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Information and Communication Technologies and the Information Society Panel Report

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The Futures Project is a major prospective exercise of IPTS that explores the likely effects of the major economic, social and technological developments which will take place in Europe and the world in the next ten years on Technology, Employment and Competitiveness in Europe by 2010. It is organised as an interactive process based on expert panels and workshops, and supported by background research.

The output of the Futures project is a series of reports to be published in the course of 1999. The first publications will be an overview report and four panel reports (May 1999):

Report 01 The Futures Project: Overview

Report 02 The Demographic and Social Trends Panel Report

Report 03 Information and Communication Technologies and the Information Society Panel Report

Report 04 Life Sciences and the Frontier of Life Panel Report

Report 05 Natural Resources and the Environment Panel Report

A series of **Issue Papers** developed by different expert panel members will also be published (March – May 1999)

All reports will be available from the IPTS and will be available from the Futures Project Website:

http://futures.jrc.es

Further reports in the series will be announced on the website as they are published.

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In a collective exercise of this type not all viewpoints can be accommodated within a single coherent text. Thus, it has not been possible to justice to the range of ideas and richness of creativity of inputs the panel have given us during the work on the panel report. And, as always misinterpretations, omissions and plain errors of fact are the responsibility of the main author.

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Executive summary

Information Society 2010

Currently, there is considerable confidence that we are on the verge of an important deepening of the Information Society. Many are calling this the era of ‘ubiquitous computing’, in which computer-based devices become so cheap, seamlessly interoperable and easy to use that they will find application across a broad swathe of everyday activities. The implications of these changes for policies on technology, employment and competitiveness will be profound.

In technological terms there remain significant challenges to achieve the vision of ubiquitous computing. The exponential trend of miniaturisation, in which the complexity of circuits on a silicon chip doubles in complexity each 12-18 months for the same price, is expected to carry on until 2010 and beyond. Nevertheless, there are already questions about what comes next, when the size limits to photolithography are reached. And even up to 2010 miniaturisation raises serious technological challenges in the areas of circuit design, interconnection materials, the cooling of tiny integrated circuits and the amazing escalating cost of chip fabrication technologies.

Further key technological trends until 2010 relate to the development of systems, including input-output and power components, which can be embedded into non-PC devices. This generally means making devices smaller, lighter and interconnectable. Further development of new materials is taking place, especially for flat displays, smart textiles and even smart ink. The ease of use of information technology devices is being achieved both through a gradual liberation from screen and keyboard with automatic data capture (especially various forms of sensors), voice, speech and pattern recognition.

Equally important are associated developments in artificial intelligence, which help to find, sift, store and retrieve information. For the moment these include linking databases together (data warehousing) and exploring and exploiting them to add value (data mining). But key development efforts are also taking place in software agents (which can be programmed to reflect user preferences in order to automate searching for information, management of data and so on). In the future context sensitive knowledge management tools are expected. Technologies will be able to learn about user behaviour and adapt their responses. They will even be able to adapt their responses according to social rules, instance by offering prompts which are appropriate to the task being carried out and the people involved.

Such tools may offer relief from the information overload, which currently confronts explorers of the worldwide web of databases formed by the Internet. Also, despite being hailed as 'user-friendly', computers and computer networks such as the Internet are still quite hard to use - they require quite high levels of skill before they can be exploited effectively. Some of these usage problems will be improved by better design. But, some of the difficulties stem from the underlying complexity of information processing tasks. The result, however, is that the use of information tools is still limited to people who are computer and net literate. Smarter, intelligent software agents may alleviate this trend towards a skill-based polarisation in the Information Society into 'information haves and have nots'. When computer devices become very intuitive and easy to use (and this implies a much higher degree of reliability and less complexity for the end user than we have today), we might have arrived at ‘calm technology’.

Calm technology would be ubiquitous not conspicuous, it would just get on with its job without continually reminding us that it is there, getting between us and the task we want to achieve.

Finally, and crucially as regards technology trends, there are strong expectations of growth in communication demand. The recent startling growth of the Internet and of mobile phones can be seen as the first steps towards a Networked Society, in which people will expect to be able to be in communication anywhere, anytime and using any medium. The vision is one of 'seamless interoperability' of communicating devices.

In the first place 'seamlessness' calls for greater transparency of telecommunication prices (structures and tariffs) for end-users. This is a trend that runs counter to the current communications market patterns, and thus represents a major challenge to policy. Seamless interoperability plus ubiquitous computing also means that linking devices to networks and getting them to interoperate will have to be simpler, without the end user having to engage in lengthy set-up rituals, or different protocols and operating systems for different devices and networks. Already, computer components and peripherals aim to be 'plug and play', announcing themselves to the computer so that they can be set-up easily and correctly. This kind of platform independence is a central feature of Sun Microsystems Java and Jini languages which were developed for information and domestic appliances. However, it is not guaranteed that the technical standards of ubiquitous computing (especially the source code of operating systems needed for software development and the protocols used to interconnect devices) will remain open, given the potential competitive advantage of proprietary ownership over such intellectual assets. This is a serious issue for policy makers, even though it is open to doubt whether single firms will be able to dominant key standards, in the very large and heterogeneous market for ubiquitous computing, in the way that Intel + Windows system has for Desktop PCs.

Implications for Technology Policy

On technology policy, there are some starkly important lines of pre-competitive research activity, which are already well reflected in the main lines of the Fifth Framework Programme. They include semiconductor design, material and production (and even replacements for semiconductors though bio computing or quantum computing). In addition there will be needs for new materials. The position of European technological breakthroughs in these areas is not generally strong (for example semiconductor strengths are mainly in the USA, Japan and SE Asia, while flat panel displays production capacity is concentrated in SE Asia).

There are, however, considerable research strengths in Europe in the crucial areas of circuit design, software engineering, artificial intelligence, knowledge management and system integration. Indeed, the greatest uncertainty concerns when and to what extent gains in programmer productivity will breakthrough from software engineering techniques (such as re-useable software libraries, component-based programming techniques or automated program assembly). The software industry is working hard in all these areas, and although there is a constant demand for more resources, the ultimate constraints on the rate of innovation may be given by the rate at which the software sub-systems can be constructed. Rates of developments are determined more by levels of innovation diffusion and learning rather than raw investment in technological invention.

For these reasons, policy for technology and innovation should concentrate on creating platforms and frameworks for innovation, rather than trying to select winning solutions. A wide variety of experimentation yielding both successes and failures is perhaps more desirable than attempts to concentrate resources onto a few flagship projects. Thus the technology policy proposals centre on clearing away of obstacles to innovation in the Information Society. For instance, it points towards a more rapid acceptance of digital authentication and signatures by public administrations, creating dynamic but common Europe-wide rules on electronic commerce such as taxation and consumer protection. Also, important will be to create platforms for innovation, especially by finding ways to encourage a faster investment in broadband connections, and thus create a fertile environment if not seedbed for interactive multi-media services.

Implications for Competitiveness and Employment

The issue of ‘ubiquitous computing’ also directly raises a series of links to issues of competitiveness and employment. Chips are already embedded into many everyday devices (particularly automobiles and domestic appliances, and increasingly locks, alarms, payment machines, vending machines, cash machines, street furniture, hand tools and smart cards for identification, financial transactions and electronic purses). One of the fastest areas of growth of semiconductor demand is in personal organisers (personal digital assistants) and mobile phones.

With the expectation that these applications will proliferate still further, a serious question arises about the preparedness of traditional industries to embed chips and interfaces into their products. Consumer appliances which can be remotely controlled are expected to be an area of emerging importance, this will require the development of home networks (again forecast for rapid growth). Likewise, the computerisation of traditional industries such as textiles and clothing can be expected, at least in special applications, such as embedding sensors, information processing and communication systems into the garments worn by police or rescue services. Also, systems to monitor heart rates and location will be found in sports wear (athletes or skiers for example) and special clothing for people with chronic medical conditions.

There are probably substantial gains (in terms of being able to define the key standards and ask high prices) to be gained from an early move into these areas. However, industry analysts already expect that ubiquitous computing will bring the PC business model into line with consumer appliance industry: i.e. fast product life-cycles will continue but with much slimmer margins and the need for products with much high reliability. On the other side of the equation, there is a big question whether Europe's traditional industries such as building and construction, home furnishings or clothing are ready to meet the challenge? All these technologies imply a merger between high technology and somewhat traditional industries - textiles, clothing, footwear, optical device manufacturers or building materials, such as suppliers of doors, locks, and windows. One can expect that a new microsystems industry supplying special purpose chips and programming facilities will spring up to serve the specialist needs of these industries - rather than firms within the industry developing their own in-house microsystems expertise. In addition, services to install, maintain and operate these devices will emerge - e.g. so-called Internet plumbers providing 'smart home' maintenance services. However, even with the support of such services, traditional industries will have to invest in new areas of competence. In the first place this requires awareness of the challenge, then it may call for changes in research and development priorities, new production techniques, new alliances with subcontractors and new management skills. Clearly, also worker retraining will be needed not only on the production line, but in marketing and maintenance departments as well.

However, the ‘ubiquitous’ adoption of computer devices is not guaranteed. Non-PC devices imply changes in the routines of daily life at home, work and play. They have to accommodate and be accommodated in these routines. As is stressed in the second part of the report, it is clear that major changes of rhythm are already underway in European life and society (see for example the Mosaic

Living theme in the accompanying Futures Report Series on Demographic and Social Trends). ICTs are involved in promoting these changes by helping to speed up the pace of life at work, in the street and home. They also help people to cope with changes, by helping people to stay in contact even though they are travelling, reducing 'downtime' when travelling or waiting, providing devices to help organise their day, by automating processes (such as ordering and bill paying).

One key area in which ICTs will be important as life tools for Europeans in the future will be through opening up life-long learning opportunities for working age people. Open and distance learning technologies will play a crucial role in meeting this need. Policy has a role to play here in establishing common frameworks and the sharing of experience, but it will also be crucial to stimulate the creation and pedagogic certification of educational software and content. Direct support for content production may also be needed where the market cannot act because demand is too low, such as to make sure that content is available in a variety of European languages - the future will not only be made in English!

European Models of the Information Society

Concerns along the lines "What kind of Information Society?" cannot be ignored from the point of view of social, technological nor industrial policy. As noted above the crucial role for policy in the Information Society is to provide frameworks and platforms for development. This is expressed most strongly in the last part of the report, in the comparison between an anarchic development of the information society and one in which some founding principles are established. For example, there are potential synergies to be gained from establishing basic rules and norms in the information society, which will give a greater sense of trust and reliability in electronic transactions. In turn, such security may be expected to promote a more rapid take up of information services, especially electronic commerce. In these cases such rules can act in the same way as standards - reducing uncertainty for investors and consumers.

Likewise, many of the potential gains from the information society are for the moment just that: a potential. Considerable effort is needed to make sure that these potentialities are realised. For example, the application of ICTs does not provide a technical fix for problems of environmental sustainability. ICTs often provide a more efficient way of producing goods. Substitutions can be direct. Electronic circuits can substitute for electro-mechanical control systems thus reducing the physical inputs to products. Telecommunications can replace travel, as in videoconferencing. ICT systems can also be used to raise efficiency. Resource use in production and services can be optimised through waste reduction, lower levels of reworking or logistical controls. For example, networks of environmental sensors can aid the management urban traffic systems to optimise air quality and traffic flow. Many of these gains accumulate through direct effects, but secondary or indirect effects are also important. For example, if less waste in production leads to lower prices will this stimulate demand so that, overall, the level of consumption of natural resources actually escalates? Likewise, does videoconferencing reduce travel or simply stimulate the demand for more face to face meetings (because more people are in contact with more other people). When these secondary costs outweigh the first order gains we face what might be called a "rebound" or "boomerang" effect. To avoid it, policy frameworks, therefore, need to take account not just of direct outcomes of ICTs, but the second and third order effects that might follow - or else good intentions could end up making things worse!

Despite five decades of development, the Information Revolution continues to turn and if anything is speeding up. In fact, we seem to be on the verge of a new cycle of growth and deepening. Computers are coming off the desktop to become embedded more firmly into everyday life. The central nervous system of communication networks is acquiring sensory and motoric capacities, through the addition of Internet appliances, actuators and sensors and web cameras. To help us use the new hardware and network capacities humans are also (slowly) acquiring new tools in the form of knowledge management techniques, software agents and knowledge representational devices.

Such technology systems are important, but will not by themselves be enough to provide an appropriate system of governance for the new era of computing. As the e-commerce example shows, technical solutions such as encryption algorithms do not provide answers on what should be the new rules on protection of privacy, confidentiality or legal responsibility in a global transactional network. It is no exaggeration to say that the game is different now if only because it is bigger (more places and actors are in), it is played faster and extends deeper into our private lives. As a result, new rules of the game are needed which will provide a mature framework of governance for the new phase of the Information Society. There are tremendous challenges involved such as globalisation and communications convergence. But, the confidence of people and enterprises will also be needed. This will call for a clear statement of rights and responsibilities in the Information Age - a Digital Charter perhaps - which could build confidence in the global networking, and thus help to clear the roadblocks to progress created by uncertainties over who will take responsibility to make the European Information Society a place for all.

Objectives

The aim of the work of the Information and Communication Technologies and Information Society (ICT &IS) Panel was to identify a number of key ICT related issues that will be important drivers of change in Europe over the next 12 years and be of vital relevance to EU policy.

Such issues were to be developed and specified to the degree of detail possible on the basis of knowledge/ expertise available to the panel and some accompanying research. As far as possible trends were to be quantified and/ or documented.

Key uncertainties that would have a significant implication for policy were to be identified and conceptualised as clearly as possible, especially as they affect the three policy areas targeted by the Futures Project - i.e.

- T - knowledge, research & technology;
- E - work & employment;
- C - production & services competitiveness.

Method

The working method employed for this panel was built around three workshop meetings, supplemented by a considerable amount of interaction and discussion outside of meetings (via web, email, etc.) and some background desk research work. The sequence was as follows:

Preliminary phase: This entailed setting up the panel (the members of which are listed in Annex I) and preparing a background document to kick-off the panel discussions at the first meeting. This document was produced on the basis of an internal brainstorming within IPTS and desk research into a set of prioritised issues.

First Meeting (7-8 July1998): The aim of the first meeting was to establish some group dynamics among the panellists who were drawn from a wide variety of backgrounds and professions, as well as to establish a list of important drivers in ICT&IS unconstrained by policy considerations. For the first part of the meeting, an electronic meeting systems tool (EMS) was used for an interactive brainstorming session. This enabled panellists to directly record issues and comments on issues proposed by others on lap-top computers linked to a central control unit with a projected display for all participants to follow the aggregate result (see results in Annex III-3).

The elicitation was followed by a categorisation procedure during which the issues were allocated to five groups (Technology Trends, New Markets -Supply and Demand, New Patterns of Life and Work, ICTs and Legislation, Changing Norms and Aspiration). Dual entries, where one issue was found in more than one category were allowed (see summary chart in Annex III-2).

The panel then used the EMS system's voting facility in order to prioritise the issues on their general importance. The panellists were split into four sub-groups for the second part of the meeting in order to deepen the examination of the top issues in four of the categories (Annex III-1). (The 'changing norms and aspirations' category was omitted because there were insufficient issues and people present to have a detailed discussion on that category). The panel met again in plenary to debate the elaboration of the issues achieved in the sub-groups.

Interim Period (July - October 1998): During this period, three main tasks were undertaken -

First Meeting Report - a digest and substantiation of the issues identified and discussed in the first meeting according to the three main policy areas (T, E, C). This report provided the input to the second meeting.

Web Site - this was set up to have an on-line area for project-related material to be made available to panellists and the wider public. It also included a discussion forum to stimulate and encourage debate among the panellists outside of the meeting setting.

