Orientations for Work programme 2011-2013

Report from the Information Society Technologies Advisory Group (ISTAG)

Final version

November 2009

Table of Contents

1. Introduction

The European Union is facing the worst economic crisis since its existence. Stimulus packages by both the Member States and the European Commission have been launched to address the most critical issues around financial services and the continuation of consumer demand. Additional investments in ICT have not been considered to the necessary extent. **ICT is at the very core of the green knowledge-based society and underpins innovation and productivity in all economic sectors.** Thus, EU-supported research activities in ICT should continue to strengthen Europe's scientific and technology base, ensure its global leadership in this sector and bring innovative solutions to address our socio-economic challenges. In many forums the impact of ICT on future growth and wealth has been widely acknowledged. Moreover, given the fact that the Internet has emerged as the infrastructure that impacts most business, governments and society, Europe should place the highest possible priority in facing competition in this sector.

In the face of the worst global economic crisis since the 1920's, Europe is now more urgently confronted with questions on how to react on the challenges of the upcoming decades such as:

- Sustainable economic recovery to prevent us from future turbulences (as those in 2007)
- The increasing competition at a global scale and the emergence of new business models, not only fuelled by ICT, but also transforming the ICT sector itself.
- Massively available ICT capabilities embedded, connected, ambient, and in the cloud.

As the underlying fundament of the global economy, the further development of ICT is playing a key role in ensuring a solid economic system. This changing role of ICT requires both a solid strategy of long-term research as well as an infrastructure of rapid deployment for immediate customer and consumer feedback. While, in the 1990's and the beginning of this decade, the product life-cycles in components and systems have come down dramatically, software and services life-cycles have just now started to shorten.

The current ISTAG, during its two years term, has envisioned the arising of a new era of the Internet. The "Internet of the Future" will be the key global infrastructure to address the challenges society will be facing. Accordingly, this ISTAG report, aiming to outline recommendations for the upcoming Work Programme 2011-2013, takes into account the major impact of the current crisis as well as the growing need and acceptance of sustainability as an urgent requirement for long-term global economic growth. Considering the grand challenges identified in the previous ISTAG report on a revised European ICT strategy as a vision for 2020[1], this report focuses on the major European ICT research initiatives and outlines future needs in the most important technology areas.

The European research activities in the Work Programme 2011-2013 will have to build on Europe's technology and industrial strengths and at the same time ensure that industry in Europe is well prepared to seize the wide range of new opportunities ahead in ICT. Opportunities are emerging from new technology breakthroughs and from new demands for ICT-based innovations in an evolving business and societal context. ICT development will be therefore driven by socio-economic/societal, business and technological trends. This report is presenting a large amount of ICT-centric opportunities for moving towards a more sustainable society with lower CO_2 emissions. But a "conditio sine qua non" is that the ICT industry reduces its own CO_2 emissions also radically. Otherwise ICT jeopardizes its own future.

[1] See report online: ftp://ftp.cordis.europa.eu/pub/ist/docs/istag-revising-europes-ict-strategy-final-version_en.pdf

2. TRENDS AND OPPORTUNITIES

2.1 Socio-economic/societal trends: ICT to drive the sustainable economic recovery

The recent financial crisis has shown the vulnerability of our economies when we exaggerate our reliance on speculative financial trading and raised questions of adequate (ICT) tools to ensure transparency and compliance in the future. The need to strengthen the so called real economy and notably innovative manufacturing and knowledge-based service sectors, is recognised as a main policy priority to preserve jobs and sustainable growth. The impact of ICT on productivity growth across the economy is undisputable and a wide range of opportunities for new ICT-based business developments is ahead. The crisis has shown that more comprehensive economic, financial and business modelling tools are needed to understand economic behaviours and to design appropriate policies. This applies at the level of enterprises, banks, stock markets or governments and at a global level as well. The present economical models are based on theories involving oversimplifying hypotheses and would greatly benefit from more elaborate approaches. ICT-based simulations of “what-if” scenarios fuelled by up-to-date real world information provided through the Internet of Things and embedded systems, as well as the global information pool available through the Internet would allow for far more precise predictions. **ICT is the only technology domain which could provide for insights in global trends and developments never achieved before.** In this respect, the role played by mathematics, behavioural and social sciences is by no means negligible. Moreover, a stronger symbiosis between ICT and mathematics will, no doubt, offer a wider range of tools compared with what is currently available.

Among the global trends identified, **sustainability of the environment** has been highly endorsed by both societies and governments. Additionally, businesses have started to consider reduction of carbon emission and use of renewable energy as a differentiator for success. The **shift to a lower carbon economy and a sustainable growth by better use of our natural resources will govern policies and drive economic and societal development for the next decades.** Although **the potential contribution of ICT to this shift is high**, we are still far from exploiting this potential and even understanding its real impact. As ISTAG stated in its report on “ICT and sustainability" (2008), the next generation ICT will have to support the targets for lower carbon emissions not only with new ultra low power consumption ICT devices and equipment but mainly through advanced ICT monitoring and control services and solutions enabling to improve energy efficiency across the economy (e.g. smart buildings, smart grids, manufacturing, transport).[2] Within the development of a more energy-efficient and a lower-carbon economy, ICT plays a dual role: as an enabling tool for sustainable performance of other sectors and as a sustainable sector on its own.

ICT will play a determining role in better controlling our consumption of energy and natural resources. First lighthouse initiatives on eEnergy or eMobility clearly show the need of ICT when it gets to manage the smart grids to come, or billing the roaming consumers of renewable energy produced in a decentralized way. Thus, a large part of the potential of energy efficiency lies in the optimization of IT-based product and distribution processes, where research should focus on both high tech components and innovative business models.

To ensure the sustainability of the ICT sector itself it is important first to develop and foster ICT systems, products and services with optimal energy consumption. In addition, the growing need of computing resources and the future explosion of ICT devices and their acceptance by society have to be addressed. It is clearly predicted that, on one hand the next billion Internet users will be on mobile devices and on the other hand, each person will be surrounded by a fast increasing number of ICT devices.

[2] See report online: ftp://ftp.cordis.europa.eu/pub/ist/docs/sustainability-istag_en.pdf

Next to sustainability of the environment, Europe is facing other societal challenges such as the ageing population, the need for a more sustainable health and social care systems. More inclusion and higher security will remain important concerns for the society and policy makers as well. The Chronic Disease Management deserves special attention, since the volume of the health budget dedicated to this purpose is nearly 75% of the total healthcare costs. Assisting the person in need from distance and not only monitoring him/her, but also taking appropriate action when required, is a task that ICT will have to find solutions for. Products and services addressing these concerns will require a relentless effort to improve the ease of use both for the professionals and the consumers hiding the inherent complexity of the underlying systems. In earlier reports, this ISTAG has addressed these issues and referred to the new web-based service economy, including the societal influence of what has become known as Web 2.0 technologies and services. Although it is probably still too early to fully understand the impact on the society and economy as a whole, the phenomenon is already transforming established businesses, for example in the media and content industries. Moreover, examples such as the use of Twitter in Iran after the latest election and the related protest demonstration show that these ICT tools fundamentally cut across existing communication and command channels. We need to research these phenomena to understand their societal impact.

2.2 ICT business opportunity: Development of a Web-based service industry in Europe

The EU ICT sectors that are most hardly hit by the crisis are the ICT equipment and semiconductor sectors with a drop in turnover of more than 30 % in 2009[3]. The impact of such a drop on the sector in Europe is difficult to predict. Recovery in this field in the short term would depend on the rapid roll out of government and regional spending on broadband infrastructures and services both inside and outside Europe. It is important to state that this is not enough as the value of future ICT product and service offerings will be on those web-based services leveraging these broadband initiatives. As this ISTAG stated in its first report on the "web-based service industry"[4], future ICT spending of enterprises and consumers will be largely dedicated to web-based business services. Thus, ICT spending will be gradually transformed from capital to operational expenditure. This will impact the way ICT infrastructures will be developed in the future. Europe is lacking large IT companies investing in such publicly available infrastructures. As this ISTAG stated in its report on "Grand Challenges" for Europe[5], lacking a clear cloud computing strategy makes Europe vulnerable, already today.

