("php/tech_'.$id.'H.txt");}
<?
<br>
if (file_exists("ima/_'.$id.'H1.jpg"))
 {
 $stringa='\r\n<img src="ima/_'.$id.'H1.jpg"><br>';
 echo $stringa;
 if (file_exists("php/tech_'.$id.'H1.txt"))
 {echo '<br>'; echo '<i>'; include("php/tech_'.$id.'H1.txt"); echo '</i>';} }
if (file_exists("ima/_'.$id.'H2.jpg"))
 {
 $stringa='\r\n<img src="ima/_'.$id.'H2.jpg"><br>';
 echo $stringa;
 if (file_exists("php/tech_'.$id.'H2.txt"))
 {echo '<br>'; echo '<i>'; include("php/tech_'.$id.'H2.txt"); echo '</i>';} }
if (file_exists("ima/_'.$id.'H3.jpg"))
 {
 $stringa='\r\n<img src="ima/_'.$id.'H3.jpg"><br>';
 echo $stringa;
 if (file_exists("php/tech_'.$id.'H3.txt"))
 {echo '<br>'; echo '<i>'; include("php/tech_'.$id.'H3.txt"); echo '</i>';} }
if (file_exists("ima/_'.$id.'H4.jpg"))
 {
 $stringa='\r\n<img src="ima/_'.$id.'H4.jpg"><br>';
 echo $stringa;
 if (file_exists("php/tech_'.$id.'H4.txt"))
 {echo '<br>'; echo '<i>'; include("php/tech_'.$id.'H4.txt"); echo '</i>';} }

?&gt;
</font></p></font></font></div></td>
<td width="8%" align="right"> &nbsp; </td>
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<p> &nbsp;</p>
\p 29/01/04
3 Appendix C – The Web Site

The website devoted to the WP2 database can be accessed at the following url: http://fistera.telecomitalialab.com.
At The Web site at the date of the issue of this deliverable contains more than 100 technologies descriptions, a considerable number of functionalities and relations between functionalities and technologies.
The web site is continuously updated with new information regarding the four levels (Technology, Functionality, Service, Ambient) and relations between them.
As an example in the following the “Active tags” Technology, the “Information Displaying” functionality and relations between Information Displaying functionality and enabling technologies are reported the same way they are described in the Web site.

Active tags          Technologies

**Glossary**        An active tag is an identification element based on a powered chip that emits (continuously or on demand) the identity. A tag may also contain additional information available upon request.

**What is it?**      An active tag is an identification element based on a powered chip that emits (continuously or on demand) the identity. A tag may also contain additional information available upon request. In most cases active tags can also be written by authorized devices. The qualification “active” indicates that the tag is powered (has a battery or is connected to the main). The word tag is also an acronym of Transcoding Active Gateways. An active tag's contains a memory whose size varies according to application requirements. The battery-supplied power of an active tag gives it a longer read range. The trade off is greater size, greater cost, and a limited operational life (which may yield a maximum of 10 years, depending upon operating temperatures and battery type). Active tags may come in many shapes and sizes. They can be much smaller in surface size than the passive ones since they do not need a reflecting spire (antenna). On the other hand they need a battery which makes them thicker.

[Active tag definition] (http://www.far.com.sg/products_active.html)

Performance

- **Current**
  - Range: 10-20 m
  - Memory size: few kB
  - Integration with sensor: marginal
Local processing: marginal

By 2008
- Range: up to 500 m
- Memory size: 1 MB
- Integration with sensors: extensive

By 2020
- Range: single 500 m; hop unlimited
- Memory size: 1 MB in practice, unlimited if needed
- Integration with sensors: common
- Local processing: marginal
- Network enabled communication: extensive

**Challenge**

Costs – the costs of the technology, which are related to the need of powering source and to packaging, must dramatically come down in price to become an alternative to passive tags in some market area.

Battery life – as of today active tags have battery life ranging from few months to few years. Reading frequency, range, greatly influence battery life span. New powering sources are crucial to extend application range and reduce costs.

Standardization – being a rather new technology there is still no single industry standard. Differences are also geographical, with the United States and Europe using historically using different frequency bands. Multi frequency reader are required for open market application. This increases cost. With mass market use common standards are likely to emerge (expected 2008)

Integration with public communications infrastructures, like WiFi (2010) and UWB (2020), will greatly augment their usage.

[RFID benefits from global alliances](http://wireless.iop.org/articles/feature/2/2/4/1)

**Cost**

Cost is now in the range of several hundreds of $. By 2008 it should come down to 100$ or less. By 2020 it should be less than 10 $ and for embedded tags (using existing power) in the order of cents.