Second Panel Meeting (22-23 October 1998): The aim of the second meeting was to identify three to four top priority ICT&IS issues for each of the three policy areas (T, E, C). Each working group aimed to develop descriptions of plausible 'end-states' (partial scenarios) for each of the selected issues detailed scripts specifying where possible the underlying trends and drivers. For this, the panel worked in three sub-groups - one for each of the policy areas. The discussion was oriented at first identifying issues that suggested highly different outcomes or conflicting/ opposing alternatives for the 2010 horizon. These 'end states' provided the basic inputs to the policy workshop which was held near Brussels in November 1998. In addition they provided an alternative cut on the ICT trends, providing an explicit link between important trends and the role of policy.

Preparation and discussion of Final Reporting: A draft final report was prepared based on the issues identified in the first two panel meetings. This was then circulated before Christmas 1998, and then again in mid-January 1999. It was discussed in depth in a full day meeting of the panel 21 January 1999.

Part 1 2010: Europe's ICT Odyssey

Issue 1 Networking Europe

The issue

By 2010 most Europeans can be expected to have access to broadband 'local subscriber loop' services both in fixed and mobile forms. However, there are concerns about the speed and breadth of this transition. An early transition could be very important in delivering 'first mover advantages' to Europe-based information businesses (providers of electronic content and transactional services) and in providing a platform for the development of the new technologies (especially software systems) as the use of multimedia services moves into mass usage. There are serious challenges in moving from today's fragmented communication networks to the objective of **seamless interoperation** of networks - and **transparency of pricing** to the end user

Background

The recent rapid growth of the Internet can be seen as the leading edge of an escalating demand for interactive digital multimedia services. Such services, which are graphics and sound intense (i.e. require broadband capacity), will place intense pressures on telecommunications networks both in the backbone infrastructures and, above all, in the local loop into consumer premises.

The problem of expanding the backbone capacity to cope with escalating demand is real (for example: US Internet provider UUNet was experiencing a doubling of traffic levels every 100 days in 1997). However, the backbone telecom system is already largely upgraded to fibre optic level through both public and private investment. For example, the research community in the US has set aside US$110 million for Next Generation Internet and in Europe the TEN-155 has been funded under The European Commissions Fourth Framework Programme, with a proposed upgrade from 155Mbps to 644 Mbps.

The real point of pressure in the coming years will be the provision of broadband capacity into homes and local shops and offices: the *sine qua non* of the networked economy. Without a widespread roll out of the 'local loop', there will be no chance of connecting into many areas of multimedia services and content. For example, at least part of the reason that the World Wide Web is currently often termed the 'world-wide wait', can be attributed to the narrow bandwidth available to telephone subscribers.

Even here, projections indicate that most subscribers will be offered access to a local loop that supports interactive broadband telecommunications by 2010.[1] Also, there are many ways to achieve broadband access including transmission compression improvements (such as asynchronous subscriber digital loops, satellite transmission and other wireless transmission options (Box 1). Telecommunications services therefore are likely to be composed of a rich (or confusing) array of alternative infrastructures, reflecting both shorter term upgrading strategies (such as compression techniques and new cable switches) and longer-term strategies (such as the use of fibre optic cable in the local loop). At the same time, third generation mobile cellular systems will be operational by the early 2000s. These will support broadband and multimedia communications and act as platforms for sophisticated enhancements of today's cellular phones and personal digital assistants. For example there are forecasts of 90 million Mobile Multimedia Users in Europe by 2010.[2] Satellite to both fixed and mobile users will be digitised and will permit mass use of integrated wireless services such as interactive multimedia, digital television.

Box 1: Broadband Communications Options

- Fixed line options
  - **Compression techniques: xDSL** is a family of techniques that expand the capacity of the existing twisted pair copper wires used in telephone local loops. For example, ADSL (Asymmetric Digital Subscriber Loop) can carry digital multimedia traffic and voice simultaneously. The downstream channel operates at up to 6 Mbps (for short loops) and the upstream control channel at 64 Kbps. VDSL (Very high rate Digital Subscriber Line) will operate at higher frequencies and carry more data over very short distances, probably just the very local loop, but will not rollout until after 2010.
  - **Co-axial cables** can provide high bandwidth over short distances. Cable penetration is already high in many countries (e.g. 50% households in Germany), but most of the installed capacity of switches do not support (duplex) interactivity and so far the penetration of modem cables is quite low - although some predictions suggest it will rise to
  - **Fibre Optics** have a very large digital data capacity and already make up the telecommunications backbone, but splitting the cable into individual home is expensive (especially retrofitting costs are also high).
  - **Power line technology** - which piggy backs on the existing electricity line - currently underdevelopment and limited to 1mBit/100 users
- Wireless options
  - **Wireless local loop** is like a cellphone system using a fixed antenna in the customer premises. It replaces a hardwired cable into the home, however, these systems are currently limited to 9.6 Kbps, i.e. below twisted copper pair capacity, although this could rise to 2Mbps with UMTS (see below).
  - **Digital cellular (GSM and UMTS) -** GSM penetration has been growing very rapidly across Europe and is now a mass-market phenomenon. UMTS (Universal Mobile Telecommunications Service), the third generation mobile protocol, will provide mobile users with full interactive multimedia capacity (up to 2Mbps)
  - **Satellite** will be used both for fixed and mobile transmission. The launch of Global Mobile Personal Communication Systems (GMPS) based on low earth orbiting satellites will provide an infrastructure for broadband communications. Teledesic plans to offer an asymmetric services (64Mbps down and 2Mbps upstream) for both handheld and fixed devices by about 2003.
  - **Digital broadcasting** is already available in trial version using set-top boxes to integrate the return path via the telephone. Current applications such as Near Video on Demand will be supplemented by interactive services, Internet and, once a high bandwidth return path is available, videomail and videoconferencing.[3]
  - **Airships and aircraft** have also been proposed as the basis for broadband wireless. Sky Station International plans to float 250 communication relay balloons in the stratosphere. Each would offer wireless connections at up to 2Mbps over 465,000 square miles. Angel Technologies plans to fly High Altitude Long Operation (HALO) aircraft above major cities offering up to 5Mbps connections.

Sources: Communications International (1998), Spectrum/DTI (1998), UK Foresight (1998)[4]

The widespread introduction of optic fibre into the domestic realm will probably have to await demand levels that would justify investment in the additional capacity. One source of demand for interactive digital broadband will be the growth in Internet use, especially with the Next Generation Internet expected by about 2002, which will support voice and video, and more generally, digital multimedia will raise demands for rapid and reliable downloading of bandwidth hungry video images. In addition, bandwidth demands will undoubtedly rise with the shift towards information appliances or ubiquitous computing (Issue 2). Not only will communication demand be drawn up by the sheer number of devices, but also many of them, such as web cameras, will raise bandwidth demands.

Ubiquitous computing has the further implication that, communication networks should become like the electricity network, and telecommunication devices should be information appliances. I.e. it should be possible to plug them in and then forget about them, or in the case of wearable computers simply to put them on and go out.

If we are going to achieve this, the first implication is that, despite the proliferation of infrastructures and service providers detailed in Box 1, users should be able to get their communication tools to work easily, irrespective of location or service provider. For instance, they should not have to even think about whether they are using a fixed or mobile service, the services should be transparent to the end user. The second implication is that pricing structures should evolve towards a low or no shock system - i.e. one in which the network use decisions are simple or so low cost as to be irrelevant and in the hands of the end user.[5] As long as end users have to worry about and compare prices all the time, usage rates will be depressed and the technologies will be under used.

Policy agendas

It is clear that Europe is already well on track to achieve a broadband digital infrastructure. In fact by the early 2000s, most major cities will probably have several such infrastructures. The questions are: how quickly it will be achieved, how complete will be the coverage and whether the systems will be fragmented or integrated from the point of view of the end user?

The speed of transfer to interactive digital broadband is important. A rapid rollout might be important for first mover advantages for European high technology companies. For example, public investments in Next Generation Internet and TEN-155 do not just aim to upgrade services and speed of websites, valuable as this will be. They aim to stimulate the rate of R&D investment and innovation spillover effects into interactive multimedia applications and services.[6] Similar arguments apply in respect of the local loop bottleneck. For example, cheap fibre optic based local loops could generate substantial spillover effects to European technology, E-commerce and multi-media firms.[7]

With the proliferation of alternative infrastructures, the role of public policy will almost certainly not be direct investment. But it might include raising the incentives to invest, by a reform of accounting rules regarding investments in infrastructures or the promotion of targeted investment in less favoured (poorer or less densely settled) areas through regulatory permissions (licenses or merger approvals). Care will be needed to get the right balance between incentives whilst not allowing incumbents to crowd out competitors, e.g. by establishing too-favourable quasi-monopoly rights for infrastructure pay-back.

The second policy question concerns the coverage of the information network. Here the issue is less about spillover effects to R&D, but more about a potential risk of 'hot spots' (where there are rich markets to be contested), 'warm haloes' and 'cold shadows' of service provision.[8] In these areas public funding may be important to leverage private investments in advanced communication services. Recognising the role of government as a large investor, procurement policies could help to catalyse of the use of advanced technologies, especially through direct investments in telecommunication and telematic infrastructures for public bodies, such as schools, libraries and hospitals. Indirect public investments might include special taxes to promote infrastructure investment in targeted objective regions (the targets could be designed to stimulate investment in peripheral or depressed regions for example or to promote access to specific user groups). Here technology policies could operate in concert with regional cohesion funds to stimulate demand through the availability of applications that demand much higher bandwidth.[9]

Thirdly, from the point of view of end users the key issues are not the technology but the functionality. They want high speed and transparent access to information. This depends on the bandwidth of the link but also on the service structures - which are becoming increasingly complex. In fact, 'convergence' between telecommunications infrastructures and media content is occurring against a background of diversification of technologies and service providers, complex patterns of competition on services and tariffs. This calls for new forms of network governance and regulatory paradigms.[10]

A key issue will be how to institutionalise the responsibilities for ensuring appropriate regulation of the global information infrastructures (see also Issue 6). With blurring of traditional demarcations of responsibilities for regulation and authorities, some rationalisation of these systems would certainly be desirable, to the extent that it reinforces the transparency of pricing offers and service access (i.e. seamless interoperability) and to the extent that issues of access and affordability are also addressed.

Indeed in policy terms, the new aim should be to develop access, servicing and storing approaches that allow the user to live in a seamless world. This in turn implies that regulation agendas will shift away from liberalisation and competition policy, towards regulation to support innovation. Regulation on openness and universality of access to telecommunications will have to take account of the ICT-enhancement of telecommunication services and the proliferation of alternative telecommunication infrastructures including: cellular digital, mobile radio, satellite (low earth, VSAT) as well as fixed line cable and PSTN telecommunications.

Also, new concepts of “universal service” will have to be developed which are more dynamic, reflecting both the evolution of the technologies and of social priorities. From the geographical standpoint, the different pace of the liberalisation process and the history behind the infrastructure investments will generate very different scenarios and paths of development in each European country. This situation makes it much more complex and difficult to obtain the benefits from the deployment of common solutions and it will have to build on localised approaches for the global network.

Issue 2 The Age of the Information Appliance

The issue

Semiconductors will continue to get cheaper and more powerful. By 2010 complete computers will be available on very small chips at the cost of a few eurocents, heralding the era of ubiquitous computing. Such chips will increasingly be interoperable and have the ability to improve their performance by monitoring and learning from the external environment or via the way they are used. The effect will be to create a new microsystems industry devoted to embedding these chips into consumer electronics and automobiles, as today, and all sorts of new devices and products.

A complementary trend will be that computer devices will have to become much more useable. Interfaces will have to become easier to use and ergonomic. Speech or sensors will increasingly be used for input instead of keyboards; software will have to be more robust and so on. The result should be that computers become more like consumer appliances - easy to use, predictable, robust and getting on with the job in the background in an inconspicuous manner. However, as these technologies disappear into the background a broad swathe of industry will have to adopt, and adapt, to the challenge of integrating ICTs into their core products.

Background

"Moore's Law", the most famous of computer world axioms, will continue to hold over the period considered by the study. Moore's Law describes the trend for memory chips to double capacity every 12 to 18 months for a constant price. Falls in price-performance ratios for storage chips may be even greater. After 2010, the continuation of Moore's Law is seen as slightly less certain due to a cluster of limitations on further miniaturisation. These include limits to photolithography - the process upon which the etching of chip circuits is based, problems of cooling very small chips and time constants for relaying signals in chip interconnects (the so-called RC-constant). The very high cost of building production chip facilities is also a limitation, as there is an increasing concern that investments will be unrecoverable.

Probably the major impact will be the possibility to manufacture complete computers (including input and output controllers) on a single chip at a cost of a few eurocents. This will greatly enhance the proliferation of computer control and interconnection. As a result it will permit chips to be embedded in all sorts of artefacts and devices which are today not computerised (clothes and furniture for example). For example, although Desktop PC markets still drive semiconductor production, current fast growth markets for 'small footprint' non-PC systems include personal digital assistants, mobile phones, smart cards, chips embedded in pharmaceuticals and embedded networks in automobiles. In the near future non-PC devices will include set-top TVs, interactive, 'magic glasses' for portable information display, and computers embedded in clothing particularly for special purposes, such as the monitoring of the physical condition of sports people or out-patients, for the tracking of workers in hazardous occupations or environments and battlefield information systems for soldiers.

Due to their low cost and wide usability, computer-based devices will be ubiquitous, so cheap as to be almost disposable and virtually invisible by dint of being embedded into products. Actually, computer chips already surround us. But there will be at least three differences from today's embedded chips:

- Ubiquitous computing means computing in all products and affecting all industrial sectors. (Will wearable computers be products of the computer industry, consumer electronics or fashion clothing?)
- These devices will 'think' - the complexity will be on the inside not (like today's PCs) in the user's (inter)face. This implies the need for very good design engineering skills (a possible European competitive strength) and that we need robust systems that we can trust (again not like today's 'feature' laden PCs).[11]
- These devices will talk to each other - today's hardwired embedded chips are increasingly operating in LANs and already there are trends towards linking them to external network control for updating, maintenance and control (although so far not real-time control).

The abundant processing and transmission power implied by the age of embedded computing will also be soaked up by the high processing power demands of high density display devices (flat panel and head-up portable displays) offering colour, animation and innovative knowledge representation techniques. A key issue will be to develop user interfaces which are much more user friendly that those we have today. The driving aim should be to make systems transparent or intuitive (Box 2). This implies both the development of very clear and easy to understand user pricing systems and much work on the interface technologies we use for inputting and outputting information. Ubiquitous computing will also feature autonomous and self-learning devices (using artificial techniques) in all sorts of areas where they are not found at the moment based on the growth of small, cheap and commonplace sensors, actuators, controllers, storage devices, and so on. Some analysts thus expect the emergence of a microsystems industry based on the exploitation of these technologies.[12]

Box 2: The intuitive interface:

Inputs:

Although keyboards will be around for a long time to come, a major area of development. Will be the use of speech and handwriting recognition systems for data entry. In addition, one can imagine direct input based on techniques of image analysis and environmental sensors that detect and analyse ambient information whether it be electronic tags, bar codes, biosensors, visual information or smell. Key advances will be in algorithms for image analysis and compression and speech recognition. Most of the fundamental problems in these areas are solved but experience and practice is needed. For instance, speech recognition systems currently have a limited vocabulary and restricted use of natural language. They also have to be tutored to work with any individual user. However, by the end of the period, wide availability is expected of speech activated computing in all sorts of devices; cheap transcription devices; and the widespread replacement of human operators for speech activated devices. Natural speech communication with computers will be available, if not widely. Simple real-time translation devices may also be available towards the 2010 horizon.