New business opportunities are emerging in web-based services and new application areas of ICT such as energy efficiency, health and wellbeing, transport or location-based services. **It is essential that Europe seizes the opportunities in web-based services immediately on a global scale and there is a wide range of opportunities in such services at local and regional level as well.** The web-based services markets are still open for established and new players and are expected to develop further with the roll out of high speed Internet, new mobile and wireless devices, the development of the Internet of things, cloud computing and the core business services in the Internet of Services. These markets are also ideal place for business model innovations as the first movers in this space have demonstrated. Still, many business models rely on 'yet to be determined' income streams and do not allow for mass adoption. A combined research roadmap covering both economics and ICT aspects has to mature.

In a broader view, ICT is the ideal tool for managing the full life-cycle of products and services in an enterprise, allowing for instance mass production of dissimilar products, agility and quick reactivity. Furthermore, improved ICT-based enterprise resource planning (ERP) will include energy efficiency data on the whole processes and facilitate green procurements and waste management.

---

[3] http://www.oecd.org/dataoecd/33/20/43404360.pdf
[4] See report online: ftp://ftp.cordis.europa.eu/pub/ist/docs/web-based-service-industry-istag_en.pdf
[5] See Footnote 1

Professional markets, enterprise and manufacturing applications will be driven by the need for cleaner and more intelligent production, by more sophisticated design and by using engineering tools and support tailored for even more networked and distributed enterprises providing end-to-end services, blurring the separation between products and service provision, and requiring further process integration across the value chain.

The new Internet of Services will be a unique infrastructure for SMEs. Reach has been the major road block for many smaller companies. The Future Internet will largely remove these roadblocks. With the existence of trustable cloud computing centres and the reach out of the broadband infrastructure, even SMEs in rural or disadvantaged regions will have a global reach. Still, one can expect that individual enterprises will face major obstacles when having business abroad, when it comes to regulatory and compliance issues. Thus, research on business models tailored for SMEs will be a key topic to be addressed by the EC.

Along with the new web-based business opportunity, another industry trend has reached the ICT sector: open innovation. Enterprises are seeking for collaboration and joint road mapping when it comes to R&D investments. The Framework Programme of the EC is most suitable to stimulate open innovation within Europe and through its international activities with other key regions. Up to now, the international network has not been leveraged to the extent possible. ISTAG concludes that the strategic directions given by the EC to the experts evaluating proposals submitted on Work programme topics have not been sufficient yet. Through the trend of web-based service economy the EC could stimulate more open innovation both with international partners but equally important with partners of other industries who will apply the ICT capabilities within their product and service offerings. Thus user-driven innovation has to be amplified today. Automotive industry and the utility sector among others, clearly demonstrate their value to the ICT sector by active open innovation. The next Work Programme should provide a clear focus on user-driven innovation to support the fast adoption required, as well as a joint road mapping of long term research.

2.3 Technologies needed: Trusted web-based Application Platforms, Future Internet, Cloud computing, ambient and embedded ICT

The development of a Future Internet with its three components (Internet of services, network architectures and technologies, Internet of things) is a key development for the ICT sector. The breakthroughs will come from bringing together converging computing and networking technologies and infrastructures and from development across the traditional layers devices-network-services.

In the short to medium term, developments will most likely happen in the service-device connection fuelled by proprietary platforms for service development such as AppStore-iTunes-iPhone or Google maps on Android phones. ISTAG recommends to the EC to stimulate an open platform strategy which invites all existing players but, most importantly, includes also other relevant parties such as SMEs or associations representing them. Lock-in issues have to be addressed, as well as mass adoption when it gets to the service-device integration. Europe’s tradition on setting global standards should be a value proposition to be acknowledged. Trusted open web-based application platforms will serve as the fundamental key to global and mass adoption.

In the medium to longer term, networking technology breakthroughs such as all-optical networks, massive multi-core computing and ultra wideband wireless communications can lead to totally new network architectures resolving the limitations of IP-based systems.

Cloud Computing, Software as a Service and their expansion to federated/aggregated on-demand service provision are trends that will transform not only the software industry but also the service industry in general. The expansion of the Clouds business will depend to a large extent on technology progress mainly in the areas of security, trust and privacy.

Thanks to Moore's Law, during the last 30 years the semiconductor industry has been a key enabler to ICT, and it will continue to be. Nanoelectronics shows no signs to slow down because new technologies based on physical properties are coming into the picture, yielding an ever greater performance, lower energy consumption and larger memory capacity at a lower price.

On top of the classical Moore evolution the 3D-Integration offers new alternative solutions to integrate a complete system, including smart sensors and actuators on a single chip. The possibility to combine different materials like for example bio and organic will open new routes and new applications for nano-electronics.

Alternative paths to components and system development, including more integration of functionalities, new materials (photonics, organic and bio-electronics, etc.) and more efficient component and embedded systems design tools, will most likely drive the basic technology development and open the door for a wide range of new ICT-based products and services. With the lithography features going smaller and smaller, statistical approaches are now incorporated in the chip design methodology and the way the architectural blocks are interconnected within a chip are closer to the internet protocol than ever.

Progress requires work across disciplines, across different parts of the value chain and the rapid integration of advances in academic labs (FET areas) into mainstream industrial research.

The move towards more intelligent (e.g. adaptive, learning, cognitive and bio-inspired) systems is crucial for the medium to long term development of the whole ICT sector. Although the industrial uptake of science and technology progress seems still slow in Europe, the opportunities not only for technology but also for business breakthroughs are wide and promising.

2.4 European instruments: Framework Programme, EIT, JTI/PPP, Joint Programming

Besides Framework Programmes, we have today several other initiatives and instruments in the ICT area to address these challenges. They address somewhat different knowledge aspects, also having their main focus into different phases of the innovation chain. In order to facilitate and increase the efficiency of these initiatives as a whole, it is important to understand their respective roles, so that stakeholders' resources are wisely spent, rightly addressing the challenges and opportunities ahead, as discussed in the introduction.

Joint Programming for instance, is a new effort to establish a common vision and research agenda shared by a number of Member States and to increase the efficiency and impact of public research funding. Additionally, in order to better take into account innovation, we have recently introduced joint undertakings in the form of Joint Technology Initiatives and Public Private Partnerships, aiming to facilitate long-term commitment in key areas for Europe, involving both Member States and industry as stakeholders. In strengthening the link between research, education and innovation, the newly established European Institute for Innovation and Technology is the first instrument addressing education, research and innovation with a European level responsibility. Finally, EUREKA provides pan-European networks for encouraging market-oriented, collaborative research and development projects.

3. FUTURE INTERNET

Among all discussed mega trends within ISTAG over the course of the last two years, Future Internet has become the most significant one. Both the technology-push as well as the creativity of consumers and enterprises prepared large parts of the society to step up into a new era: The Internet as the most significant global infrastructure. While we are still experiencing the down side of a global "flat world" and the misuse of global scale by the financial industry, it becomes clear for all of us that the future will rely on a fully connected world with access anytime anywhere. Moreover, users as well as machines will become producers of an unpredicted amount of data that will practically mirror the real world into the digital world. The potential will be in consuming the right data to the best of any given situation. It may be car-to-car communication to minimize risks of accidents, machine-to-machine communication in production for optimal throughput, or build-to-order processes to serve consumers best by allowing mass customization of products while keeping the required effort affordable. In all of these cases, the Internet will become the key infrastructure and is expected to accommodate all of these demands. Thus the Future Internet will develop to the most critical infrastructure in mankind.

Digital and broadband technologies are reshaping information and knowledge industries, as well as our means of communication and entertainment, the wider economy, and the way of life for all of us. The Internet has already today become to be the key network of our society, capable of responding to today's broad spectrum of business and societal needs and challenges.

We can expect that the next wave of internet-driven transformation to have a profound effect on the way we live, entertain ourselves and do business. It has the potential to:

- Transform the delivery of public services, including healthcare, education etc.
- Create new opportunities for wealth creation in the digital service economy
- Transform the business landscape by:
    - moving enterprise IT into the cloud
    - creating new service eco-systems
    - deliver fully secure communication channels
    - changing the way that firms organise, and do business
- Establish agile business networks and a networked economy
- Build communities both local and global, and maintain a more coherent society
- Be a platform for innovations that we cannot currently imagine.