**Application areas**

Some of the possible application fields can include:

- **Inventory Control** - inventory can be updated in real time without product movement, scanning or human involvement. Active tags could also trigger automatic orders for products that are low in inventory.
- **Container & pallet tracking** - active tags can be programmed with contents and assigned locations and then placed on containers and pallets that are stored in a warehouse. Additional information can be collected and added to the RFID tags as the pallets move through the warehouse.
- **Manufacturing lines** - Manufacturers can track and record in-process assembly information into the RFID tag as an item progresses along the line.
- **ID badges & access control** - active tags can provide a hands-free access control solution with many advantages over traditional access control badges and systems.
- **Fleet management** - can provide hands-free access to commercial, government, and private fleets maintenance depot. It is possible to efficiently collect, track, and report operations and maintenance data for all of their vehicles that are in the depot.
- **Airports and high security** - access control and tracking system can assure
that only authorized personnel can enter restricted areas. To enable rapid response during an emergency, active tags can quickly identify the location of key personnel, and continuously track employees working in critical or sensitive areas.

Hospitals - can be used to track patients, doctors and expensive equipment in hospitals in real time. RFID tags can be attached to the ID bracelets of all patients, or just patients requiring special attention, so their location can be tracked continuously.

Main Actors

A few companies that work with active tag technology include:

- [Activewave](http://www.activewaveinc.com/)
- [IBM](http://www.ibm.com/products/us/)
- [Motorola](http://e-www.motorola.com)
- [NCR](http://www.ncr.com/index.htm)
- [Pacific Northwest National Laboratory](http://www.pnl.gov/)
- [Philips](http://www.semiconductors.philips.com/technologies/)
- [R.Moroz Ltd](http://www.rmoroz.com/)

Market size:

<table>
<thead>
<tr>
<th>Year</th>
<th>Value</th>
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<tbody>
<tr>
<td>2003</td>
<td>1</td>
</tr>
<tr>
<td>2008</td>
<td>3</td>
</tr>
<tr>
<td>2020</td>
<td>5</td>
</tr>
</tbody>
</table>

Information Displaying

Functionalities

Glossary

a functionality converting digital information into a form visible by a human being.

What is it?

Digital information can be accessed in a visual form through a component such as a screen converting them, usually by displaying a multitude of points (pixels) that all together give the viewer the impression of an image. Displays can be achieved through a variety of technologies varying in complexity, cost, capabilities. Digital displays are measured by physical characteristics such as: weight, size (dimension of the displayed image), thickness, flexibility and by their display capacity (resolution, 2D or 3D, speed in changing the displayed image, contrast, brightness). Depending on the application these characteristics and capacity play a different role. The general trend is obviously towards better capacity (more of each parameter) and increased dimensions, thinner and lighter screen, increased flexibility. Much of today’s information is hidden from us because there are very few screens available to display it. This is going to change. Different technologies are promising to offer many ways to display images and clips. From OLED to 3D display, from over glasses projection to implants for the blinds.

Entire walls may be transformed into screens through special paint that once dried can perform as an LCD display. Many objects will be equipped with screens and stand alone, foldable screen, will communicate wirelessly with the telecommunications network and with objects in the environment to let image speak to us. Clearly the growth in the display area foster a greater use of the bandwidth and will stimulate bandwidth demand. Disruptions may come from the use of novel (actually old) communications paradigm. Visual communication can become common and natural as it used to be. The availability of screen does not steer towards a piggy back visual communications (as it was the case with the attempts of the video phone) nor would propose it as a value added (and at a price like the one through 3G phones).
Performance

In the past displays used CRT of different flavour: interlaced and non-interlaced (for television and for PC respectively), raster and vectorial (for images and drawings respectively) and with resolution of 72 dpi. Current top of the line have resolution of 90 dpi. A variety of technologies, see relations, is now available and will continue to grow and boost display functionality, at a lower price. Displays are going to be self standing (like a walkman) or can be embedded in any object. Both directions are likely to be pursued. By 2020 display function will be ubiquitous at very low cost.

Challenge

The main challenge for display are contrast (so that it can be seen outdoor) and power consumption (in mobile use). Other "social" challenges are related to the Big Brother concern.

Cost

Display cost will keep going down and for hand size display it will be negligible by 2020. Cost will decrease linearly with respect to area size (that is it will not decrease linearly with respect to the diagonal of screen but at a root square). A 10% decrease per year may be a reasonable figure. Breakthrough in production processes may slash cost more significantly.

Application areas

Any area where interaction with humans is of interest

Main Actors

Samsung, Sony, NEC, ...

Market size:

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<td>2008</td>
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<td>2020</td>
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Information Displaying Relations

In this picture the green box displays the information on the specific relation between Information Displaying functionality and Flat screen technology.
4 Appendix D – Presentation Material

The presentations prepared for the second Fistera workshop and for the Italian Roadshow are attached in powerpoint format.