Displays:

Over the time frame, Cathode Ray Tubes (CRT) will provide higher definition and remain a major technology for desktop displays and televisions. Applications of Liquid Crystal Displays (LCD), however, will grow very fast, especially in mobile/portable. For example Active Matrix LCDs in vehicles and for personal digital assistants and wearable computers or 'Magic Glasses' using ferro-electric liquid crystal Spatial Light Modulators. Larger flat panel screens and video walls will use plasma displays and LED. Other technologies include: mirror displays (arrays of thousands of tiny mirrors reflecting red, green or blue light; flexible light emitting displays, rear projection of images. Not available in the time frame would be 3D (and real time holographic display) would be more limited to special applications that demand a higher level of fidelity of representation.

Power supplies:

With very fast growth expected in personal and portable computing there will pressures for big gains in battery weight, life and power-performance. Levels of energy storage per kilo are now substantial, to the extent that they could be compared with explosives, and are thus potentially dangerous. Environmental concerns will lead to attempts to tackle heavy metal content in batteries, such as a move towards Lithium Polymer batteries and lower power devices (especially screens, communication devices, etc). With the exception of kinetic energy, other energy sources such as photovoltaic cells, fuel cells, and micro gas turbines face problems of size and cost for applications such as portable or wearable computing.

Policy implications

Ubiquitous computing raises important technological and competitiveness challenges for Europe. On the technological front, there are many emerging areas of development that will still be *avant guarde*, even in 2010. One such is the tactile interface (not just the look but the feel of shaking hands in a video meeting). Another is the development of remote noses or a sense of smell.

However, perhaps key technological challenges will be to create new software tools and protocols to bridge the gaps between the potential of the hardware technologies and interfaces applications described above and what can be delivered today. At the fundamental level, software-engineering developments will be needed. These include the building up of software libraries and reusable components, and the automation of coding through the application of artificial intelligence techniques to software design itself (Issue 3). Such basic software production problems create numerous bottlenecks in the transition to ubiquitous computing. For example, software tools are needed in the automation of integrated circuit design (necessary for the cheap fabrication of ubiquitous chips). Likewise, there is a massive challenge to create the middleware to facilitate the interoperation of Internet devices. Behind both these examples lies the issue of how to achieve a mass customisation of software systems and how to design in or, more probably, how to retrofit interoperability into legacy software systems. In other words, the challenges are 1) how to tool up to meet the sheer potential size of demand for software production implied by the term *ubiquitous* computing and 2) how to establish protocols which will permit these device to talk to each other.

Interoperability, being a standards issue, impinges on both technical and competitiveness concerns. On this latter point, the way in which standards for ubiquitous computing are permitted to emerge could have a major impact on the future openness of technological markets, and thus the competitiveness of European producers. It is worth pointing out that the stakes are also rather higher with ubiquitous computing, than with for example desktop PC markets, because it will affect all industrial sectors.

For example, as embedded chips become interoperable one strong possibility is that there will be a move from custom designed to standardised operating systems. This will be for reasons of pricing of devices, to increase the pool of plug in software that the device can access and to ease the training of developers and operating staff. Contenders include Windows CE (currently not small and agile enough but offering IP access, a familiar GUI, and a standard communications protocol), Sun’s Java language and the UK firm Psion's EPOC operating system used on small mobile computers and next-generation phones and communicators.

The Java option is interesting because it is platform independent and can be written and sent over the Internet to the device (making remote control and maintenance easier). In other words it implies that ubiquitous computing could develop to be independent of the physical platform and of the operating system. However, it may also be that de facto proprietary standards are established. The obvious parallel is the case of the desktop PC industry, where a couple of firms with strong intellectual property rights have captured the design and development paradigms, so as to dictate the pace of change and to be able to lockout alternative technologies.[13]

There are alternatives to proprietary dominance, such as ‘GSMism’ and open source standards. The Europe-wide Memorandum of Understanding in 1987 which led to GSM gave first mover advantages to European mobile phone firms Ericsson and Nokia. However, the GSM-effect was achieved because of the rapid growth of digital mobile telephone use. Thus, to achieve the GSM effect again with embedded computing would require a rapid development of mass markets for ICT-based products in Europe. A second approach is to promote an open professional developer community based on open publication of source code. Examples such as Linux or the Internet Engineering Task Force indicate that ‘open but not owned ‘ standards can develop rapidly and relatively robustly.

The operating systems example serves to underline the need to extend ideas about network governance and interoperability (see Issue 1) to fit it for the era of ubiquitous computing. Already, we can see how the International Telecommunications Union has been drawn into concerns about Internet domain naming. With ubiquitous computing the convergence issue takes another leap in complexity, because it leads to a new generation of actors, services and devices joining the network. The already blurred separation of content and infrastructure is made more murky by the introduction of new forms of content and even new infrastructures.

The new generation of on-line actors of which account will have to be taken includes many firms such as consumer appliance or building control system manufacturers (such as heating, lighting, lifts or security systems). These firms will not only be responsible for attaching devices to networks but will probably offer 'content' over the network in the form of new telematic services, such as remote monitoring and maintenance of Internet appliances. It will be important for such companies that standards and protocols are transparent and reliable so that they can enter put products and services on the market with confidence. Indeed, the creation of a robust foundation to support innovation by these industries is probably the most important contribution of competitiveness policy to ubiquitous computing. For this reason it will be important to take stock of the areas in which Europe is likely to maintain a competitive advantage across the industries which will be affected by ubiquitous computing. A stock taking exercise along these lines could provide the basis for both awareness raising and support for innovations and developments that will help European industry to prepare for the challenge and opportunity of ubiquitous computing.

The areas of emphasis of such an effort might include:

- A presence in the emerging ‘microsystems’ industry which will design the systems for embedding computer devices into all sorts of everyday objects. This will build upon existing strengths in the areas of specialised circuit design, the writing of middleware applications, computer graphics and knowledge representation and the important growth area of mobile and personal digital devices (and associated big demands on design and engineering services as devices get smaller and more intuitive).
- Design and engineering services for 'intuitive interfaces', such as flat display technologies (the actual production of which will remain mostly East Asian), speech and natural language recognition (especially natural language automation), pattern recognition and vision systems and ergonomics. The great demand for software engineering and programming will provide many opportunities for European producers. Key growth areas for instance might be for translation devices and services, localisation of software and hardware, and the design of middleware and knowledge based software services.
- Many traditional industrial fields (from mechanical engineering, through construction to textiles) will experience new forms of added value creation as a result of embedded computing. It is well known weakness of Europe that it is strongly represented in low-growth medium technology industries[14]. Ubiquitous computing may provide scope for an innovative impetus to such industries.

Issue 3 Information Industry to Knowledge Management

Issue

Computing is already in transition from data processing to being an information industry. Over the coming period the next transition will be to knowledge management. This will require software that integrates technology with human systems and social systems. The kinds of technologies involved will include software agents to automate many data management tasks, knowledge representation methods such as 3-D browsers and GroupWare for working in distributed groups.

The drivers of this trend will undoubtedly be the sheer scale of ubiquitous computing (Issue 2) and the extreme complexity of achieving seamless interoperability (Issue 1). However, more generally, problems of information access and overload affect all classes of ICT user from individuals to mighty corporations: tools for managing the information explosion are very much needed.

Critical bottlenecks in this area are in software systems and human-machine interfaces. Software is already a serious drag on the potential of developments in hardware capacity while the design and engineering of systems which augment, rather than overwhelm, human capacities is a serious area of challenge for research and industry.

Background

A transition is underway between information capture and transmission and transaction processing to full-blown knowledge management techniques. This is a long slow road starting with traditional information management techniques such as better structuring and managing of information (including datamining and datawarehousing) and the development of self-generating software through to artificial intelligence and agent based systems and complete integration of technologies with human and social systems.

The revolution now - structuring and exploiting of information

A current driver of the digital economy is the business intelligence market, which has been projected to be worth $70 billion by the year 2000.[15] Firms in transaction intense sectors such as financial services market, utilities and retailing have led data warehousing and mining. Traditionally, such transactional data and consumer profiles have been kept in stand alone and special purpose databases used for logging credit payments, tracking deliveries, ordering, stock and inventory checks. Techniques for managing such information more effectively are becoming a major business opportunity. However, the techniques are largely build outs of well established data management techniques such as indexing, archiving, creating libraries, creation of metafiles and tagging.

On the basis of such developments firms such as Teradata, the market leader, and others such as IBM, Informix and NCR, are now offering database warehousing software systems. They aim to help firms to exploit their databases so as to target their customers more effectively, add value to their products and services and hopefully improve productivity. For example, BP has now built a data warehouse to improve its procurement practice across the world to achieve major savings.

Inter-firm data warehousing is also important and involves the establishment of central warehouse by a lead vendor that other (backward-linked) suppliers can access. These systems allow suppliers to monitor sales data on products for which they supply components and materials. This in turn permits them to respond to more rapidly to changing supply requests by the lead firm and to enable firms more specifically to move towards mass customisation: i.e. to individualise goods and services without sacrificing economies of scale. Walmart, the major US retailer has been in the vanguard of this development allowing suppliers to use its data warehouse so that the suppliers actually are responsible for stocking the shelves of their products in Walmart's stores. European retailers have also been very active in developing such systems. For example, Sainsbury and Nestlé are using Internet browsers to share planning, forecasting and performance data[16], helping both companies to make better decisions about which promotions to run, and allowing them anticipate demand levels (see also Issue 4).

In the short term, datamining and warehousing will be a key area of growth. We can already see important software developments here are centred on enterprise resource planning systems (ERP) provided by SAP, Oracle and Baan, although Microsoft has entered the market with a low cost system, Plato, based on Windows NT-based systems. Overall the major technical challenges here are in the development of effective middleware to permit the reliable interoperation of different databases. This includes issues such as social filtering, user profiling, and multimodal operations. However, as described above, even here the problems are those of processing of structured data. The problems, if not the solutions, already quite well known to the practitioners. So it is likely that the technical base of this information industry will be well diffused by the early 2000s.

The Software bottleneck

Greater uncertainty about rates of development, however, cloud the development of software systems, and especially software engineering and self-generating software systems (see also Issue 2). Performance gains in software lag well behind the eight orders of magnitude improvements that have been achieved in hardware. Software remains a craft-based industry, with very little standardisation. For example, US sources report that 73 percent of software projects are late, substantially over budget, cancelled, or outright failures.[17] There is a lack of ability to describe large-scale systems, which makes them very hard to update and to modify, as it witnessed by the enormous scale of the Year 2000 problem. And techniques for testing software remain under developed.

Software engineering techniques have long aimed to increase the productivity of programming but they have never achieved the widespread use that would be necessary to match the kinds of gains achieved in computer hardware. Recently, the US President's IT Advisory Committee (PITAC) put investment into basic software at the top of their agenda for government research with the following typification of the problem:

"The demand for software has grown far faster than our ability to produce it. Furthermore, the Nation needs software that is far more usable, reliable, and powerful than what is being produced today. We have become dangerously dependent on large software systems whose behavior is not well understood and which often fail in unpredicted ways. Therefore, increases in research on software should be given a high priority." [18]

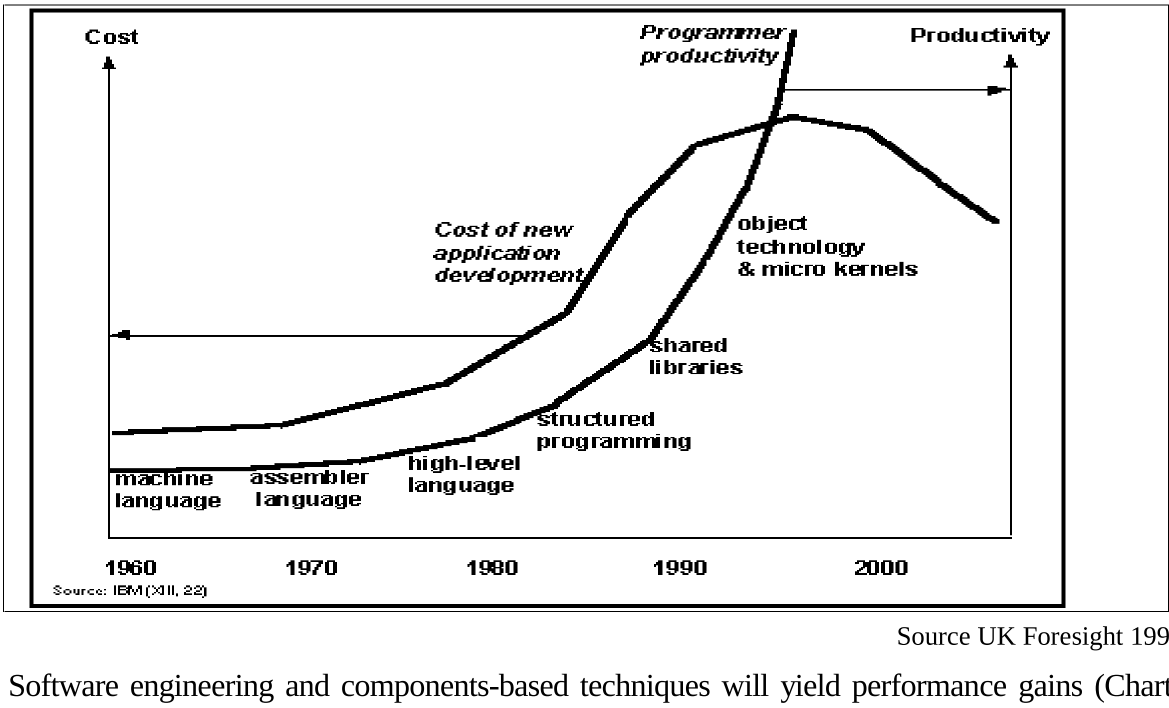
For these reasons, in the coming years attention is likely to focus upon the development of components based programming techniques, the development of formal libraries of software and self-generating software.

Customisable software will most probably be built out of current growth in the use of object orientated or component-based software (such as Java and SmallTalk). At the very least, these provide a library of software, which can be used to deal with specific tasks. These libraries will permit an on-going upgrading of software and therefore device performance. Also, users of the libraries will increasingly be 'end users', who employ the software components to customise and update their computers, using simple scripting languages, such as the HTML used today for the Internet.

Software systems mirror the organisational routines of the organisations, and therefore represent a deposit of organisational know-how and a constraint on change and development (because such programs are a digital legacy of the evolution of the firm and are hard to change once embedded in the computer system). These are the drivers of a search for more modular and standardised systems. However, given that the legacy systems are almost impossible to eliminate, there are also considerable efforts being invested into middleware routines and software agents, which permit systems to interoperate and to share resources. The Internet's computer language, HTML, and platform independent systems such as Java provide a glimpse into such a future but there is much further work to be done.

A further possibility for the future of software development stemming from the Internet is that software development will become more decentralised. As the example (and success) of the Linux operating system illustrates robust and technically superior systems can result from self-organising networks of developers. This could create a more open, flexible and rapid alternative to traditional hierarchically organised software development teams. Perhaps it would even be more testable, if combined with a more modular approach to software construction.

Chart 1 - The productivity of programmers and the cost of application development



Source UK Foresight 1998

Software engineering and components-based techniques will yield performance gains (Chart 1). The encouragement of more open developer community based approaches may help to apply more effort, more rapidly to solving technical problems. But given the sheer scale of the potential expansion implied by ubiquitous computing, they will they will probably not solve the software bottleneck. Rather, what will be needed are self-generating and self-updating software systems. Already some software is being designed with develops capacities (known as "reflection" and "introspection") of automatic inspection and modification of system performance, even whilst the system is running. In essence, the result is a software system that can offer, for instance, automatic updating of a set of interlinked records. This automatic signalling or changes can also operate through universal addressing systems (such as area used in the World Wide Web) to make sure for instance that logical changes in one device are echoed elsewhere.

The development of mass customisation systems will be determined by the rate at which knowledge can be accumulated on the component software building blocks and on artificial intelligence systems. Features such as introspection and reflection have not been provided in software until now because of the difficulty of controlling the results of such autonomy. There has been professional resistance as it is not clear what changes to the code are being implemented when the software updates itself and whether they can be reversed. These are clearly major concerns, especially where the software is being used to control safety critical systems (such as air traffic control, intensive medical care or even financial management systems). New techniques provide rules to control these capabilities are emerging, but much further progress is needed. However, given the opacity and lack of testability of existing software it is hard to completely believe that the new self-generated software will be any less safe than legacy systems.