There are several technical developments emerging more or less in parallel, that are the enablers for this next wave of transformation, and these have a compounding effect. The developments that are particularly significant for the discussion here include:

- The increasing availability of higher access bandwidths to the Internet, on both wire and wireless links, including major investments in "super fast broadband".
- The migration of functionality and services into the Internet, or "Cloud". This migration can be seen with web-based applications and web services (Internet of Services), and with computing resources themselves ("Cloud Computing"). It is discussed in more detail below in sections 4 and 5.
- An explosive increase in the number of devices attached to the Internet, including many machines, sensors and intelligent devices (the Internet of Things).
- Core business services provided as "built in" services of the Internet of Services

With these developments, the internet is becoming a much more pervasive fabric, and a more powerful platform, and the term "Future Internet" is often (and usefully) used as an umbrella label to describe the emerging and broad wave of disruptions that this will enable. In fact, almost everything covered in this Report could be described under that heading, to some degree or other. This is clearly significant, and there is a need for a European initiative for the Future Internet, to coordinate European R&D efforts and to form and drive a strategic European research and innovation agenda. Without this, there is a danger that Europe will fail to capitalise from the emerging transformation. There is increasing convergence within the European R&D community around this, as demonstrated in EC activities such as the Future Internet Forum and the industry activity to form a Future Internet PPP (see Annex A, sec. A.2).

In this section, we attempt to put some bounds on the definition of the Future Internet by concentrating on two perspectives, and following this with recommendations for each. In the first place, there is the perspective of the emerging digital service industry, requiring the support of a set of new “horizontal services”. Secondly, there is the architectural perspective set by the “legacy” constraints of the current architecture (technical, regulatory and business), that threaten to limit innovation. At the same time, it is necessary to be aware of unwanted, unintentional or malicious infection of Future Internet with fake information.

At the same time new developments are already ongoing, bringing much higher capacities and capabilities than are provided by today’s Internet. As the Internet becomes the natural platform for addressing key societal and economic challenges in areas such as health, ageing and inclusion, transport, energy, and sustainability, it becomes essential to understand how the unique requirements arising in these sectors, can be met by the Internet infrastructure of tomorrow.

3.1 Future Internet Infrastructure – service industry view

The vision of an emerging Web-based service industry is set out in section 5. As discussed in more detail below, this will be enabled and supported by a holistic Future Internet infrastructure. This infrastructure will provide pervasive, reliable internet connectivity and flexible, on demand computing resources (Cloud Computing). It will further provide a rich set of “horizontal” services, analogous to the simple “capability services” of Next Generation Networks (authorisation, identity, location, directory etc.), but expanded to support the, creation, trading, and composition of value adding services across the global Internet. This will raise difficult problems of federation, openness, trustworthiness, scale, reliability, as well as governance quality and trust relationships. This service infrastructure must also address legal, policy, security, logistics, and business issues as well as technological enablers.

The infrastructure of the Future Internet will provide a common open and global service delivery platform to support both the visions of the Internet of Services and the Internet of Things. In particular, it will support. rich mechanisms of global service supply, providing opportunities for new aggregation and intermediary services, and for creating innovative channels for service consumption. It will be an open platform for tradable, composable, value added services delivered over the internet, enabling community driven service innovation on a large scale.

Currently, the more disruptive developments in Cloud Computing and the Internet of Services are driven by US companies, and the challenge for Europe is to work out how and where it will add and gain value in this transformation. There is value to be taken as a consumer of the new services, with opportunities for productivity gains, or as an early adopter of the new platform for service and business innovation. The biggest opportunity, however, is to take a more central role in driving the transformation, and to seize the service and infrastructure opportunities.

A European scale open service platform can play an important role in this, but only if there is a plan to accelerate its use in real and smart applications. This can be driven by focussing on some “quick win” applications that address carefully chosen societal challenges.

ISTAG Recommendations

- Focus on a few selectively chosen European lighthouse projects with soon available solutions as implementation examples in real business services and smart applications, particularly in services directed at urgent societal challenges. These lighthouse projects may be set up as extra large integrated projects (XL IPs) to allow for significant impact and worldwide visibility. They should serve for the preparation of a larger FI PPP initiative that was announced recently.
- Facilitate a European wide dialogue between the network research community and the application and service research community for a joint effort as the Future Internet will be driven both “bottom up” and “top down” at the same time.
- Stimulate extensive use of research outcome following the rapidly emerging deployment strategies of the new web-based application and services through real living lab infrastructures available to consumers and application industry sectors.

3.2 Future Internet Infrastructure – underlying architecture view

The Internet acts currently as a critical global infrastructure, for entertainment, commerce, communications and business processes. Tomorrow there will be more than 50 Billion devices connected with a diverse set of services ranging from very low-speed (few bps) to very high-speed (Gbps) having vast different quality of service requirements and power limitations (hibernation). This usage takes it well beyond the design point for the original technical architecture. It is timely to undertake a fundamental re-assessment of this and a portfolio of projects and activities in FP7 are already doing this. The issues that must be addressed have been discussed in an earlier ISTAG paper.

The increasing availability of higher speed internet access (“super-fast broadband”) will only increase the pressure on the underlying Internet architecture, and we believe that this raises the urgency of an architectural re-assessment. There is a need to re-examine the underlying technical, business and regulatory architectures, since they could become barriers to innovation. On the one hand, at the network level it has some inherent properties of resilience, but it was not conceived as a critical global infrastructure. There are issues of security, resilience, service quality, and there are also major concerns with value flow, that inhibit investment in the infrastructure. There is also much debate about the rights and responsibilities of the various players in the value chain in the (legal and illegal) distribution of digital assets.

Different stakeholders in the internet value chain have different perspectives on these issues, and any change is constrained by the difficulties of achieving consensus, by the problems of implementing change, and by the business and regulatory contexts. In consequence, any technical architectural development must be matched by parallel business and regulatory discussions that involve the full range of or relevant stakeholders. This is well recognised[6] but there are no major initiatives to do this.

Recently in the UK, following the Digital Britain report into the future national digital infrastructure, a national “test bed” initiative was announced, to carry out societal scale investigations with real users into the potential blockages to innovation. This is a “challenge led” approach, and current issues under consideration include digital content ownership, copyright, privacy, value flow and service quality. This is still at an early stage, but there is real value in extending this approach to European scale, so that a European consensus can emerge, taking in different cultural perspectives.

Another example of a major initiative within the Member states is the German lighthouse project THESEUS, a research program initiated by the Federal Ministry of Economy and Technology (BMWi),

[6] EIFFEL report online: http://www.future-internet.eu/fileadmin/documents/reports/Report_TT2008.pdf

with the goal of developing a new Internet-based infrastructure in order to better use and utilize the knowledge available on the Internet. As an umbrella organization THESEUS is uniting up to 50 researchers from the public and industry sectors to collaborate in developing and designing innovative basic technologies to create the basis for the development of new Internet services. The TEXO project within the THESEUS program can be considered as a front runner for the Internet of Services by developing reference architecture, first standards and a pilot implementation.

A new architectural framework for the Future Internet must produce a Sustainable Internet. We mean this to be a broader description than having a low and sustainable carbon footprint (which it must). It must also sustain:

- Innovation – must be open, flexible, dynamic, with a clear capacity for migration and change
- Value – to all stakeholders in the value chain
- Business networks – to warrant economic growth
- Communities – protecting individuals and society (in different cultural contexts)

ISTAG Recommendations

- Facilitate a European wide research dialogue about the architecture, frameworks, and platforms to serve the needs of the applications and services provided via the Future Internet. An open innovation based approach allows for rapid adoption while avoiding single proprietary solutions leading to unintentional dependencies.
- Invite for an international dialogue to promote a European way of establishing standards of the Future Internet, particularly with the emerging and developing countries.

4. CLOUD COMPUTING

Cloud Computing can be defined as a way to benefit from massively scalable and instantaneously deployable IT resources through the Internet. These Cloud offerings can be divided into three different categories: hardware clouds, development platforms and application delivery clouds. A well-known example is “Software as a Service” (SaaS) which gives remote access to applications based on a given business software package. However, Cloud Computing goes far beyond SaaS and encompasses mainstream offerings like computing power (CPU on demand), storage, archiving, messaging, office applications, communications and even services that a company can grasp on the cloud, enrich and resell with some added value.

Clouds provide major opportunities for new business models by restructuring the value chains in the information and communications industry. In addition, cloud computing dramatically changes the dynamics for new service offerings since it considerably lowers the entry barriers for newcomers by shifting from huge initial capital investments to pay-what-you-use business models. The demands that the visions for the Internet of services and the Internet of things place on the infrastructure can be met most economically by the cloud computing model. It is especially small, innovative companies who will use cloud computing as a scalable service. Large companies might be forced to use cloud computing more often to reduce operational costs, particularly those of their IT systems. Using cloud computing will certainly give companies a competitive edge.

Large service companies are already preparing SaaS offerings. The development of Cloud Computing will lead to the emergence of new agile companies referred to as “IT-less companies". These companies will develop their business rapidly without investing in IT, through the use of IT building blocks taken from the cloud. All these cloud services are based on huge investments in data centres, networks and servers. Three US companies, although coming from different universes, are far ahead in building cloud infrastructures. Google, Amazon and Microsoft invested in 2008 more than 10B$ each, followed by IBM, PeopleSoft and e-Bay. It is urgent that Europe catches up with major investments in data centres and computing facilities.

As the question of investment into the hardware for a European Cloud is more or less a question of cut-throat competition with the American cloud providers, there are remaining many “white spots” on the level of development and application clouds. Europe should therefore foster its R&D activities in creating development and application clouds to explore the mostly positive impact cloud computing can have on the economy in general.

The paradigm shift that Cloud Computing presents is the combination of instant self-provisioning, mass scalability of resources via the Internet and business models based on actual utilization. An important role for governments is to guide this shift from private to public environments by introducing additional standardization and regulatory requirements concerning privacy, trust and security issues, in particular with multi-tenant services and the freedom of moving these services between clouds. It also enables the new concept of the IT-less company.

4.1 Cloud Computing provisioning

Cloud Computing platforms (such as Microsoft Azure, Amazon EC2 and S3 and to a lesser extent Google AppEngine) are all based on Virtual Machine technology, dedicated middleware (fabric), very scalable storage services (blobs, scale-out storage and queues) and background processing capabilities. While often moves between off-premise (Public) and on-premise (Private) are possible, it is not possible to migrate easily from one cloud provider to another. A federation of clouds for different (types of) cloud providers has to be investigated and should result in interoperability standardization.

As an intermediate step businesses, often driven by QoS guarantees and security, also deploy “Private Clouds”, e.g. taking advantage of the above mentioned provisioning and to some extent scalability capabilities but on a privately owned and controlled set of machines.

“Public Clouds” have the advantage that they can also balance load between users and can be collocated at sites with green energy (hydro, wind, etc.) hence reducing the CO_2 footprint of the outsourcer.

To ensure that the European (service) industry can thrive on the utilization of European based Cloud Computing facilities significant investments are required. While the European Telecom Companies are the likely candidates to offer these facilities, they have expressed limited interest. Maybe public-private partnerships will be required to address this European infrastructure need.

4.2 Trust in Cloud Computing

Lack of Trust is one of the major barriers for the widespread adoption of new generation internet services and the migration towards Cloud Computing. Lack of trust is caused by users’ and businesses’ concerns about the security and privacy of data and services moved into the cloud.

These concerns are motivated by factors like: the vast amount of personal data being processed, lack of an interoperable identity management framework, the difficulty of providing guaranteed levels for security, privacy, dependability and accountability due to scale, heterogeneity and complexity, compounded by the inherent lack of certainty on jurisdiction and law enforcement.

The increased level of vulnerability will affect both consumers and public and private organizations, with a possible damaging effect on the take up of new services.

Therefore the question arises how to ensure national and European privacy and security standards in a global cloud environment. So far a few cloud providers have addressed national privacy and security regulations by establishing national or regional hardware clouds. However, in the long run, the global harmonization of national privacy and security regulations would be desirable in order to exploit the full potential of cloud computing. The need for a systematic approach on issuing governing regulations within European cloud computing should be encouraged. Universities could play, at least in the beginning, a significant role by experimenting on the legislation and enhancing it so as to fit the need for large PPPs.

4.3 Cloud Computing Consumption

Instant self-provisioning means that the developer of an application to be provisioned on the cloud is not dependent on an IT infrastructure organization where setting-up machines may take days but can provision a cloud virtual machine within minutes.

Cloud Computing also permits a different charging structure that is based on actual utilization of CPU cycles, bandwidth and storage utilization allowing transparency for offering Software as a Service. This means that Cloud Computing opens up the possibility for new, usage based business models.

On the side of the consumer of cloud computing, Europe lags behind the United States both in actual uptake and in the ecosystem to rapidly take advantage of clouds. This is Europe's potentially largest risk: missing out on the mostly positive impact cloud computing can have on the economy in general. It is therefore urgent for Europe to catch up and use this opportunity to create a cloud infrastructure that satisfies the business and regulatory requirements also for sensitive business applications such as healthcare information storage, trusted social networking, (semi) governmental services processing and storing privacy sensitive information (public transport and road pricing based on position-based systems). Also the Web-based Service Industry in Europe will greatly benefit from a standards based and interoperable cloud environment.

ISTAG Recommendations

- Initiate the guidelines (standards, interoperability) for a pre-commercial procurement of European cloud services to enable European industry to establish a European-based cloud environment
- Assure the identification of new trustworthy cloud computing solutions and approaches, simultaneously addressing technology, standardization, policy, law and socio-economics. Technology wise, the EC should stimulate RTD in areas like: cloud threat modelling, identity management platform, interoperable encryption and key management, assurance of security in storage and processing, physical security of the core network and the critical nodes, incident response.
- Stimulate easy consumption of cloud-based services to European enterprises to explore business opportunities quickly. Easy and trustworthy consumption will be key for the global competiveness of European enterprises.

5. WEB-BASED SERVICE INDUSTRY

This ISTAG has coined a new mega trend: business services offered and provisioned over the Internet. Thus, the news is not the single service provisioning but the establishment of a whole industry sector which will focus on the web-based service supply chain. While first movers have entered this segment already, most of them are lacking a sustainable business model and an open but trusted web-based service and application platform to support the complete supply chain. Section 7 addresses the Business Model aspects.

The rapid evolution of Software and Hardware platforms including devices are posing new requirements onto the Internet, both in speed and in capabilities. The development of the Future Internet (section 3), and Cloud Computing infrastructures (section 4), will enable the service industry to leverage these new capabilities rapidly. As a consequence of these changes the future web-based service industry will provide the ability to address the requirements of our society like health, aging, environment and mobility and our core industries like manufacturing, logistics, finance and telecommunications in a way never experienced before.

In a recent EC Communication[7] the web-based service industry is identified as an essential sector for which a shared European vision is urgently needed not only for R&D but also and above all for the whole innovation and skills development chain and the role of public policies in boosting competitiveness.

Especially now, with all the stimulus packages to recover from the economic crisis, the traditional manufacturing and service sectors should prepare to capitalize on the Future Internet and exploit this web-based service infrastructure by rapidly migrating their business software towards this platform enabling them to improve productivity and better integration within their ecosystem.

This integration with new generation horizontal Internet services and Cloud Computing environments will present complex integration challenges for established vertical services, which are typical in government, healthcare, banking, and telecommunications. Also we see that both professional users and casual users have to adopt the new mental models that these services and their business models provide. This requires significant adaptations in the user interaction with these new and very complex interconnected services and in the legal and regulatory requirements for these services such as safety and privacy. Finally we should not lose sight that the ultimate goal is to reduce cost and to improve the quality of the experience.

To allow the service industry to comply with Regulatory requirements a need of a credible and competitive European Cloud has been expressed by ISTAG, to avoid sensitive information from being stored offshore potentially without security, privacy and trust compliance.

A rich portfolio of web-based content and social services will be used to enhance more traditional services in new channels such as the growing world of handheld devices, requiring a separation between the presentation and the service. This experience will be further enhanced with Smart Environments that will seamlessly integrate into these services and enhance the service experience such as the improved wide-area location-based services offered by Galileo and new wireless technologies for in-building location based services emerging from European research and industry.

The web-based service supply chain of the future will provide an ecosystem of service gateways, service aggregators, service brokers, and service channels which will make the right connection between the service consumer and the appropriate service provider. Issues of local presence and visibility, often limiting the growth of small and medium enterprises, will become less important. Service adaptation, service compliance and service life cycle support will be key differentiators when selecting services in the future. Consumption and composition models taking service level agreements and accountability into consideration will be the cornerstone of the future web-based service industry sector. The web-based service industry will also offer new ways to integrate more women as service providers and entrepreneurs by offering access, creation and delivery options that fit e.g. with remote working conditions and gender specific preferences. Given the fact that women often have to absent themselves involuntarily from the working life due to their familiar situation the new opportunities could

[7] http://ec.europa.eu/information_society/newsroom/cf/itemdetail.cfm?item_id=4698

mobilize additional female labour resources and initiate a major boost for the European economy.[8] In this context, it is important to analyse the specific needs and requirements to integrate women properly into the new service economy - both from a skill and process perspective.