Machine learning, knowledge based systems, expert systems, software agents

Self-customising will be both an important building block and a result of developments in expert systems and artificial life techniques (based on genetic and evolutionary algorithms), that provide the rules for artificial learning and adaptation. These developments signal a shift in systems design challenges away from handling structured data towards the facilitation of communication and the processing and manipulation of symbols. Software agent developments tend to follow two strands, the simplification of complex distributed computing and the overcoming of limitations of current user interfaces - i.e. making computers more user friendly.[19] In the first case, the aim is to get devices to interoperate in a seamless fashion, notwithstanding the fact that the network brings together independent systems based on quite different principles.

The development of middleware, i.e. software that will permit interoperability between widely divergent systems, is one area in which intelligent software agents will play a crucial role. In principle, they will allow different people, teams and networked devices to share resources and work together without all the problems of incompatibility and lengthy set-up procedures that typify network operations today. Networks of information appliances will require real 'plug and play' compatibility and robustness of an order that exists neither in hardware, software nor systems today. Software agents will also be important in the direct interfaces of knowledge management - with people. One of the critical areas of development for the next period is to develop software interfaces that appeal to ordinary people. They must be reliable, intuitive, predictable, safe, private and present complexity in a way that is amenable and interesting to ordinary human users.

Artificial intelligence is being used to pursue these objectives by building learning abilities into personal assistant systems. Some software agents such as 'knowbots' can be instructed by the user to perform tasks. For example, 'shopbots' are used to search out the bargains by lurking on the network looking for offers that match a predetermined user interest. On-line retailers, such as Amazon, use these kinds of developments to make book recommendations to readers. Instructing software agents can be hard work, and many also learn from 'looking over the shoulder' of the user and copying their actions. They also prompt for direct and indirect feedback on suggestions that they make and offer to automate oft repeated processes and so on. Anthropomorphic techniques (cartoon like representations of faces or moods and humour) are used to provide these agents with personalities, with the aim that people invest time and into tutoring the software agents. Development of analogous representations of software agents can help to clarify the place and purpose of such agents, Negroponte for instance likens their role to that of a digital version of his sister in law (someone who knows his film preferences and what is showing in the local cinemas) or a Digital Butler (who guards access to your time and reminds you of obligations).[20]

Human-machine integration

At the end of the transition from data processing to knowledge management lies the challenge to develop systems which are not just 'user friendly' but are fully integrated with human and social behaviour and desires. From the perspective of today, the creation of such physical 'cyborgs' may seem an extreme vision but the roots can already be seen in the way that Internet creates a view on the world which is undoubtedly beginning to filter reality, just as have other audio-visual systems before. In this sense the Web is beginning to act to augment human capacities for information processing, social interaction and, now, sensor-motoric action. For instance, a key issue will be knowledge processing into forms where complex results can be represented in very intuitive ways via simulations, 3-D models, virtual reality and so on. Rendering these results is very technologically demanding both in terms of enabling technologies (such as high performance computers) through to software for complex systems. In the future, trends could even go so far as to have direct physical integration of humans and machines, with the embedding of computers into humans and of cells into machines.

However, there are serious bottlenecks in terms of our ability, as humans, to process and control the new systems. The limits of human intelligence mean that we are in need of much better supporting technologies if we are to exploit the possibilities of the technology. In addition, there is currently an inadequate fit between human systems and technological systems, which generally are very good at identifying patterns in data and information but are weak on interpreting them, especially when they are symbolic.

Tackling these bottlenecks to the transition to knowledge management will require considerable fundamental research on human systems in areas such as human sensory-motor systems, perception, attention, pattern recognition, and decision-making. Critical fields of research, therefore, will to understand natural intelligence (i.e. how humans think and act) as much as building on artificial intelligence.

Policy Issues

It is clear that there are fundamental research challenges in negotiating the transition to a knowledge economy. Here we identify two of them: first the direct research and development demands and second the need for policy frameworks that will provide a platform for widespread experimentation and development of information and knowledge economy systems and services. .

First, a listing of research and development challenges related to the discussion above would be rather similar to those recently suggested in the US by the PITAC, when they called for increased funding for basic research on:

- Capturing, organising, processing, and using information. Information management is based on the classic computer science disciplines of new and better data structures and algorithms, but also includes theories and new approaches to digital libraries, databases, knowledge discovery, data visualisation, and information-intensive applications.

- Software tools that augment our intelligence and increase our productivity will be key components of prosperity in the future. The research in this area should extend both existing information technologies and those of the future so that non-textual information (pictures, audio streams, animations, etc.) is fully incorporated and integrated.
- Improved technologies for filtering information, for data mining, and for tracking the lineage and quality of information, while protecting privacy and intellectual property rights.
- Digital libraries that can enhance the scientific and educational processes, and that include mechanisms for the long-term preservation of valuable information.
- New technologies for incorporating rich information management services into complex, distributed, demanding applications.
- Tools and technologies for modelling and understanding the semantics of information.
- Tools that make it easier for people to manage, visualise and exploit information and knowledge.
- Fundamental research in human sensory-motor systems, perception, attention, pattern recognition, and decision-making to improve the interaction of people and machines.

Second, there is a requirement for platform building measures that will widen the take up and experimentation with techniques associated with the Information Economy. For example, there may be scope to build on areas in which Europe has technical and commercial leadership, an obvious example is in datamining techniques (SAP is German and BAAN is Dutch). But also Europe leads in some of the enabling technologies of the information industry such as electronic purse technologies, smart cards, secure payment systems and so on. There are likely to be very important and synergistic interactions between e-commerce and the technological capabilities of the information industry.

For this reason, policies to develop electronic commerce are likely to also impinge on the transition to the knowledge economy, to the extent that the current policy goals are to create a coherent and consistent framework for developing the information economy (see also Issue 6). For example, recent proposals by the EU and the UN have aimed to create a clear minimum set of liabilities for cross-border electronic contracts, with the aim of increasing trust and confidence in electronic trade. Similar concerns pervade the recent implementation of the EU Directive on cross-border mobility of personal information, which seeks to impose privacy norms in order to raise confidence.

The current situation in Europe is one of fragmentation and confusion that militates against the construction of common platforms across many areas of the emerging information economy. For example, there are currently 22 standards across Europe for the use of smart cards, which reduces the portability of these cards and slows the rate at which they become commercially viable. Likewise, for electronic payment systems there is no lack of payment technologies (Net-money, E-purse, SET, CEPS), but there is a lack of coherence, which contributes to uncertainty over the technologies, which once again slows the transition to critical-mass and here may contribute to a lack of confidence in e-commerce.[21] There are considerable differences on how advanced are different countries in respect of digital signatures (i.e. authenticated and encrypted versions of electronic signatures) [22], with only two countries in Europe so far that have enacted special laws (Germany and Italy).[23]

Overall, then, a key paradigm for supporting innovation in the knowledge economy will be through adaptations to rules of the game in ways that will create wide adoption of e-commerce and growth of the information industries. The aim should be to stimulate the technologies upon which they depend, such as encryption algorithms and datamining. An example of such platform building could be the recently proposed Commission Directive that tries to create appropriate legal frameworks for cross-border e-commerce, within the Internal Market.[24]

It is likely that as information industries grow, therefore, there will be important technology multiplier effects in associated technologies. The direct effect will be to increase demand for complementary technologies in areas such as recognition sensors and user identification algorithms. Early movers in these areas are likely to make important gains in knowledge that will provide useful intellectual property assets. In addition, it can be expected that the take up of digital media will require rapid scale up in knowledge management techniques. There will be very significant technological developments in collaboration technologies, especially version control, data mining and information retrieval.

Overall, for Europe, the policy choice can be typified as that between continuing to develop with piecemeal national-level agreements (islands of acceptance) versus the establishment of a digital Euro-zone, in which there is a concerted EU level effort to agree a programme for implementing the acceptance of these technologies. Such a programme might be analogous to the single currency agenda, based on national agreements to establish an agenda and timetable for change.

Part 2: Crossing Frontiers: Space and Time in Cyber Europe

Issue 4 Going Glocal? Business Location in the EU15+

Issue

Information and communication technologies will be one of the key drivers of changes in the economic and industrial geography of Europe. Especially important will be their role as a force for globalisation: through the establishment of globalised firm level networks and trends towards the virtualisation of enterprises.

However, there are equally important countervailing tendencies, especially the tendency towards the 'localisation' of economic activities. It seems that, with the increasing mobility of investment capital, places will have to strive to be 'attractive' in order to maintain stable growth within the global economic system. This means that place specific factors such as skill and education levels, effective institutions and administrations, a modern infrastructure and an innovative industrial base will be the key attractors in global economy.

Going 'glocal' (i.e. local strategies for the global market), therefore, will be the touchstone of economic development in the years to 2010. However, Europe is currently unevenly developed in respect of them: disparities that will be accentuated by enlargement. The policy challenge, therefore, will be to identify appropriate glocalisation strategies for different regions in the broader context of a Europe in the Global Information Economy. In particular, it will be necessary to find ways to use ICTs to lever the regional comparative advantage.

Background

The novelty in the current wave of the Information Revolution is that for the first time it is realistic to talk of a 'Global Information Society'. The new global infrastructure of ICT is clearly directly affecting firm-level strategies and the competitiveness of places. This fact has generated a lot of interest in recent years in the future industrial map of Europe, with extensive analysis of subjects such as the virtualisation of enterprises, the growth of transborder telework, the delocalisation of employment to newly industrialising countries and, most recently, cross-border electronic commerce. The most important key drivers of these phenomena are undoubtedly the global strategies of multinationals, particularly market development and investment and sourcing patterns. However, also important at least in symbolic terms are emerging Internet based industries and firms (such as Netscape and Yahoo!) that have used the Internet in order to go global before becoming big.

Assessing the future scale and pace of such ICT-mediated globalisation trends is a major analytical challenge. However, as this section tries to illustrate, there are some early results that provide a useful basis for policy development. The section begins with a short discussion of 'virtualisation', as a lead into to a consideration of the implications for competitiveness.

‘Virtualisation’

ICT-based ‘virtualisation’ has a wide variety of different meanings (See Box 3), but two key dimensions concern us here. First it can reduce the need for direct physical presence, thus providing geographical flexibility. Second it can reduce the need for ‘permanent’ organisational structures by making goal-orientated network relations easier to manage. It is thus associated with trends towards carrying out of activities remotely and indirectly, often by outsourcing.

Virtualisation allows firms a greater geographical and temporal flexibility. For instance, it could lead to a move away from having geographically centred operating divisions towards more flexible organisational geometries, such as multi-site and temporary teams formed to undertake a specific project and afterwards dispersed. ICT related space/time efficiencies in knowledge activities also facilitate concurrent or 24 hour cycles of research and software design. Teams located in different time zones around the world relay on their work as each day ends.[25] The implication is that ‘virtual enterprises’ will be free to choose where to invest. In other words, over relatively short time horizons, they will be able to reconfigure their activity portfolios to achieve, for them, the most advantageous combination of access to markets, skills, finance and so on.

Box 3: The uses of ICTs in the Virtual Organisation

1. To balance demand and supply more closely - e.g. the US firm Frito-Lay uses real-time sales-delivery information to see the entire physical value chain from order levels and timings from suppliers, to production capacity to truck loadings and routings.

2. To change the structure of the supply chain through cutting out middlemen (‘disintermediation’) or by introducing new opportunities for intermediaries ('re-intermediation' or 'infomediation'). E.g. backward integration by retailers (based on efficient consumer response techniques) has tended to eliminate warehousing functions (disintermedation). While, US travel agent, Summit Travel of North Carolina has created a software package that allows users to search the Web for flights and book them direct (re-intermediation).

3. To lever innovation capabilities for competitive advantage - e.g. Sun Microsystems allies its strong technological, design and marketing capabilities to information systems tracking production and sales within its supporting virtual production chain to retain control over points of competitive advantage in their main technology markets.

4. To increase productivity and speed to market by using ICTs to ‘mirror’ physical elements - e.g. Ford’s R&D departments have set-up a virtual automobile development environment on computer. This system involves simulated prototypes in place of physical prototypes. The result is that dispersed development teams have access to a shared task space that crosses barriers of space, time and functional division. It thus reduces the number and size of the links in the innovation chain.

5. To create virtual ‘mini-storefronts’ where information is used to individualise the service to end-customers - e.g. FedEx provides real-time parcel tracking services and Dell pre-loads customer software, this increases customer loyalty and retain market share.

(Sources: Magretta. 1998, Chesbrough and Teece, 1996, Rayport and Sviokla, 1995, Tapscott, 1995)[26]

Information systems can also allow a simultaneous achievement of both economies of scale and scope on a more dispersed organisational structure. This affects the organisational geography of the virtual enterprise. For example, ICTs, networks of very small ‘pico-units’, which in the past may have been sub-optimal in terms of efficiency, may now improve access to local factor of end-user markets.

An important element of added value will arise from ICT enhanced dematerialisation, resulting from direct efficiency and productivity improvements, or the substitution of physical processes and services by informational ones. Dematerialisation could add value by improving the co-ordination of activities, lowering waste, reworking, redundant production, by better matching of supply to demand and by reducing the travel by virtualising meetings and workplaces. Such developments, however, raise questions about the spatial consequences of such efficiency gains. If activities become spaceless, will some places feel the reduction in physical resource use in the form of lower levels of economic activity?

Overall, virtualisation can be expected to have a major impact on competitiveness and the winners and losers in the new industrial geography of Europe, especially in service industries. In many cases virtual organisations will service end-clients without establishing a physical presence, leading to relocation and possibly delocalisation outside of Europe, as firms master the art of working in a dispersed mode. Certain types of jobs may disappear and others may emerge, for example by disintermediation leading to the elimination of middleman activities.

However, the scale and pace of these trends are poorly understood. Also the advance of virtualisation is not immutable. Virtualisation is accompanied by an increased emphasis on face-to-face contact and the continued need for the physical transformation and delivery of goods and materials. Indeed, cyberspace depends upon an infrastructural build out of the physical world - it does not happen in a vacuum. In particular, high tech is usually "high touch". Knowledge intensive businesses (such as strategic-level management, consultancy, financial control, engineering and design) involve considerable transfers of tacit knowledge. This usually involves 'situated' learning, where conveying an understanding depends on direct social interaction. Also, people want physical presence for many services (especially where there is a high need for trust such as in education and health services, but also financial advice). In many cases they will still want to touch, feel and smell the goods they want to purchase. As Charles Handy has noted "Paradoxically, the more virtual the organisation the more its people need to meet in person."[27]

ICTs and the new European landscape

But what factors will be determine the winners and losers in the Europe's Information Economy of 2010? First, ICT is encouraging a new global geographical specialisation and integration of industry. This is particularly apparent in the ICT industries themselves. For example, it already appears that there is a division of labour in enabling technologies. The US is leading in software services and key intellectual assets (especially content, technology patents and telematic services). Japan and South East Asia are leading in specialised ICT hardware such as processors, displays, disk drives and storage media. Europe has particular strengths in certain competences such as systems integration, software and systems design, portable computing and communications.

However, as we have seen above, the critical technological challenges are often on the level of system technologies. Thus, at the system technology level, there is a growing global interdependency in the design, development and production of ICTs, where no individual firm or region can go it alone any longer. The complex international alliances are indeed an example of the virtualisation of enterprises. Of course, there are questions as to whether such co-operation is between equal partners. As we noted above, there are signs that certain firms may be in much stronger positions to dictate the direction and pace of change than others, because they own key intellectual assets. There are fears that these strongly positioned firms are mainly US-based. Likewise, the trend setting technology firms are also locating in the USA, because it is there that the risk capital to set-up such ventures is most readily available. Nonetheless, it is clear that participation in these global alliances is crucial for firm-level and regional growth. Such participation depends both upon the capacity to maintain leading edge competences and being integrated within the innovation networks that are engineering the technical breakthrough.