The next step in the industrialisation of services is ‘digital informatisation’ through the creation of new digital platforms for integrated service provision of sophisticated services to increase accessibility and functionality and simultaneously reduce the complexity and the skills required. Achievements in this area will stimulate the migration of low qualified workers to higher value added areas and will help to reduce unemployment.

ISTAG Recommendations

- Research, development and innovation initiatives should focus on tools for service development, federation and deployment on top of the horizontal services offered by the infrastructure (Future Internet and Cloud Computing) in order to facilitate a wide variety of end user solutions & services both in the professional and consumer space.
- Capitalize on the new capabilities offered by wide-area and in-building location-based services and stimulate a dedicated Work programme objective.
- Stimulate barrier-free access to European based cloud resources to deploy new products and services both in the ICT sector and industry and service sectors where innovation capabilities rely on ICT, particularly the Future Internet. Special emphasis should be given to small and medium enterprises as well as governmental and non-governmental organisations as prime user community.
- Define the appropriate instruments focused on commercial acceptance of these web-based services and their effectiveness beyond the level of wide-scale testing and behavioural analysis.

6. SMART ENVIRONMENTS

“The environment is everything that isn't me. “ *Albert Einstein*

The Internet of things will help to create smart environments that proactively assist people living in such environments responding to their needs and preferences. Commonly such smart spaces contain embedded agents and robots, acting for and acting with humans, and enabling these environments to personalise themselves in response to the occupant’s presence and behaviour as well as aiding the normal activities related to work, education, entertainment or healthcare. In addition, such smart environments are designed to be resource-sensitive, saving physical as well as cognitive energy. From smart homes, smart cars, smart factories and buildings and smart offices and conference rooms up to smart shops and smart hospitals, and even smart open spaces on land and on the sea, the era of embedded sensor and actuator systems networked by wireless Internet will shape our daily life in the future and thus create new digital lifestyles. Embedded and interconnected computational devices equipped with the abilities to sense, to elaborate, to communicate, and to act will be the basis for smart environments, given that they understand each other based on semantic technologies. Over the last decade a number of research areas have contributed to the concept of smart environments, including embedded systems, the Internet of things, mobile communications, intelligent user interfaces, intelligent sensor networks, augmented cognition, and ambient intelligence.

[8] see recent study of the Swedish EU presidency at: http://europa.eu/rapid/pressReleasesAction.do?reference=IP/09/1527&format=HTML&aged=0&language=DE&guiLanguage=en

In the future, there will be a continuum of the network proper and "end systems": passive and intelligent sensing devices, sensorimotor devices and pure actuators - the internet of things. Sensing devices (e.g., mobile cameras) will provide information about their environment and their user (e.g., live video streams). Sensorimotor devices (e.g., cognitive robots) will act based on their perception of the environment, on behalf of their user, and actuators (e.g. decentralised power stations, robots, traffic lights) will perform actions based on information gathered by some other device and/or background knowledge.

Embedding sensors, actuators, communication and computing capabilities will enable a whole variety of physical objects to seamlessly gather and use information throughout their entire lifecycle. By capturing and interpreting user actions, smart items will be able to perceive and instruct their environment, to analyse their observations and to communicate with other objects, the user him/herself, and the Internet.

The Internet of Things can integrate pervasive computing with pervasive robotics, truly filling the gap between the ICT world and the physical world, and thus allowing the Internet to exchange not only information but also action. The seamless integration into the smart environments of robotic systems will significantly increase the potential benefits the final users can get from the Internet of Things. The robotic system will increase the range of possible physical interaction between the smart environment and the user.

The level of "autonomy" of the individual system will vary along a continuum of self-determination. Each 'system' will be interconnected on the physical level through IP-based networks, but more importantly they will form transient groups of collaborative intelligent devices that work together on a certain task and, on completion of one task, will be ready to take on another task; a dynamic resource. From the network's point of view, these are intelligent network terminating nodes; from the devices' point of view, the network is a collection of services providing access to other devices and - to some extent - computing power that can be used "on demand". In other words: there will be a plethora of semi-autonomous "cyber-physical" systems (which all rely on embedded computers) with different local intelligence, but they will all be connected to the "information ether". This ever-growing set of devices will actually constitute a new kind of physical intelligence. The network itself will be ubiquitous, it will be even more easily accessible from everywhere, even under the most adverse conditions, it will transmit data in real-time, and it will provide a multitude of new services. These developments, which are already taking place, will change the way users see the network and the way to get access to it.

Collecting information about objects in such smart environments and making it available - for example about an object's origin, location, movements, physical properties, usage history, and context - can help enterprises improve their business processes and create new ones. This can be the case for the expanding market of products and services for active longevity in an ageing society. In particular, two efforts are needed to develop more effective and usable smart environments, in this context: (1) gathering a significant amount of sensory and learning data to increase basic knowledge of user abilities and lifestyle preferences; (2) testing prototypes of ICT products and services in natural environments (e.g., “living labs”).

Existing business processes may become more accurate since information taken directly from the point of action can be used to manage or adapt processes and related decision-making procedures. The continuous evolution of embedded and ubiquitous computing technologies, in terms of decreasing costs and increasing capabilities can overcome many limitations of existing centralised top-down approaches by complementing them by decentralized bottom-up processing schemes. Moves to integrate smart devices into packaging, or better into the products themselves, will allow for significant cost saving and increase the eco-friendliness and sustainability of products.

Digital object memories comprise hardware and software components that physically and/or conceptually associate digital information with real-world objects in an application-independent manner. Such information can take many different forms (structured data and documents, pictures, audio/video streams, etc.) and originate from a variety of sources (automated processes, sensors in smart environment, users). If constantly updated, digital object memories over time provide a meaningful record of an object's history and use. They provide an open infrastructure for the exchange of object-related information across application and environment boundaries.

New commercial applications for smart environments and the potential for new digital enterprises and innovative business models in Europe would derive from the above mentioned considerations. Even today, large parts of European industry are crucially dependent on keeping a competitive edge in various types of embedded physical systems, in their underlying technology as well as in their development processes. In Europe, we have been able to maintain leadership in this area up to now, but with embedded systems becoming increasingly networked and complex, the challenges for staying "on top" will reach a new dimension. In the future, virtually all products of European industry will become network "end systems", e.g., cars and airplanes, process control systems, medical devices, mobile phones. These devices themselves may also have the capability of being employed as nodes and linked other devices, in time and space, such that network can be extended and dynamically configured. Additionally, and possibly even more importantly, the entire invisible set of end systems which keep our industrial, traffic and utilities infrastructure up and running will become "end systems" as well. This will have an even more significant impact in the long run. Therefore, keeping a competitive edge in design methodology for such networked systems is vital to the success of European industry.

Some of the challenges are:

1. We must overcome the structural limitations in the current Internet in terms of scalability, flexibility, mobility, security, trustworthiness and robustness of networks for smart environments. There are three ways to improve and to go beyond current Internet for the Future Internet: increasing the performance of the infrastructure supporting the Internet; improving the services offered through the Internet; and through “The Internet of Things”, integrating more effectively the “world of the Internet” with the “physical world” outside the Internet. In particular, smart environments require truly ubiquitous wireless network capacity that can handle orders of magnitude more data.
2. Instead of the classical human-machine interaction, a new paradigm of human-environment cooperation is needed, where organic, tangible and multimodal interfaces in an “Internet 2.0” will play a major role. Very important will be the development of algorithms for implicit communication where the person’s affective state (e.g., anxiety, engagement, and fatigue) is interpreted by the machine. This possibility will make human-machine interaction more intuitive, smoother and more efficient. In a long-term perspective, explicit interfaces should disappear, being progressively replaced by implicit interaction and embedded artificial perception and reasoning.
3. The smart environments of concern here encompass the dynamic integration of real-time data acquisition, and multimodal sensor fusion with compute- and data-intensive systems. This requires advances in the modelling methods and interfaces, in algorithms tolerant to perturbations of dynamic data streams, in systems software, in pervasive robotics, and in infrastructure support.
4. A major push in socio-economic research is needed to ensure societal and economic factors and objectives, such as "ageing well in the information society" or a sustainable, besides economic, growth, are taken into account in the smart environment development.
5. True Green ICT, more focused on energy efficiency and environmental sustainability, can only be achieved by networked smart environments that actively try to optimize energy consumption in a context- and situation-aware manner.
6. Dealing with high bandwidth to guarantee real-time control and communication (and control of semi-autonomous units).
7. Miniaturization of Devices is fundamental to implement the Smart Environment. European Leadership in Nanotechnologies needs to be sustained being key to achieve better system integration.

ISTAG Recommendation

- Stimulate special research focus on smart environment “by design” including the development of new paradigms of human-environment cooperation (interfaces, cognitive and physical models).

6.1 Embedded Systems

European Industry has a strong position in Embedded Systems. Embedded Systems enable the real-time computer control of physical devices and systems, ranging from mobile phones, to television sets, to automotive engines, and to robots (to take a few examples) in order to achieve an unprecedented level of performance and utility. Embedded systems are also called Cyber-Physical Systems (CPS) to denote the emphasis and the close synergetic interactions of a real-time information processing subsystem (the Cyber System) with a physical device or subsystem that is to be controlled (the Physical System).

Already today more than 90 percent of all CPUs are deployed in embedded systems, making embedded systems one of the very important domains of the ICT sector. In the coming *Internet-of-things* embedded systems form the endpoints of the communication channel provided by the Internet and offer tremendous opportunities for innovation, growth and new products.

The full exploitation of the benefits provided by interconnected intelligent Embedded Systems will require the development of an Internet of Things infrastructure featuring a rich set of service parameters, supporting in particular real time interactions, with an high degree of availability, integrity, privacy and trust. The concepts, models and algorithms required to provide such capabilities are the enabling factors to build future complex systems operating in unstructured environments.

One of the most notable technological developments during the last few years in the embedded system domain is the advent of multi-core system on chips (MPSoCs). In an MPSoC the IP cores can form self-contained components that communicate with other IP-Cores on the chip by a high-bandwidth Network-on-Chip (NoC). MPSoCs are fundamentally changing the characteristics of the execution environment of embedded systems with the following consequences:

- The structure of an MPSoC—many concurrently executing IP-Cores—maps ideally to the requirements of embedded systems, where many application tasks have to execute concurrently. MPSoCs thus offer new possibilities to realize a truly component-based design style, where large systems can be built effectively out of existing components (IP-cores).
- Since small IP cores are much energy-efficient than large sequential processors (*Pollack’s rule),* the battery lifetime of portable devices that are based on MPSoCs will be significantly extended.
- The distributed nature of MPSoC-based execution environments offers new possibilities to increase the robustness of embedded applications by tolerating the failure of a single IP-Core.

Multi-core processing is considered to be one of the most significant developments of the past 40 years. New architectural approaches, operating systems, methods and design tools at all levels of system design are needed to master this revolutionary change. It is recommended that Europe invests heavily in research in development of this new paradigm in order to stay ahead in the world-wide embedded system market.

Embedded systems that are employed in a dynamic open environment (e.g., sensor networks, ambient intelligence) must have the capability to adapt autonomously to the given circumstances and organize themselves dynamically to make relevant contributions to the given high-level objectives and plans (*self-organization*). Fault awareness and autonomic diagnosis are needed to avoid costly human intervention in the case of the failure of a part of the system.

Given the trends of growing demands and greater than ever technological capabilities, the future opportunities for the embedded system sector are enormous, provided that the technological and societal requirements and challenges are properly addressed.

The Framework Program should take a longer-term view and contribute to the solution of the demanding current and future technical challenges that are facing the embedded system sector. Some of these challenges are:

- *Complexity Management.* The management of the ever-increasing cognitive complexity of embedded system is a major concern in all application domains. A recent (2007) report on "Software for Dependable Systems: Sufficient Evidence?" from the US National Academies contains as one of its central recommendations: "One key to achieving dependability at reasonable cost is a serious and sustained commitment to simplicity, including simplicity of critical functions and simplicity in system interactions. This commitment is often the mark of true expertise".
- *Composability*, i.e., the ability to build large embedded systems out of pre-validated components is considered to be the most pressing need across many application domains.
- *Robustness*: Embedded systems must deliver an acceptable level of service, even if a software or hardware fault occurs in a part of the system or the system is used outside its specifications. The impact of device scaling and energy efficiency on the robustness must be studied. With the connection of embedded systems to the Internet and the formation of the Internet-of-things security issues are also moving the forefront of concerns.
- *Energy-efficiency*: This topic is of decisive importance for mobile devices. The shift to energy efficiency as a design goal impacts not only the hardware architecture, but all phases of the design cycle.

In conclusion our recommendation is that it is of fundamental importance to sustain the European Leadership in Embedded systems to build a European Leadership in Smart Environment.

ISTAG Recommendations

- Consider the multi-core systems on Chips (*MPSoC challenge*) as a major opportunity to strengthen the European lead in the embedded system domain. Focus related objectives onto research and developments that tackles this paradigm change, considering all levels of system design and architecture in a holistic manner.
- Support research and development in the area of self-organizing embedded systems and autonomic diagnosis to provide the infrastructure for new applications in the coming *Internet-of-Things*.

6.2 Socially Aware Ambient Intelligence[9]

One of the most challenging issues of a future information and knowledge society is “Socially Aware Ambient Intelligence”. Applications and services will behave “socially aware”, this means having a sense of involvement and knowledge about the social behaviour of persons, such as their degree of attention, desire for customization and control, their emotional state, interests as well as their desire to engage in social interactions. A socially aware ambient environment will be composed of a collection of smart artefacts and understands social signalling and social context resulting in the capability of improving social orientation and collective decision making. Research challenges and requirements for socially aware ambient systems include:

[9] This contribution is based on the work of the Working Group "Ambient Computing and Communication Environments" of the EU-funded InterLink-project

- to build systems that understand social signalling and social context
- to provide people with smart tools for an informed and mature decision-making instead of fully automated systems.
- to improve collective decision making
- to provide infrastructures that enable intercommunication of a wide range of devices, sensors, actuators and a functional coordination and intelligent scheduling in a self-organizing fashion
- to integrate reflexive systems for semantic interpretation of contexts, user preferences and profiles
- to extend group-oriented interfaces from a single user to groups and teams and communities

Challenges we are facing when developing “Socially Aware Ambient Intelligence” confront us at various levels. One way of investigating them is to state general goals for designing a Humane City. They include: (1) to enable the development of a humane and creative society, (2) facilitate social interaction and communication, (3) foster social creativity and collaboration, (4) facilitate social networks in real and virtual spaces, (5) facilitate personal expression, (6) address emotional and affective aspects (7) address and involve all our human senses (8) keep the human in the loop and (9) assure privacy, trust.

Mainly the last challenge “Privacy, Trust, and Identity” is most important for Socially Aware Ambient Systems. In today’s connected world, where computers mediate frequently our interaction and communication with the outside world, many people suffer from the ‘Big Brother’ syndrome. Especially “privacy” is an elusive concept because not everyone’s sense of privacy is the same. Therefore we have to overcome the privacy/trust/security concerns of people by initiating an open dialogue and providing transparency about system design decisions. The question “why data is being collected” is becoming more and more a focus of attention.

ISTAG Recommendations

- Stimulate research on Socially Aware Ambient Intelligence systems that understand social signalling and social context and 'keep the human in the loop'.
- Address the conflict of ubiquitous and unobtrusive data collection/provision with human control and attention in an open fashion.

6.3 Robots in Smart Environments

The integration of robotics and smart environments (often referred to as Ubiquitous Robotics or as Network Robots) is an emerging paradigm that arose in the last years, from a shift of the focus from the “traditional” ICT concept of Ubiquitous/Pervasive Computing (i.e. from information) to matter and physicalness. Networked, ubiquitous robotic systems that convey data and physical actions, like motion and forces, in intelligent environments, could generate a profound and pervasive impact on virtually all new products. Therefore it is important to recognise the necessity of integration of environment and robotic devices in ‘smart environments’. Physical devices with ‘embedded processing engines’ linked to data streams to provide intelligent interaction and actuation with the environment (other smart objects AND humans) must embrace embedded systems and the Internet of Things / Future Internet.