Competitiveness in the ICT sector, therefore, will depend increasingly upon competences and connections. These features are likely to be duplicated in most other high growth and high technology fields. Indeed, as we have seen in Issue 2, computerisation will steadily spill out of the ICT industry into other sectors. This will affect both manufacturing and services raising the knowledge intensity of growth in these sectors, and in turn making it harder for firms and regions that are lagging behind to compete with the industrial leaders. On the other hand, as we have also noted above, there are some expectations that, as computerisation becomes ubiquitous the margins in the industry will become squeezed in the new computerised consumer goods sectors (including PCs and communication services). Lowered prices could increase demand for services dramatically, but yield very low turnover growth for technology vendors and services. For this to be achieved, large parts of the computer and the computerised consumer goods industries will have to conform to a commodity-production business model, i.e. with a considerable amount of the physical production taking place offshore.

In addition to being a kernel of manufacturing product innovation, ICTs provide a major avenue of service and process innovations in their role as the infrastructure of the Information Society. In other words, given that innovations are in the bedrock of competitiveness, they are a condition for a successful EU economy. Here policy attention is shifting towards creating facilitative structures for the adoption of ICT and includes technical concerns (interconnection and interoperability) as well as commercial issues (such as ensuring an appropriate legal context for e-commerce as described in Box 4).

Europe in the Global Information Society

It is not clear what will be Europe's role in this new global structure. In a globalised economy, the investment decisions of multinationals are critical to economic prosperity. It appears that multinationals base these decisions upon access to markets, the effective performance of domestic institutions (i.e. stable tax and macroeconomic systems, effective and transparent governance) plus the quality of the information infrastructure and the knowledge base of the region. Of course, one can be sceptical about the real extent of globalisation. Some commentators argue that rather than globalisation there is actually an intensified regionalisation. For instance, European firms have tended to restructure their strategic investments within Europe rather than globally and despite rapid internationalisation there are still strong ties between core countries and the core research technology efforts of multinationals.[28]

Box 4 Globalisation and the Information Society

1. Who is responsible for paying indirect tax and tariffs? E.g. if music is downloaded from the Web with no physical goods transferred how can VAT be charged? Should it be based on the location of the consumer?)

2. In whose jurisdiction are we? E.g. can a lawsuit be brought against an organisation which is accessible over the web but has no interests in the country concerned?

3. Transborder work: E.g. with the possibility of "virtual mobility", what apparatuses do we need to enforce labour standards and resolve disputes?

4. Intellectual property protection: E.g. one country allows the right of communication of work protected by copyright for teaching and research, it is available via a website to a second country where no such exceptions are permitted. Is this an infringement of copyright?

5. Data protection: E.g. data collected on Internet purchasers is sold on to third parties without the agreement of the consumer. Is there any legal remedy for the consumer?

6. Trademarks: E.g. Two companies have the same trademarks but in different national registration schemes - both of them cannot have the same Internet domain name. Which of them should have precedence?

7. Authentication: E.g. there is no harmonised system of verification and certification of correspondents, how can cross-border trust be built up if there is a risk that mutual recognition fails?

8. Consumer protection: E.g. How can a consumer know or be confident in the laws or regulations and terms of contract that govern transactions on-line?

9. Harmful content: E.g. can public decency controls in one country be used to take action against purveyors of offensive material operating from a second country?

(Source: CEC (1998) Globalisation and the Information Society, The Need for Strengthened International Co-ordination, Communication from the Commission, CEC Adopted 4-02-98)

Also, the features of the industrial pattern of ICT-based growth have mixed implications for the accession states.[29] On infrastructure, innovativeness and institutional capacity most indicators are rather weak with a significant lag in terms of ICT and media penetration rates and network infrastructure provision. Undoubtedly there will be some catch-up but ICT use, provision and investment will continue to lag through to 2010.[30]

On the one hand there are bright spots in that these countries generally have relatively well educated citizens and there are strengths in research capacity. However, much of the research and education base and the training systems and skill pools are not appropriate for the 'new economy' of the Information Society. Research has in the past been too focused upon basic research, with relatively little applied research and even less know how about how to transfer this technology into industry. The skills and training systems (with the large exception of military technologies) have been orientated towards heavy and medium technology industries. Also in the early years of transition there was a substantial drain of scientists from these countries to west and, with the collapse of public funding for research, a large part of the technical skill base is now under employed in unrelated private sector organisations. There is also a lack of competence and tradition of teaching of economic and business skills.

However, a reform and upgrading of the universities is underway and, with high levels of youth unemployment due to the low job generation, many younger people are opting to stay on in education. This raises the hope of a transition to EU 15 levels of high education attainment amongst the younger age cohorts by 2010.

For these reasons, there has been a substantial increase of inward investment in accession countries, such as the relocation of some manufacturers, such as Siemens and General Electric. For the moment, however, these tend to be routine and low value activities (e.g. light bulb manufacture) which are attracted by low labour costs and an easy access to European markets. But with the relatively high education levels there is scope for relocation of higher-level knowledge intensive activities, especially where there are extreme skill shortages such as in software programming and engineering. Thus, both EU and US companies have recruited software engineers and designers in these countries. There is some fear that the Eastern European technologists are in direct competition for such 'bodyshopping' with alternative very low-cost programmers and systems analysts and circuit design in SE Asia and, notably, India.[31] However, again as noted above, the software skills bottleneck is likely to be of such a size that workers and firms who have marketable software skills are unlikely to find themselves idle.

Policy Questions

It is clear that ICTs are a carrier of globalisation. Direct policy leverage on such globalisation trends is quite limited. In fact, from the perspective of the emerging trends towards 'glocalisation', basically two arenas of action are open for policy makers. The first aims to establish an institutional and regulatory platform across Europe that will support ICT innovation and adoption (Issue 3). The second is to identify and support the development of regions that are lagging behind to an extent that damages cohesion and drags down the economies of scale of European integration.

The aim of platform building is to make sure that Europe performs at its full weight in the international economy, in terms of its size, wealth and its innovative potential. Policies that provide facilitative regulation are now standard practice within the Commission. An example is the recent communication on electronic commerce, in which the Commission called for greater international co-operation on the global e-commerce, rather than more regulation.[32] The aim is to broker co-operation and to reduce the transaction costs and uncertainties associated with innovation.

The second main policy thread is the reinforcement of regional level capacities to attract investment and support innovation. The indicators of regional attractiveness outlined above can explain a large proportion, although by no means all, of the regional variations in GDP performance.[33] This indicates that, in general, regional policies will tend to be directed towards the identification and adjustment of disparities in institutional capacity, infrastructure and human resource stocks. In the specific case of ICT related locational patterns the key issues will be raise ICT skills, to try to attract knowledge-based enterprises and to stimulate investment in the basic infrastructure of the information economy.

Also, in an economy that is virtualising the key policy tool will be the stimulation of networking on both the local level and by building linkages to high quality networks beyond the region. Local networks are necessary to build up local agglomeration economies - through the sharing of know-how, training facilities, labour pools, sources of finance and infrastructure. Of all these the most important is to achieve critical mass of innovative actors that are interacting, so that learning and know how can be acquired and diffused rapidly through the regional economy. This also implies policies to interconnect existing stand-alone networks. As a corollary to glocalisation, and as stressed above, these local networks also, need nodes that are interconnected to international innovation networks in order to keep them up-to-date and competitive. The rise of virtual science parks and virtual SME networking projects (for instance, seen in respective projects run by the Universities of Leeds and Wolverhampton respectively in the UK) are examples of just such schemes using ICTs that can help address these issues.

Issue 5 Net Working: new structures of work, life and learning

Issue

New ways of working will emerge due to ICT, resulting and inducing change in patterns of living and consumption and the need for news ways of learning. The main consequence will be that ICTs will promote a blurring of the boundaries between work and non-work, private and public life and social institutions and norms. ICTs will also be an active ingredient in striking patterns of life, work and learning and in the process will create important new demands, markets and therefore opportunities for European industry.

Background

The organisation of the life and times of Europeans still mainly reflects the needs of the industrial age. Whether they span the life-cycle or are just the daily routines much of our life patterns are based upon: the synchronised presence of people in time and place; clear distinctions of time and place between work and private life; and sequential patterns of activities (e.g. initial education, working life and retirement). These models and the distinct spatial and temporal zoning with which they are associated are breaking down at work, in consumption and lifestyles and in learning. ICTs are an active ingredient in these changes and this section tries to illustrate some of these changes with a view to identifying some of the key policy challenges that result. Key challenges that revolve around the transformation of patterns learning.

Work

ICTs are a central factor of change in working life, the are associated with the transformation of skills, the growth of new sectors of industry and new working conditions. Many new patterns of use of time and space stem from their use. In an extreme example, they make it possible to live and work in two different countries, even continents. These changes reflect the ‘dematerialisation’ of work (automation will lead manufacturing employment to fall below 10% whilst relatively ‘footloose’ informational employment is expected to rise) and the increased flexibility of work (rising part-time and temporary employment contracts plus more flexible work organisation regimes). As a result, we can expect new concepts of work and skill such as:

- The types of jobs on offer: associated with technological change, the sectoral drift towards services and knowledge intensive work, and the feminisation and ageing of labour markets.
- The ‘virtualisation’ of firms: leading to increased organisational ephemerality of work, delayering and smaller units, and more requirements for polyvalent and knowledge intensive work (multiskilling and/or multiple job holding).
- Trust-based management and work relationships: work performance measures will become more based on results than physical presence in the workplace.
- The blurring of work and non-work: changing notions of workplace (the employer’s office, home office, car or customer’s site).
- Growth of hobby work, dependent work, gift work and entrepreunership: new meanings of work for the individual, family, community (e.g. work as hard fun, affiliation shifts from employer and work mates towards self, family, community or professional associations).

Box 5: What happens to work when ICTs come in?

1. ICT destroys work (automation & rationalisation) vs. Creates work (develops new markets & human capital)

2. Work takes over life (pressure to work everywhere & all the time) vs. work integrated with, & subordinate to, life (work adjusted to needs of family and life style)

3. ICT isolates & stresses individuals (working in different places & times and overwhelmed by info) vs. interconnects & stimulates individuals (widening of networks & access info of choice)

4. ICT enslaves people (dull routine work) vs. liberates people (exciting challenging work)

5. ICT downgrades skills & competence (to single task, push-button, machine-tending) vs. upgrades skills & competence (to multi-tasking, creativity and innovation)

6. Organisations becomes machine-like (hierarchical, centralised and bureaucratic) vs. organisations become brain-like (delayered, decentralised decision-making and responsibility)

7. ICT restricts & impoverishes education (impersonal, mass produced & standardised) vs. widens & improves education (personalised, networked, flexible and not dependent on where live or income)

8. ICT destroys localities (through common denominator of globalisation) vs. Enhances localities (based on quality of people & immaterial attributes rather than material attributes)

9. ICT leads to a divided society (centralises power, control, secrecy & surveillance) vs. Increases democracy (decentralises power, flexibility & freedom of choice)

(Elaborated by Jeremy Millard, 1998)

ICTs play a facilitating role in these changes, but they are not deterministic (see the extreme dichotomies presented in Box 5), outcomes depend on social choices and policies, not technologies per se.

ICTs and consumption

Many new ICT products and services can be expected in the coming years based on the growth of information appliances (see Issue 2) with the automation, embedding of artificial intelligence, greater possibilities for remote working and techniques for virtualisation, 3-D representation and sensory systems. The conventional ICT markets formed through the convergence of computer, communication and content industries, consumer electronics, office automation can easily be expanded to include, electronically aides, computer games, toys and services. Many vanguard applications may seem trivial (such as *tamagotchi*), but there could be major impacts on industrial development, work and lifestyles. In fact, there is a vast set of areas in which new ICT goods and services could emerge including:

- Healthcare ICT products, such as prosthetics, ‘intelligent’ diagnostics, remote diagnostics or remote surgery.
- Service robots used in cleaning, personal care (especially for the disabled and elderly) and harsh environments.
- Embedded intelligence products.

- Tools for remote working and living.
- New forms of leisure and pleasure products.
- New educational and learning products.
- New automated business management tools.

Box 6: ICTs and the shifting patterns of living:

Technology aids for the daily routine:

- Devices for routine monitoring of health and checking for medical risks
- Active time management systems (combinations of alarm clocks, secretaries, reminders, personal advisor and counselling)
- The 'Daily Me' (personalised electronic news selections)
- Food purchasing, meal planning and preparation systems
- Security systems and auto-nannies
- Financial advice and portfolio investments
- Sleep management technologies to maximise the effectiveness of sleep time and perhaps effective learning while you sleep technologies (the idea is not new – university students have been attempting this for centuries!)

Life cycle shifts:

- Pre-birth scanners and foetus condition monitoring
- Robositter for nursery and toddler care
- Technoplay to improve mental development from games and exploration
- Adolescence - systems to teach interaction and social skills (co-operative games)
- Transition to work and adulthood - virtual professions and lifestyle planning
- Mature people - personal digital assistants become lifestyle planner and counsellors
- Active retired - health status monitors, time management and educational guidance
- Old elderly - pain alleviation, home robotics, etc
- Death and beyond the grave - Assisted death and holographic mausoleums

Social space:

- *Virtual communities* the demand for contact especially in an era of rising (international) mobility
- The electronic agora - the growth of e-democracy in order to increase transparency and participation in political and civic life
- The cyber-panoptican - surveillance and security and corrective control
- Infopathologies - people deluded into thinking their knowbots are alive or feeling locked into the machine, isolation or alienation or a virtuality leading to psychosis

(Sources: Dertouzos, 1997; Coates et al. 1997)[34]

However, technological possibilities do not determine rates of market creation and "killer applications" are notoriously hard to spot a priori[35]. Given high uncertainty and high costs of development, especially in complex products that call on cross-disciplinary skills, there is a shift in the innovation model away from technology-push and market stimulation, towards attempts to amplify market signals. In particular there is growing interest in user-centred design and development.

At the same time there are growing numbers of consumers who want to be in control of the 'where', 'when', and 'how' of consumption (i.e. greater 'prosumerism' or producer-consumerism is needed).[36] See for example the rise of the mobile phone and interest in speech recognition. Ease of use and how well ICTs fit into daily life will be a key aspect of such demand-led growth. For example, the 'battle for the eyeballs' between web browsing TV and the PC is a case in point. A television may be user-friendly, but perhaps it confuses functionalities - you do not put a fridge and an oven together either.

New patterns of life

New patterns of work and the new possibilities offered by ICTs will permit the adoption of different lifestyles.[37] These changes to more networked lifestyles will undoubtedly raise psychological and identity issues, as people struggle with perceptual and cognitive dissonances between lived experiences in their physical milieu and their virtual experiences in the cyber domain.

The fact that it will be possible to live and work in two continents does not mean that markets and or consumer behaviour will automatically 'globalise'. Instead, variations in values and the need for personal contact will probably lead more to a "glocalisation" (global localisation) of markets. This implies that markets will actually become more differentiated, perhaps encouraging vendors to localise (rather than individualise) the specification and delivery of their market offer in order to encourage brand loyalty, consumer confidence and matching of needs. However, these new axes of differentiation may operate less by geographic clusters and more by distinctions of social or interest groupings (associated with the new virtual associations enacted in cyberspace).

Lifestyles and ICTs will also develop in relation to social and demographic factors (see also the Report of the Social and Demographic Panel). For instance growing single person households, growing numbers of active elderly, increased participation of women in the workforce), the balance of time available for work, family and leisure, wealth and disposable income levels. The interactions between work, living and education will be a key nexus of the growth of demand for ICT services, which will call upon a significant part of people's economic and time budgets.

These features will have major impacts on the form and nature of demand for ICT-innovations in the home and in the public sphere (Box 6). For instance, rising time pressures will increase demand for instantaneous and easy access to information that is useful to the user's context. The result will be a strong development in personal digital assistants in a wearable form (so that they are less intrusive - the same miniaturisation process can be expected here as with PCs, mobiles) and which are sensitive to the user's context (so that they provide punctual and appropriate assistance).

Learning

Changes in patterns of 'work' and living strongly imply increases in individual responsibility, skills and independence. Overall, it is expected that a transition to a 'knowledge society' is taking place, in which ICTs are playing roles as both driver and facilitator.[38] A knowledge society heightens the necessity for life-long learning, which in turn implies new rhythms of working life, both along the career path and within the annual, monthly and daily cycles. Learning in the future will have to focus on competencies and qualifications seen from two perspectives: requirements in relation to the work life, requirements in relation to the societal life.

To achieve these changes, in addition to individual initiatives, new institutional responses are needed at governmental and corporate levels, not least because we are in an era of steadily increasing demographic ageing of the workforce. By 2010, those nearing the end of their working lives (55-64) will outnumber the 20-29 age group. This decline of recently educated workers taken together with continuing high levels of technological change and on-going rapid changes occupational structures, makes the overhaul of adult (and indeed initial) education systems an urgent necessity (see also the results of the Futures Project - Demographic and Social Trends Panel). The educational system will play a central role, but will not be the only actor in this development.

In the present circumstances, given the higher pace of technological change, the more rapid turnover of products and services and the fact that people change jobs more often than previously, more frequent renewal of knowledge and skills is needed. As a result, the importance of lifelong learning is stressed as crucial in a knowledge-based economy. (…) Opportunities and incentives for learning and re-learning continue to be limited and the potential role for learning in non-institutional settings has not been sufficiently exploited."[39]

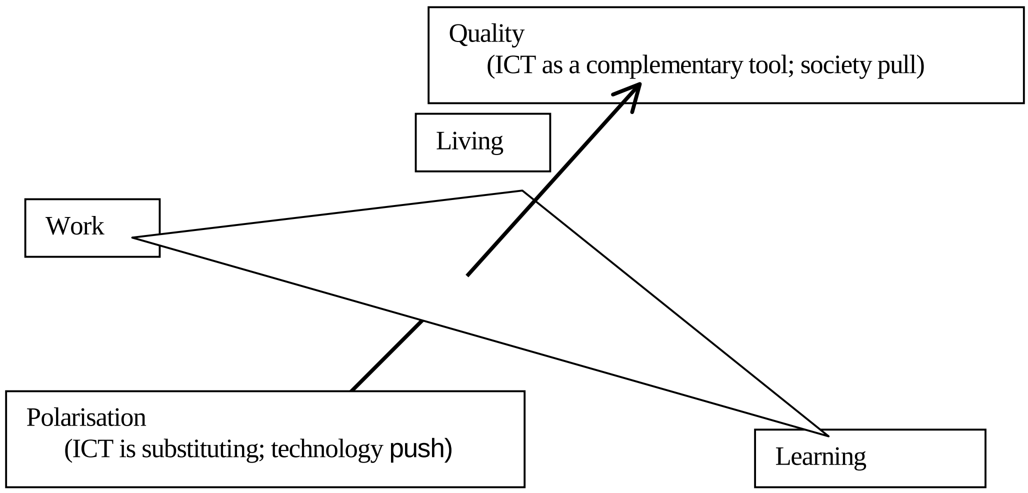
If in the future, Society shall overcome this 'efficiency trap' - more actors should be involved in contributing to a sustainable education and training system. The Danish report 'Borderless Education' concludes that this calls for a new type of public-private partnerships as a solution to develop new concepts and provide new economic schemes for lifelong learning.[40]

It is also important to remember that ICTs could also facilitate these changes - although there remain many barriers to effective introduction of ICTs into learning environments.[41] Due to inadequate consultation there is often a mismatch between grass-roots needs and commitment and ICT in education plans. On-going investment in ICTs is not yet built into the budgeting of educational authorities. 'Computer into education' programmes are often still driven by student: computer ratios rather than learning targets. In-service training of teachers is still underdeveloped. Teaching practices have not yet adapted to exploit fully the new technologies or the new broader concept of life-long learning. There is still little conclusive evidence that ICT-based learning is more effective than traditional techniques. There is also a continuing lack of educationally valuable content, especially for non-anglophone students. In addition, it is quite clear that although there are potential economies of scale in the delivery of some forms of open learning material, the overall effect is rather more often to increase demands on trainer time. In addition, open and distance learning requires different skills from both learners and trainers. Because of the sheer size of the educational workforce, retraining the trainers of the new methods will be a long, slow and very expensive, not least because good practices are not yet firmly established. For learners, open and distance learning call for extra degrees of self-reliance and self-directed learning that are best acquired as skills for life in initial education. This implies that a population equipped for life-long learning will emerge only slowly as new cohorts exit initial education, and even then only if a reorientation of the initial education system is achieved.

On a more positive note, many areas of computer skill shortage that are of major concern today might turn out to be short-run problems. Improvements in the design of the user-interface and the embedding of artificial intelligence could make such learning almost invisible. More complex machines will have increasingly intelligent user interfaces that will permit 'just-in-time-training' or learning by using, perhaps in the form of context based help screens or troubleshooting dialogue boxes.

In the more developed cases (Issue 2), software-agents and intelligent devices may also shift the focus away from a need to learn how to use the machine towards more fundamental human attributes creativity, cognitive skills, communication abilities. In other words, the computer might become invisible, the technical complexities will be hidden away for experts to deal with, and users will be able to get on with the task they really want to achieve.

Figure 1 - Social pull or technology-push?



Policy Questions

In this chapter we have described how cultures work and the role of work in society. But this process is complex and it is difficult to foresee how the interactions between social, demographic, industrial and technological trends will play out in different regions and amongst different social groups. For these reasons, appropriate policy responses will depend upon the local situation and the social group involved.

Nevertheless, it is possible to provide a general schema for policy development (Figure 1), which stresses we should avoid the technology-push mode (which seeks at ICT substitution for human services in an attempt to deliver low cost services). It aims instead at a social-pull model (where ICT is seen as complementary the aim of upgrading 'quality').

This is not to deny that there will be considerable scope for ICT-based goods (such as home help robots) and care services (for example voice text transcription for disabled people). On the contrary it will be necessary to encourage innovations in these areas in order to achieve the productivity gains needed to deal with increased demand for such services (especially with growing elderly population). These will be important areas of innovation and industrial development and could be encouraged through public sector trials and purchasing.

In the pursuit of 'quality', however, we need to recognise the challenges as well as the extra possibilities lent by new ICTs. First, because the new technologies alter our experience of time and space, they can also change perceptions of self, community and society. These changes are rather significant and we do not yet fully understand them. We can give some examples. What are the psychological consequences of abstraction of working in virtual environments or what are the stresses on families of the blurring of work-home boundaries? We have suggested that ICTs actually offer us more options for sequencing and overlaying activities. This raises the question whether it is possible to achieve a balance, for instance, between times with fast flows of event and times with a more tranquil pace, just as some places are busy and noisy and others quiet.

What would be needed would be social norms that would allow these kinds of practices to be established and maintained - for the well being of people. The mechanisms for establishing these norms, however, are not yet clear. It would probably require a combination of consultation and promotion of good practice. In the next chapter (Issue 6) we suggest that such norms have a wider role in forming the foundations of a mature vision of the Information Society, perhaps in its early stages it perhaps could promoted as a Digital Charter for Calm Technology.

A second fundamental theme in this section concerns the knowledge intensity and high rates of innovation in the Information Society of 2010. This requires a concerted effort to achieve the shift to a life long learning society - i.e. a social system in which learning permeates work, life and learning. Knowledge intensity points towards a need to evolve new concepts of skill and literacy that emphasise creativity. This would have a dual effect as both an instrumental gain (creative and original workers are more able to respond to change and less structured work environments) and an emancipatory effect in society.

However the new life-long learning models must be structured so that learning ceases to be marginalised as the responsibility of the education sector and the prerogative of privileged high skill groups. Again the rationale can be constructed on the purely instrumental grounds that all advanced countries face on-going difficulties in ensuring access, through the labour market, to remunerative work to all people with lower levels of qualification. Traditional passive labour market measures are now being supplemented (although far from supplanted) by more active measures including: training, job placements, wage subsidies and employment counselling. A strong qualification bias is operating in labour markets today, which is accentuated by ICTs. Thus training is emerging as the crucial component of employment policy.

It is true that in some regions (especially in some of the accession countries) and for some groups, (especially older or traditionally skilled manual workers) structural unemployment can be too ingrained for training to have an effect on joblessness. Under these circumstances alternatives include job subsidies or the promotion of non-market work. One big area of potential growth of employment will be in the apparently unlimited demand for care. As we have seen above, health services and education services are key areas for ICT innovation, but ICTs are unlikely to substitute satisfactorily for the human element of care. Generally, the aim is for ICT-assisted care services not automation. In addition, there is likely to be growing interest in the support, rather than deterrence, of self-employment, perhaps by encouraging free agents schemes that provide guarantees of continuity of work but with different employers. Policies to promote Local Economic Trading Systems (LETS) could also provide a means to gain economic and social development leverage over the 'barter economy'. ICT might assist in this process by providing a means of formalising and tracking transactions, thus making a link to the market economy and perhaps a means for economic development for otherwise marginalised communities.

However, all these features point relentlessly to a demand for a substantial transformation of the social practices and educational institutions that allow people to acquire skills. The result in the educational system is considerable institutional strain, as it struggles to make a transition from the

19th Century, industrial age model, on which it was founded, to a life long learning model that is appropriate for the Information Society.

In the context of an ageing Europe the crucial challenge is the upgrading obsolescent knowledge. On this, we still know far too little about the cognitive processes involved in retraining older people, which involves forgetting and unlearning as well as acquiring new layers of skill. There are signs that people are at least taking the issue seriously, for example already half of the college students in the US are over 25 years.[42] We can also expect to see substantial growth in the learning/training system, with more providers (and of various types) and a high growth in the number of training places offered and taken up.

The key question is where will the resources come from to fund this expansion? Tight public spending budgets and institutional inertia (given by the 80% of public education budgets fixed into wage costs for initial education) means there is very little scope for a widespread enhancement of public further education provision. The size of the problem undoubtedly means that people have to be more self-reliant as regards acquiring new skills, but this calls, above all else, for a high quality initial education - which for many does not yet exist. But firm and individual level efforts will not resolve the problem - it also requires concerted and brave policy efforts over the long term. In many ways, the life-long learning challenge is the most basic of all policy challenges for the Information Society, invoking a wide range of fundamental policy questions such as:

- Above all, how to assure a rising learning curve for a large minority of people whose skills are being made obsolete by the Information Society, and indeed who in the future might even find it hard to function as citizens and consumers.
- How to place a sense of order over the emerging chaos in training and accreditation systems, especially as regards ICT skills. With the rising importance of corporate universities (e.g. Motorola) and vendor-based certificates of skills (e.g. Novell and Microsoft) there is a clear privatisation of learning. How this will affect the role of public learning institutions remains to be seen.
- To decide on the new roles and career structures for teachers. With life-long learning old teaching models cannot be sustained. Not only can society not afford it, there are neither enough teachers nor enough capacity to train them. New styles of learning will have to be codified including self-learning (especially using ICTs) and, especially mentoring by colleagues, community and family. In other words, knowledge sharing techniques will be a key aspect of an effective learning society.
- Lastly, how can we create incentives so that people devote a sufficient part of their disposable income to learning?

Part 3: Digital Europe

Issue 6 Information Warfare or Information Welfare

Issue

The Internet is characterised by its openness. The result is that a rich and chaotic wealth of information, images and ideas are being made available on a worldwide basis, to anyone who has the tools and interest to go on-line. Because of its size, global scale, complexity, openness and dynamism, this chaotic network effectively renders obsolete traditional mechanisms for structuring and controlling informational content. Strains are apparent across a broad range of legal domains: decency laws, privacy protection, security services, intellectual property rules and in authentication systems.

With extensions of the Web to include more and more people and, with ubiquitous computing, to more and more devices a large credibility gap could open up between the scale of the information flows and regulatory tools. This, perhaps stimulated by some high profile failures to protect individuals, could lead to a loss of confidence in trust in the network society. Unless, that is, there is a serious commitment by policy makers to a substantial clarification and re-tuning of the legal frameworks for the Information Society.

Background: Trust and prosperity

So far, governments have allowed the Internet to evolve in a relatively hands-off manner. However, its increasing importance as a conduit of financial flows, of sensitive information on people and as a major source of content means that it will become an increasing focus of attention in the coming years.

The Internet economic phenomenon is extremely recent, but it is currently generating a lot of attention as the fastest growing area of business (Box 7). We have already seen (Issue 4) that it raises serious challenges to existing rules on how to conduct trade, to protect consumer rights, to combat tax avoidance and so on. The intrinsic global nature of the Internet also means that new international conventions on these issues will have to be established and considerable effort is being expended by national and international bodies to adjust legal frameworks to create a coherent system of liabilities (Issue 4).

An important barrier to a rapid expansion of the on-line economy will be to build security and trust in the on-line economy. For example, the 1997 OECD Turku conference concluded:

"Business and consumers will not embrace electronic commerce until they have confidence that their use of services on open networks are secure and reliable; that their transactions will be safe and private that they can identify those they are dealing with; and that there are appropriate mechanisms to the if something goes wrong"[43]

Box 7 E-commerce

E-commerce is widely seen as a key area of growth for the future information economy in the next 15 years. Estimates of growth vary from 1997 figures of $10bn (0.05% of trade) to $100bn in 2003 (SRI) or $400bn in 2002 (IDC = 1% of global economy) or even more (the US$1.2 trillion Forrester). In the late 1990s Europe is lagging in the development of e-commerce by 3-5 years. Forecasted growth in E-commerce suggests that the USA will decline from a position of having 80% of the market to 70% or less by the early 2000s. But growth is expected to be weaker in Europe than in Asia, which will emerge as the second largest E-commerce block. The full introduction of the Euro in 2002, combined with Europe's competitive advantages in secure payment technologies and smart cards could help to counteract its lagging position.

What are the security and trust issues at stake? With the proliferation of information sensors (such as cameras, smart cards, scanners, electronic badges, mobile phones) the body of electronic information on individuals, corporations and communities swells everyday. The inherent non-territoriality of cyberspace means that this information is in movement, flowing across national borders as records of payments and purchases, medical treatments, physical movements of people and things, and of the virtual movements of Internet surfers.

One area of concern centres on the potential abuse of this information by private firms (whether it refers to at private, corporate and collective levels). For example, data capture, data mining and data warehousing techniques used by direct marketing firms raise questions about privacy of individuals. In many cases information is collected (e.g. using 'cookies' which record the browsing activities of people using web sites or 'cyberwoozles' that siphon off data from the user's system while they surf the Net). This information can be transmitted and collated with other information in order to build consumer profiles. In a trivial sense, this can result in unwanted junk mail being emailed to individuals ('spamming'). But the real fears are personal or social damage, illegal abuses of this information.

For example, computer profiling of individuals may result in them being rejected for certain jobs, insurance policies, health services and so on, because on the basis of the records they are identified statistically to be a 'bad risk'. Socially the increased accuracy of customers profiling will probably lead to the targeting of market segments which will yield higher profits. In such a process, inevitably, some groups of people (mainly the poor, elderly, temporary workers) will be less interesting and may that they are marginalised in the marketplace, especially in financial services.

Possibly the most fundamental face of personal data abuse is the assumption of false identities using information collected about real people. The most direct risk is that electronic and digital signatures will be stolen in order to commit crimes. Examples of such crimes include the 'cracking' of computers to steal information, commit fraud, steal electronic money or just cause damage. The increased use of virtual technologies means that it is hard to distinguish the real from the fake. People could, indeed, find that criminals have hijacked their face, their body or their whole identity.