Besides extending the concept of Ubiquitous Computing and of Internet of Things with the ability of interacting with and acting on the real physical world, thus opening a wide range of new applications, the integration of robots into smart environments will pave the way to innovative and affordable solutions and products. Sharing the intelligence between the “thing” and the environment reduces the complexity and cost, and increases robustness, performance and acceptability of products. “Smart” robots sharing intelligence with the environment could be developed in addition to “intelligent” autonomous robots.

Optimization of size, cost and performance of the smart robotic sensing and actuation devices are key factors for success. If on one side the roadmap of electronic components already targets such kind of optimization at chip level, it is recommended that electronic subsystems leverage on that trend by combining key IC technologies onto Robotic Embedded Platforms designed for flexibility (e.g. broad range of operating conditions), adaptability (e.g. capability to deliver the expected outputs in environments and contexts not foreseeable at design time) and reusability (e.g. interworking with a broad range of robotic systems).

The actual deployment of robots in smart environments calls for the solution of critical problems, such as:
- convergence and merging of different constituencies
- integration and management of different components and subsystems (hardware and software) by a “general contractor” responsible for the smooth functioning of the whole environment
- interoperability of modules and standardisation of interfaces

A few concrete scenarios and driving factors for the deployment of smart environments and robots are the following:

- Government and administration
- Public safety and security
- Factory automation, including flexible “built-to-order” manufacturing
- Service to humans, particularly to the elderly, by means of Ambient Intelligence (AmI) and Ambient Assisted Living (AAL) paradigms and robots, including humanoid robots.

The scenario of care of the elderly is particularly representative of the integration of smart environments and robots. Europe must deal with the problem of the ageing society. The cost of providing care and support for an older section of communities is a problem for all Sovereign states and this can only increase. The solution, based on social and economic factors, must include better provision for older citizens in their own homes. Integrated intelligent systems which link coherently together will be needed. These linked systems would need to include health monitoring, communication, physical interaction with the environment (e.g. robot devices lifting, passing items etc) and appropriate cognitive interaction. Such sub-systems are embedded in the ‘contextual wrapping’ of a coherent AI presence with social intelligence.

Some features and actions to be pursued are:

- Distributed, smart sensing devices should pre-process signals and transfer to the robot only meaningful information, e.g. in the form of events. Heterogeneous event streams can thus be processed by the robot at a higher level of abstraction, enabling a more advanced awareness of complex contexts and supporting the artificial decision process.
- Smart objects, when manipulated (or “observed”) by a robot, should provide it with information about how to interact with them, or about the effect of manipulation itself, or about their function and more.
- Distributed interfaces allow ubiquitous and enriched human-robot interaction, including augmented/virtual reality information based on distributed sensing.
- A smart environment framework should significantly enhance robot-robot co-operation (also in networks), as well as the development and deployment of low-cost, highly connected and high performance single-function robots.
- A key factor in the efficiency and acceptability of smart environments is human-machine interface. Human-machine interfaces should be designed in order to evolve according to the needs of the users. Particular attention has to be devoted to the development of algorithms for the multimodal fusion of different sources of information.

ISTAG Recommendations

- Address specifically the problem of data explosion and management of data complementing management of smart robots in action.
- Stimulate socio-economic research to ensure uptake of smart robots beyond traditional (industrial) environments, such as environments in health and wellbeing.
- Stimulate a cross disciplinary dialogue about the legal consequences of robotics and new human-machine relationship.

7. BUSINESS MODEL INNOVATION

The ICT industry, particularly the early movers of the web-based service industry, has demonstrated how innovative business models will allow building up a customer base incredibly fast. The global reach of the Internet provides immediate access to large target audiences. Still, the industry is lacking commercially viable and scalable business models innovation. While consumers are easily addressable if software and services are provided for free or very little money, enterprises are looking for ways to reduce financial risks of capital expenditures by moving more and more of their ICT spending into operational expenditures. These diverse goals will require a diverse set of business models to mature in the future. First movers in both have demonstrated that they can attract large target audiences and create a successful business. At the same time, it becomes clear that these examples do not scale for a whole industry nor could they be easily adopted by other industry sectors which are facing equally strong push back on their existing business models. Given the fact that business model innovation often come along with technology breakthrough or disruptive technology innovation, it becomes obvious that the ICT sector has to research on this subject, as well. Moreover, the new world of the Future Internet will make both kinds of innovation "two side of the same medal". Chris Anderson's (the author of the Long Tail) latest book "Free" exemplifies this. Besides the two traditional models for buying ICT products (initial purchase of hardware, licenses and maintenance or lease including maintenance) a large variety of business models have evolved for hardware, software and services.[10]

Until today companies are using information technologies mainly in a supportive service-manner to optimize their traditional business processes. Accordingly the Lines of Businesses still focus on the business-management perspective, creating processes without a full exploitation of the potential of IT. The rapid developments in the ICT-area and how inventions will impact on the way how business processes are modeled by offering new possibilities of data acquisition (e.g. the possibility of "smart meter measuring" enables the utilities industry to adjust their business processes to the individual consumer behavior, which could lead to new "intelligent" types of energy markets).

The exploration of this potential – the future business processes in the "Future Internet" – will lead to a major task for national economies and the European market. This includes not only the matching of technological possibilities and business needs, but also research on questions regarding security and trust, scalability (Cloud Computing) or the qualification of employees and experts both in technological and business studies. Companies will therefore start developing their business processes in order to tap into the full potential of IT: using the underlying IT infrastructure as well as the applications.

One of the issues that companies with innovative business models are being confronted with is that European procurement regulation makes it sometimes difficult to tender.

[10] http://www.hec.unil.ch/aosterwa/PhD/Osterwalder_PhD_BM_Ontology.pdf

The best example of an innovative hardware/maintenance business model is the inkjet printer and cartridge model whereby the profit is made on the "disposables". Similar concepts drive the business model of mobile operators offering "free" handsets.

The traditional way for selling software is based on an initial (volume based) license. After the guarantee period most vendors offer maintenance contracts including helpdesk, bugfix and update services.

Software as a Service (SaaS) is a business model in which the user pays for the actual usage (pay per active user, pay per transaction, pay per storage unit). This model also includes maintenance and updates and upgrades to newer versions. These models can be very sophisticated (guaranteed SLA with automatic compensation in case not reached, transaction may change over time e.g. paying per stored picture where today the size is 1 Mbyte but in the future maybe 10 Mbytes). It essentially allows the transformation of the currency of the vendor (CPU cycles, storage units, bandwidth) to the currency of the user (a shared document on which many collaborators can work together, a movie streamed to a group of consumers).

Cloud Computing will use business models similar to SaaS for the various elements like compute (VM) units, storage units, network traffic etc.

An example of an eco-system business model is the iPhone AppStore of Apple. In this case Apple acts as the reseller of applications and games with a 30% margin and Apple offers a very sophisticated store and infrastructure to allow for low entry barrier development shops to develop applications.

Entertainment buying or renting business models exist for downloading entertainment content (music, video, games and books), protected by digital rights management and often into dedicated products like a mobile operator selected cell phone, Apple's iPod or Amazon's Kindle. Often digital rights management is involved to protect the software product or content. A main issue is that the publishing rights are often negotiated at country level thus depriving many consumers from ready access to music, movies and books.

In particular the "free" (as in beer) [11] model targeted at consumers either based on advertisement placements (like Google, newspapers and magazines, YouTube, LinkedIn, etc.) or on teaser services whereby more advanced features are available for paid services (LogMeIn, Amazon Kindle first few chapters per book for free, etc.) are very popular.

The original business model for Open Source was to supply software for "free" (as in speech)[12] by leveraging the developer community. However the clauses in the associated license may make it difficult to deploy (so-called toxic licenses). A new business has developed around the support and maintenance which is not free at all and various companies like IBM and Red Hat have developed specific service offerings for several of these products, sometimes even taking over the liability exposures.

Open Innovation expands the horizon of companies beyond their own boundaries. It fosters the cooperation with external sources of R&D. This applies both to hardware and software. Proper use of this model can speed up innovation and reduce the time to market and risk. Because innovation combines technology, cost and business model it is important that more insight is obtained about the various business models and their economic impact for public services, for private enterprise and for consumers.