Such fears lie at the extreme end of the digital signature debate (Issue 4) which centres on encryption (to protect the content of messages) and authentication (to make sure that people are who they say they are). Some of the encryption concerns will be addressed through important technology developments. But this is a currently a hotly contested area of policy development, whose outcome is not yet clear. In the USA, only recently has it been permitted to apply private key-public key encryption (PGP or "pretty good privacy") to messages, because use and export of the technology is controlled under munitions regulation. The security services were afraid that the technology could be used to shield the operations of potential enemies, terrorists and criminals. These rules have been broken down through on confrontation with the Global Information Society. The encryption algorithms were published on the Web, illustrating well the fragile state of national level regulatory controls.

Authentication issues are being addressed through the emergence of trusted third parties. Here, again, regulatory changes tend to lag behind commercial developments. In the private sector there is already an emergence of bilateral relationships with firms such as VISA and MasterCard that position themselves as a trusted intermediary in electronic payments. However, digital signatures are not limited electronic payments but affect the whole range of legal contracts, and on this the European scene is still highly fragmented. Some countries such as Germany and Italy have already made moves (to establish digital signature acceptance or certification authorities). Other countries are still wedded to paper contracting. In either case the current situation is one of fragmented and incompatible developments.

"Big brother inside": privacy and surveillance

Running parallel to the issue of trust as a barrier to e-commerce, there are parallel concerns about the how the Internet raises the transparency of our lives to the security forces (the police, secret services and military). Some of the most powerful surveillance systems and methods are in the hands of security On the one hand, it is argued that they need these systems to tackle crime and fraud and, in particular to combat cyber-terrorism and particularly noxious forms of pornography, such as paedophilia. On the other hand there are fears that such surveillance might invade individual privacy or be used as a means to interrupt and dislocate political activism or dissidence. The absence of international (or supra-national) co-ordination on this creates loopholes through which abuses of privacy by either private agents or public agencies can operate.

In recent years there have been a number of cases where the embedding of surveillance and tracking capacities into computers has caught the headlines. In the USA there has been a stream of such electronic privacy incidents. There has been the attempted banning of PGP encryption (see above. The US federal government has tried to introduce the so-called 'clipper chip', and more recently Intel has been severely criticised under the banner "Big Brother Inside" for designing a unique serial number identifier into semiconductors. Likewise the US government has draft "Know your Customer" regulations that would require banks to track and trace all customer transactions and to report anything "suspicious".

In other countries there are similar problems of invasion of privacy by government agencies or regulation. For example, the recent European Parliament Report on the Technologies of Political Control[44] identifies a range of worrying developments in surveillance technologies in areas such as: closed circuit television, algorithmic surveillance, bugging and tapping. At a European level, the concerns include the fact that European technology (such as traffic cameras) could be used to suppress political opposition in undemocratic regimes. However, even within Europe, international communication interception networks, are provoking concern. The example which has generated the most heat is Echelon, the co-operation between the UK's MI6 and the USA National Security Agency to intercept EU (and indeed worldwide) communications on leased lines. Ostensibly such systems are used to monitor the activities of anti-democratic organisations and crime rings, but there are fears that it might also be used for economic espionage and to interrupt legitimate political activities. Also, such systems have a questionable status under the Maastricht Treaty.

Towards Information citizenship

The debate over privacy is part of a wider concern over the social norms that will operate in the Information Society. At the moment we are in a state of flux, there are no longer commonly accepted standards that are effective and enforceable and that people and organisations find acceptable. The legitimacy of many forms of authority and control is breaking down. As a result many people are experiencing dissonance and internal conflict on how to allocate their time (and emotional) budgets.

As noted in Issue 5 the time and space collapse brought about by ICTs raises serious problems in making the adjustment to the Information Society. There is for example a danger that telework (and 'tele-'everything else) will eat up time which has been traditionally spent in the family or at leisure. An important issue within this is that individuals may suffer a much deeper level of alienation as a result of the abstraction of any sense of control over their own their control many aspects of their own lives.

Thus an important dimension of policy for the information age is to ensure a framework of rights appropriate to the digital age. These could include rights such as the right to disconnect and the protection of time-buffers. For ICT-based public and community services, it will be necessary to lay down new management approaches, possibly with the aim to reinforce and create space for community in the Information Society.

Overall, the future can be cast in terms of a contrast between a potential "information archipelago" (where informational ownership benefits a relatively few powerful and/or rich actors) and a true Information "Society" (where there are significant guarantees of access to information resources).

Box 8: Whose Information Society?

Issues	Information "society"	Information Archipelago
Competitiveness implications	A level playing field for big and small players. Content services reflect social priorities rather than just commercial gain.	The main advantages accrue to big players who can mine data, trade (+combine) valuable information assets. Likely stimulation of enhanced information services researching and interpreting personal data. Europe more attractive to firms who resist constraints on intrusion
Personal privacy and civil liberties	More elaborated rules about use of personal data, including markets for services.	Availability of detailed personal info at a price. Little control over data on self.
System features	Trust and confidence supported by certification, professional standards ensuring even-handedness. Open systems.	Closed proprietary standards or 'open but owned' systems that strengthen the position of dominant players.
Governance	New framework for "data protection", wide acceptance and diffusion of knowledge and practice.	Laissez-faire; organised interest groups.

These two alternative positions are depicted in Box 8 along a number of dimensions including the implications for competitiveness. The Box underlines the close link between competitiveness and other issues of governance and institutional change. Directly on competitiveness, a sound basis of informational security will be needed to permit a broad-based acceptance of information services markets.

Policy Questions

The key policy goal will be to create a robust system of rights and responsibilities, of authentication and guarantees and of trust and security for the on-line economy. Certification proposals are being developed at national government level, by the European Commission, the OECD, the UN Commission on International Trade Law and by consensus bodies such as Internet Engineering Taskforce and the Worldwide Web Consortium.[45] The CEC Communication "Towards a European Framework for Digital Signatures and Encryption" (1997) and the proposed CEC directive on a common framework for electronic signatures are seen as crucial steps along this road.

A further step, which could accelerate the gains for technology and industrial growth, could be a 'Digital Euro-zone agenda' (analogous to the Single Currency Eurozone). As we have noted, above, European government action on digital signatures is tending to lag behind commercial action. As a result it is not clear whether there will be a role left for Certification Authorities as trusted third parties in e-payments unless they are established soon. If they miss out in the payments area, perhaps, this will weaken the ability of governmental certification authorities to promote high standards in complementary areas such as authentication and maintaining fair play contract in electronic contracting.

Thus, perhaps European governments should try to position themselves more proactively, for instance by establishing a common framework for digital administration in Europe (the acceptance of authentication technologies) could provide an important boost to such efforts. E-commerce would gain, but so would related technologies such as secure payment systems and cards (where Europe has technology strengths), sensor technologies (cameras, biometrics) and above all in developing knowledge management software and tools to deal with the information explosion that electronic trading and filing will unleash (Issue 3).

More generally there is a need for an effective legal framework to secure business and private security for the Information Society. The OECD has been a leader on this issue since with its 1980s privacy guidelines. Also important will be the effects of the implementation, in October 1998, of the 1995 EC Directive on Individual Data Protection and, potentially, a Directive on Electronic Signatures and Encryption.[46] These developments would all help to establish the trust and security for electronic trading needed to encourage a higher level of investment and innovation in Information Services and e-commerce.

The overall result might be a "GSM effect" in which the establishment of an agreed framework for the information age could deliver 'early' mover advantages for dynamic European firms. This could occur because the USA is still reluctant to move away from its preferred 'self-regulation' model (as regards commercial use of data) and to permit the transfer of encryption technologies (because it might limit police and security service investigations). However, in the medium term the global nature of the information infrastructure calls for a global legal framework to protect individual rights in the Information Society.

There are major doubts of course whether data privacy rules are really enforceable. But, it is clearly important for public confidence that serious efforts are made to develop a legal framework of privacy protection. Although the Directive is in force, it is not clear what data security instruments will be implemented and what bodies will oversee authentication, or if they will be state, private agencies or self-regulation agencies.

However, such efforts could even be extended to become a bill of rights or 'Digital Charter' that lays out a protective framework for individuals in the Information Society, within their private lives and at work. Such a ‘Digital Charter’ might cover issues such as time structure, access to data and connectivity, the transparency of services and anonymity of individuals, and the quality of services purchased. The point will be to use end user pressure to pressure to oblige authorities, firms, state organisations and service providers to subscribe to certain standards through privacy and data security policies, as a part of building confidence in a European vision of the Information Society.

Issue 7 The 'Boomerang': Information Society and Sustainability[47]

Issue

ICTs are ‘dematerialising’ technologies. Physical goods can be made lighter and smaller by replacing mechanical components with electronic components. The physical delivery of goods and services can be replaced by communication services, transport by communications. ICTs permit efficiencies allowing better waste control, process efficiencies and logistical performance. But, these are all first-order gains. What happens when, the cascades of effects that follow from these substitutions are worked out? For example, will the continuing decline of ICT component costs stimulate in the end a profligate consumption of limited natural resources? In other words, will there be a ‘rebound or boomerang effect’ in which the Information Society is overall less sustainable than the Industrial Society it replaces?

Background

There is now considerable evidence that competitiveness and sustainability can be complementary objectives. Competitiveness, just like social and environmental sustainability requires long term goal setting, stability and responsibility rather than opportunism in customer and labour relations, and care and attention to detail in operational management and in lowering levels of waste and/or reworking. The growing interest in eco-business strategies reinforces the view that these objectives can be mutually reinforcing. In other words, sustainability is increasingly being built on the basis of informed self-interest.

Box 9 Costs of transport

UK workforce bill for car commuting	£13.5 billion
Estimated costs to business of congestion	£20 billion
Asthma (including prescriptions, car and lost working days)	£100 billion

(source: UK Government, White Paper on Transport)[48]

The possibilities that the Information Society might be a more sustainable society stem from four sources. First, there are potential environmental gains from organisational re-engineering. ICTs can be used to lower waste for instance by reducing material usage or more accurate matching of production and delivery levels to realised demand.

Second, ICTs are 'dematerialising' technologies. This has three dimensions: first the replacement of traditional control technologies by information technologies is helping to yield direct reductions in the amount of physical resources consumed in making goods - thus products are getting lighter and smaller. Second, the informational content of physical goods is increasing. So, for instance, 50 per cent of the value of an automobile is now informational in the form of research and design costs, production and marketing. Also important is the shift in the base of society from trading physical goods to immaterial services. Most of the fastest areas of growth in our economies are in “informational services” such as software, design, new media and telematic services - all areas that depend upon ICTs.

Box 10 Sustainability gains from ICT:

Telework saving **1.29 million tons** from reduced commuting, business trips and travel despite increases resulting from the construction and operation of info-communications networks.

Intelligent Transport Systems saving **1.10 million tons** from the diffusion of enhanced car navigation systems, electronic toll collection systems and optimised traffic management systems, among the various subsystems.

Intranets saving **0.53 million tons** from reduced paper consumption, including the consumption of slips, forms and printer paper, through the installation of LANs.

Internets saving **0.50 million tons** from alternative access to work, reducing waste paper, decentralisation of cities.

Building Management Systems saving **0.36 million tons**: from energy consumption reduction through heat-recovery air-conditioning systems and automatic lighting adjustment and on/off control systems.

Electronic publishing and newspapers saving **0.25 million tons** from assuming that 10% of the total volume of books, newspapers will go electronic.

Distance learning courses saving **0.03 million tons** from reducing the use of transportation systems.

Total reduction per year = 4.06 million tons = 7% of the Japanese Kyoto CO_2 target

Japanese estimates of CO2 emission reductions by 2008**,** Source: MPT News and Oniki, H, Mitomo, H, The IPTS Report, Special Issue on Sustainability 1998[49]

Likewise, many of the growing areas of work are in information professions, especially those concerned with organisational co-ordination, logistics, systems analysis and business systems -all of which are heavily reliant on ICTs.

Third, there are potential direct substitution effects, especially in transport. Transport, especially road transport, is one of the biggest and fastest growing environmental and social concerns. Each year, it accounts for billions of direct and indirect costs from congestion and accidents (45,000 deaths per year) in addition to the environmental degradation and health costs of pollution (Box 9). There are both ICT substitution possibilities including teleworking and teleshopping. Teleworking, in particular, holds out a promise of a more efficient use of people's time and the World's resources. Telematics to achieve a higher efficiency in the transport system, such as inter-modal integration, more efficient routing and loading of trucks, intelligent highway systems for demand management and convoy driving and so on (see Box 10 for Japanese estimates in relation to the targets of the Kyoto protocol).

Fourth, ICTs also provide decision tools for monitoring and controlling the use of the environment. These range from remote sensing systems for observing environmental problems and hazards, to pollution control in urban traffic systems or river catchments.

Putting the different sources of eco-gains together can yield further gains. For instance, innovations (related ICTs) in production techniques plus the direct dematerialisation effects of ICTs in the auto industry are projected to cause the weight of an average automobile to fall by about one-third by 2020.[50] And there is a further potential gain in that a lighter car requires less fuel to make it move.

But the picture is not all positive. ICTs can actually be damaging to sustainability both directly and indirectly. As is indicated in the proposed Commission Directive on waste from the electrical and electronic products,[51] a high turnover and a lack of recyclability in computerised equipment is already serious risk to the environment, given the rapid life cycles of each generation PC chips. If we move towards a version of ubiquitous computing that is based upon disposable computing, as is already being suggested, the direct waste of material resources is likely to expand dramatically. In addition, there are many other potential direct costs in terms of electromagnetic pollution, aesthetic pollution (e.g. ugly developments of ICT transmitters) in addition to potential risks to socio-economic sustainability (such as the division of society and the differentiation strongly polarised camps of winners and losers).

Less obvious, and possibly harder to combat, are the indirect or second order effects. Here there is a strong risk that the environmental gains from eco-efficiency, dematerialisation and substitution in the economy will be outweighed by extra resource intensive or polluting demands elsewhere. A 'boomerang effect' might occur where, for instance, consumption in 'environmentally friendly' ways is so successful that the absolute level of environmentally damaging consumption rises.

The risk is that eco-gains of ICTs will generate complacency, whereas, in order to avoid being hit by this boomerang, practices will have to change at both local and global levels. For example, the estimates of lower CO_2 emissions provided for Japan in Table 10 depend upon patterns of behaviour, not just the introduction of new technologies. For example, the information worker of the future will have to place significantly different demands on the environment than the office worker of today, if we expect to be able to support the development of a global information society (i.e. a society in which most workers are information workers). Currently offices are empty 90% of the time, office equipment (especially computers and peripherals) are treated as consumables, people commute ever greater distances to the office. The CEC (1998) DGXIII-B report suggests that, on current trends, we need to increase resource efficiency per head by 20% every 5 years, to stay in the same place as regards natural resource use.

At the higher level, a clear recognition is needed that sustainability and the Information Society are linked in that they are both *one-world* challenges: the opportunities for growth and development offered by the Information Society are worldwide, but so will be the problems generated by this growth. We will not be able to achieve such growth unless we find new ways to grow, hence the slow recognition that sustainability is a matter of informed self-interest.

Policy Questions

The pay-off of the rising information intensity of business and work is an opportunity to lower the negative impact of economic growth on the environment. The existing policies and projects that support the emergence of electronic commerce, teleworking and virtual organisation practices (for instance within the European Commission's Framework Four Programmes ACTS and ESPRIT) are all important and appropriate forms of establishing the ground conditions for a sustainable information society.

Like social and environmental sustainability, competitiveness is about taking the long view and responsibility rather than short-termism and opportunism. Care and attention to detail are consistent with lowered levels of waste and/or reworking the view that such these objectives can be mutually reinforcing. There is already a growing awareness of the need for effort to search out and exploit these areas of synergy where prosperity and sustainability coincide. These can occur at a micro-level with developments that support the dematerialisation of the economy, but this also requires global level co-ordination.[52]

Attempts to tackle global level problems such as sustainability, however, have generally yielded few robust solutions. Centrally planned or co-ordinated structures tend to be too slow and inflexible. There are too many different interests at stake and too much churn and evolution of problems and solutions. But, leaving the situation to unbridled markets results in solutions that are short-term and reflect the lower valuation of social, cultural and environmental capital in systems of economic trade.

Recently, however, there are signs that give some hope that systems of global governance might emerge. These come from attempts at an inter-governmental to define coherent but minimal platforms of standards. Examples of this were discussed above in respect of digital signatures and e-commerce. Second, there is the emergence of authorities such as WTO, which have specific powers to implement international agreements. There is a question whether the referee role of the WTO could be transferred to enhance the international activities of other bodies (such as the ILO, UNCTAD or OECD).

Box 11 Sustainability Scenarios

Issues	A sustainable IS	The rebound effect
Competitiveness implications	- Global markets emerge for environmental industries and technologies emerge - Relocation of industries and functions	- EU as a desirable site in short-term for industries using up eco-capital
Governance	- Framework setting based on wide spectrum of interests	- Reactive - Lobby driven
Technologies	- Telepresence - Smart systems for conservation - Sensors and activators	Slower, less sustained and driven by interests of more affluent groups
Markets	Markets created by tax and investment regimes	Personal care dimensions of environment
Features	Eco taxes or other EEIs employed *combined with* stimulation of IT infrastructure and services for cleaner production and consumption	Naive assumption that ICT use leads to sustainability – but rebound effect
Problems	Developing country perspective - creating markets for EU environmental products	

Also a model of a mechanism for achieving targets agreed in these forums could lie in the Tradable Permit proposals within the Clean Development Mechanism of the Kyoto Protocol. The Permits would allow countries to explicitly pay for their pollution by buying the pollution rights of other countries. This allows for the global problem of pollution to be tackled on a global level, but through action at the national governmental level. It also allows a much higher marginal efficiency of pollution control actions; given that developed countries already have a relatively high level of ecological efficiency. It also provides a means for developed countries to assist developing economies through economic and technical transfers - which are trade rather than aid. Overall, then the mechanism provides a means of promoting global governance without introducing a new supranational organism and further rounds if complex multinational negotiations. The question is what is to stop such the Clean Development Mechanism from being developed into a Sustainable Development Mechanism by transferring the approach to other issues of international concern for example social and cultural arenas? Efforts in this direction could also provide route for European traditions of social market economy and consensus building to provide indicative models for the 'Global Information Society'.[53]

Annexes

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Annex II References

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2 UMTS-Forum (1997) forecast cited in UK Foresight ITEC Forward Look Paper, version 8, 20th may 1998, op. cit fn. 1.

3 Whether consumers will want to use the television to surf the Internet (i.e. WebTV) is a moot point. The functions are different. It could be compared to trying to market a hybrid freezer-oven - a marriage that pleases no one!

4 Gengler, B. (1998) The Sky's the limit, *Communications International*, Vol 26(3): 26-27 Spectrum DTI (1998), *Moving into the Information Age, International Benchmarking Study 1998*, DTI, UK; UK Foresight (1998) op. cit. fn. 1

5 The idea that the telecommunication service offer and pricing should become like a utility flies directly in the face of the status of the industry, where there is enormous complexity and differentiation in tariff structures. It does, however, fit with recent attempts (and success) of Internet strikes in Spain and Germany in favour of flat price or low prices for Internet access.

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12 See: Bell, G and Gray, J. (1997) The Revolution Yet to Happen, in Denning, P and Metcalfe, R. (eds) *Beyond Calculation*, Copernicus, New York

13 See: Zysman, J and Borrus, M. (1997) Globalisation with Borders: The Rise of Wintelism as the Future of Global Capitalism, *Industry and Innovation*, 4(2): 141-166. The fear of a repeat at a larger scale of this kind of design dominance must surely be a motivation for the recent court dispute between Sun and Microsoft over adaptations to the Java language.

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Annex III Background: the issues listed

Annex III -1 The top issues (EMS rankings by area)

This annex provides the average scores by category of the top issues, from a panel vote where any issue could receive up to 10-Points.

ICT and legislation

1	New concepts for knowledge, information, and learning	**7.85**
2	Reinventing government (rethinking the role of public Adm./Government) Both services and internal organisation	**7.77**
3	A new legislation paradigm - laws, regulations in the fast changing virtual society/market	**7.54**
4	Virtualisation of businesses, decline of capital?	**6.77**
5	Speed of convergence of computer and telecommunications.	**5.69**
6	Data mining	**5.00**
7	Cyber terrorism - risks and security lacks in technology and business systems	**4.77**
8	Impact of disasters - millennium bug and similar	**4.69**

Market demand and supply (Vote)

1	Globalisation of markets (electronic commerce)	**8.31**
2	New access modalities - ease of use	**8.08**
3	Mass customisation	**7.54**
4	Massive ICT/services/applications rollout will be a necessary but insufficient condition for sustainable development (sustainability in all its dimensions: environmental, economic, social, cultural); dematerialisation, immaterialisation, and rebound	**7.46**
5	Personalised mobility	**7.00**
6	Virtualisation of businesses, decline of capital?	**7.00**
7	Cohorts of young people savvy in media & culture as well as new IT, generating new markets through apps that might appear bizarre/trivial/illicit at first sight / GAMES (non-traditional markets)	**7.00**
8	Services and applications vs. real needs	**6.46**
9	Greater user involvement in developing ICT systems	**5.77**
10	Enforced use of telematic administrative services	**4.92**
11	Impact of disasters - millennium bug and similar	**3.85**

Technology

1	New access modalities - ease of use	**8.38**
2	Impact of convergence of computer and telecommunication (networks)	**7.54**
3	Seamless broadband connectivity becomes available	**7.46**
4	Personalised mobility	**7.46**
5	Mass customisation	**7.31**
6	Massive ICT/services/applications rollout will be a necessary but insufficient condition for sustainable development (sustainability in all its dimensions: environmental, economic, social, cultural); dematerialisation, immaterialisation and rebound	**6.15**
7	Greater user involvement in developing ICT systems	**5.77**
8	Data mining	**4.69**

Norms

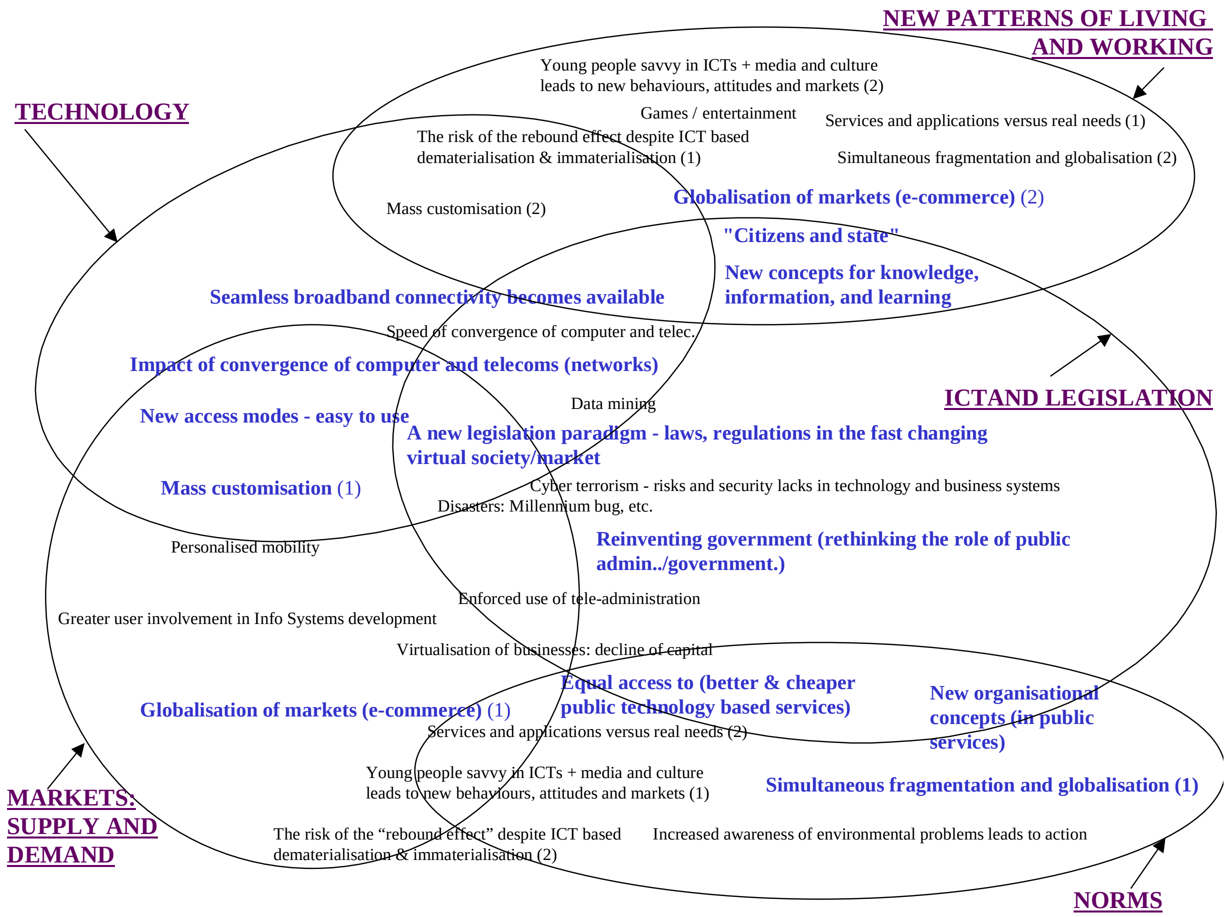
1	Equal access to better and cheaper public technology supported services (health, environment, ICT infrastructure, Vans, etc)	**7.69**
2	Simultaneous impact of 2 cultural-societal developments: fragmentation and globalisation	**7.23**
3	New organisational concepts, specially for public administration and civil services (impact of ICT)	**7.08**
4	Massive ICT/services/applications rollout will be a necessary but insufficient condition for sustainable development (sustainability in all its dimensions: environmental, economic, social, cultural); dematerialisation, immaterialisation and rebound	**6.77**
5	Cohorts of young people savvy in media & culture as well as new IT, generating new markets through apps that might appear bizarre/trivial/illicit at first sight	**5.92**
6	Increased awareness of environmental problems and the chance to reduce them using ICT	**5.77**

Patterns of life / work

1	“Citizens and state”	**8.15**
2	New concepts for knowledge, information, and learning	**7.54**
3	Globalisation of markets (electronic commerce)	**7.31**
4	Simultaneous impact of 2 cultural-societal developments: fragmentation and globalisation	**7.08**
5	Mass customisation	**6.92**
6	Games / entertainment	**6.31**
7	Cohorts of young people savvy in media & culture as well as new IT, generating new markets through applications that might appear bizarre/trivial/illicit at first sight	**6.00**
8	Services and applications vs. real needs	**5.46**
9	Massive ICT/services/applications rollout will be a necessary but insufficient condition for sustainable development (sustainability in all its dimensions: environmental, economic, social, cultural); dematerialisation, immaterialisation and rebound	**5.23**

Annex III -2 The issue map

This annex maps the issues selected as top issues by the panel into the different key categories.



Annex III -3 EMS Results: Private lists

This annex provides the entire list of hot issues that the panel was able to cite at the start of the first meeting….

- Cheap transmission bandwidth
- Continued penetration of mobile communications, ubiquitous remote access?
- Increased bandwidth of mobile access
- Discrepancy between mobile services and fixed services
- Computational power per fixed cost increasing 100 fold per decade for >2 decades
- Ubiquitous computing,
- Computers out of sight out of mind.
- Home use of computing becomes everyday, e.g. Via tv etc
- Body networks
- Information overload solved
- Electronic commerce dominant
- Virtual companies grow
- Soft (capitaless) companies
- Massive opportunities for monopolisation of software
- Software complexity becomes unmanageable
- Agents software essential
- Spin-off/trickle-down of advanced industrial applications
- Demand for portability, hassle-free access to power and communications links everywhere
- Proliferation of application-specific devices despite connectivity
- Markets rethought due to explosive growth of unexpected applications, often for purposes initially seen as trivial/unsavoury/bizarre
- Cohorts of young people savvy in media & culture as well as new it.
- Concerns over health & safety: RSI, electromagnetic fields
- Catastrophes - millennium bug and others: need for fail-safes etc.
- Globalisation in trade and investment
- De/re-regulation and liberalisation
- Local and community issues
- Global and regional political developments
- Democracy and accountability
- Micro-chip development: massive performance-price improvements
- Macro-network development/ macro-network development: pervasive and global in extent
- New rules of the network economy
- Cultural and ethnic fragmentation

- Cultural and social pluralism
- Three major ICT & IS drivers: technological, social and economy.
- The assumption ,at this stage is that we are looking at a global economy and not at a eu autonomous system
- Technological drivers: how fast the convergence of computers and communications will be completed;
- Social implications and wide acceptability
- Globalisation of markets
- Electronic commerce
- Emerging information society in developing countries ("the south")
- Improved access to on-line information world-wide
- Increased awareness of environmental problems and the potential to solve them through ict within the is
- Better means for education (long-distance) and life-long learning
- Technological drivers: lighter and easier-to-use equipment, better functionality, better operational features (e.g. Longer operation times of batteries for mobile uses), better interoperation between networks/services/applications
- Economic drivers: increasing percentage of economic/commercial activities go over the net, pulling more users in (snowball effects)
- Social drivers: new ways of working and living (tw, tele-education and -training, teletransactions, teleshopping, telemonitoring, etc) over the net
- Technologically: everything will probably be possible. Hence the main driver will be demand
- Personalised (tailor made) mobility as generic driver of demand.
- Ease of use (one stop shopping, one push button functionality, one number access point, etc.) and affordability as main driver for acceptance
- Job creation or not: essential barrier
- Self regulation: possible barrier
- Information overload
- Broadband wireless becomes available
- Increasing emphasis on the negative impacts of productivity growth
- Reduced expectations concerning distance learning
- Work and learning integrated
- Knowledge workers select employment opportunities based on long-term development interest
- New control systems for speculative electronic trade
- New concept of knowledge
- A speedup in e-commerce deployment due to 1999 market crash
- Seamless connectivity
- E-commerce on the web

- Virtual enterprises
- Speech recognition
- Digital TVs, also in the area of business (“business TV”)
- Object oriented software
- UMTS - new mobile communication networks and services
- Embedded systems - cars, intelligent houses etc.
- Consumer oriented services in the web - private photo/video archive
- Reduction of government funds
- New organisational concepts in the public area/civil services
- Cocooning vs. Globalisation
- Cyber terrorism
- Security and safety of ICT and business
- Deregulation of service provision
- Availability of broadband infrastructure
- Education on ICT
- Enforced use of administrative telematic services to the citizen
- Cost reduction in telecom services
- Further reduction in size, power consumption,
- Usefulness of new services
- Convergence of infrastructures
- Mobility
- Need for qualifications
- Continuously updating of qualifications
- Bigger differences in the labour market
- New forms of employment - diversified employment arrangements
- New organisational settings in the work environment
- Changing learning paradigm - the learner in the centre of development
- Need for interdisciplinary research at all levels
- A new legislation paradigm - laws and regulations in the fast changing virtual market/society
- Better and cheaper public technology supported services (health, environment, education, information etc)
- Cheap access to technology
- Equal access to technology based services (common technology infrastructure/ vans)
- Rethinking the role of public administration/ government
- Data mining
- Data mining
- Intelligent agent

- Intelligent agent
- Data privacy
- Open government
- Open society
- Cultural diversities and religious autonomy and open world trade?
- Old society/west and young society/east, very south
- Games and education
- Highly sophisticated knowledge systems