---

[11] http://en.wikipedia.org/wiki/Gratis_versus_Libre

[12] See footnote 11

ISTAG Recommendations

- Stimulate research on business models (mathematical modelling) and tools (simulation based) to allow for rapid deployment on the Future Internet. This certainly should be done using a multidisciplinary dialogue including economists, domain experts, and ICT experts.
- Add business model research as a topic to Living Labs and furthermore to all ICT research projects where the business model is essential for the market impact of the results. Make this a priority within the proposals evaluation process for proposals submitted to this Work programme.
- Ensure that Public procurement regulations encourage business model innovation.

8. Application Domains

8.1 Supporting mobility

The adoption of mobile communication technologies over the past decade and half has been nothing short of phenomenal. From industrialized to developing economy countries, the proliferation of mobile technologies has demonstrated how much humanity values the convenience of being able to communicate while on the move. The high adoption of mobile phones as the primary communication device has created possibilities to provide ICT-based services to both *people* and *service scenarios* that are not addressable with the personal computer (PC).

At the same time as new business opportunities are emerging and new application areas of ICT are introduced it has become apparent that technology as such is becoming more of an enabler, and the services and capabilities provided to the users must be able to handle the concept of full mobility across available platforms and devices. A key to continuous innovation and driver for the creation of future business models will be the design of end-to-end solutions capable of realizing new applications or services that at low cost bring value to end-users regardless of channels or devices used. Smarter networks together with the conversion to all-IP broadband networks with increased deployments of broadband access will enable access everywhere and use of any type of devices. This raises the need for development of services and applications that are able to operate in a fixed and mobile converged world providing different characteristics depending of the channel and devices used.

Europe’s ICT industry is today moving towards a larger focus on applications and services, both within the ICT sector itself but also providing solutions cross-sectors. In order to provide competitive solutions it will be important to understand and address the convergence early in the innovation and design phase.

As an export-oriented Economy Europe has to take account of another trend regarding the future mobile user development and as well the mobile user behaviour – as the next billion users of the internet will be mobile and mainly domiciled in the emerging markets. Europe has a major opportunity to foster research to exploit the full potential of these potential mobile users on the one hand and should focus on the same time on the specific needs and preferences of the younger generation of users, today mainly addressed by American Providers.

Whereas fixed installations using fibre may offer virtually limitless growth, the success of mobile will depend crucially on the more efficient use of radio frequency spectrum. Recent European work on new coding systems and new modulation technologies such as DVBT2 increase spectrum efficiency by over 100% as well as enabling other techniques such as single frequency networks. Cross-disciplinary workshops and research into the technical, commercial and regulatory issues will be needed to encompass the new technologies and support growth in mobile activities. The likely demands from

Smart Environments, High Definition and 3D television need to be included in any future studies. In the case of broadcast media, the issues are much political as commercial and technical.

Another critical success factor is the user experience when being mobile. While many user interface technologies and methodologies of the past have been centred on ever larger PC screens with higher resolution coming along with it the next generation UI technology must address both scaling factors towards reduced screens as well as user ergonomics. Simply scrolling a larger screen is not working as the cognitive capabilities of mankind are too limited for this. Moreover, combining the issue even with another mega trend on elderly population in developed countries like Europe itself it becomes even more crucial to provide a new generation of user experience for mobile devices.

ISTAG Recommendations

- Stimulate research and innovation initiatives on usability and context aware applications and services including rapid innovation and deployment of mobile devices into their focus.
- Stimulate R&D instruments to focus on the next generation of users, particularly taking into account cultural and IT skills diversity.
- Stimulate all digital technologies supporting spectrum conservation and efficiency to continue a rapid uptake of mobile Internet infrastructures, particularly in rural and remote areas.

8.2 Sustainability

In the area of energy efficiency, new opportunities include greener operation of data centres, servers and storage, from rack lay-out and air-flow management to smarter applications on shared platforms. The problem of power dissipation in idle infrastructure elements should be addressed through virtualization and dynamic load shift (see se. 8.3)

The concept of sustainability is well defined in biological and ecological systems: it is the capacity to endure and remain productive over time. *Natural* systems are typically characterised by balanced *cycles* ranging from the chemical domain (elements that are re-distributed through living and non-living systems) to the ethological one.

Humanity brought in such a scenario the capability of a *goal-driven modification* of the natural world, being motivated by continuous improvements in wellbeing. Targeting this overall goal – especially after the western industrial revolution and within developed countries – had two “side” consequences, in addition to the improvement of *wellbeing*: the first one is the establishment of new, powerful *knowledge and technology*, the second one the introduction of a linear, non circular model of development, potentially against sustainability, which is typically characterised by natural cycles. The challenge we are facing is to conjugate, through knowledge and technology, wellbeing improvements with sustainability.

ICT represents one of the most advanced areas where prominent instruments have been developed and it is therefore particularly appropriate to look for ICT technologies as enabling means for sustainability. In the following, three main categories are addressed as key domains for such a challenge in sustainability*: (1) human beings, (2) our artefacts* and *(3) the environment*.

As for (1) major ISTAG recommendations are on strengthening research and development on enabling technologies that allow, at the same time, effective work and quality of life. Workers, professionals, employees should contribute, at the same time, to the wellbeing of the families and to the society. Here are a number of ICT technologies that could enable such a win-win situation and that, therefore, should receive priority in funding:

- better *communication* infrastructures (especially efficient and cost-effective wireless technologies) enabling remote work;
- *assistive* technologies (e.g.: robotics) for an increased independence, efficiency, and wellbeing of all people categories;
- *ambient intelligence*, including MEMS, and especially targeted to safety in transportation;
- *user-friendly* tools for "natural", non-tiring jobs (e.g.: advanced human-machine interfaces, natural-like indoor environments, etc);
- *visual analysis interfaces* for efficient handling and utilization of massive amounts of data, including tools that encourage workers to manage complexity instead of avoiding it**;**
- efficient economic, *financial and business modelling tools* for understanding economic behaviours and design appropriate policies;
- tools to guarantee high *security* and *privacy* standards (such as quantum key distribution protocols), also in consideration of the increasing use of communication (internet based) means.

Regarding (2) it is mandatory that consumption of materials and energy, and emissions are compatible with a "circular model" in the use of resources. Examples of ICT key technologies are:

- *clean and efficient production processes*: artefacts should be designed for disassembly, re-use of components and/or recycling of materials. Polymers derived from fossil reserves should be used only in case of recycling potential, otherwise biopolymers should be adopted. Silicon-based processes should be minimized (e.g.: limited to computing chips) and alternative technologies should be made-up, for example, in the case of photovoltaic cells. In this line ICT has the main potential of developing standardization and design tools, supporting material and production sciences;
- *renewable, zero-emission energy sources*: ICT has the potential of enabling the development of clean energy sources such as thermodynamic or photovoltaic solar plants, bio- production of fuels (e.g.: hydrogen) in bioreactors, other forms of energy scavenging (e.g.: harvesting from environmental vibrations or movements);
- *power management* of systems, as in the case of illumination, mechatronic units for domestic or outdoor use, hybrid vehicles, but also greener operation of data centres, servers and storage, from rack lay-out and air-flow management to smarter applications on shared platforms. The problem of power dissipation in idle infrastructure elements should be addressed through virtualization and dynamic load shift.

Environmental issues (3) can be effectively addressed by ICT mainly regarding *monitoring* of biological and ecological parameters. New, ubiquitous, autonomous and self-reliant sensor nodes should be developed for a local monitoring of *climate* parameters, concentration of *pollutants*, preservation of *biodiversity* and for screening in waste production and management (as enabling tool for the zero-waste approach). Networks of mobile robots could allow a dynamic and large-areas environmental monitoring, in addition to remediation actions in highly polluted sites.

ISTAG Recommendations

- Address ICT for sustainability in three domains: a) Society; b) products and services c) natural environment.
- Stimulate research for a sustainable ICT sector including societal aspects such as inclusion or ambient living, sustainable ICT products and services including efficient production processes, as well as environmental issues including energy consumption as design principle.
- Stimulate cross-domain research on ICT technologies and applications to allow key European industry sectors to implement more sustainable solution and services.
- Promote adequate ICT tools for ensuring transparency and compliance in real economy towards a sustainable growth.

8.3 Energy Efficiency of the ICT Sector

The carbon footprint of the worldwide ICT sector—an estimated 2-3 % of the total worldwide energy consumption—is in the same order of magnitude as the carbon footprint of the worldwide air-transport industry. Server farms alone consume more than 1% of the world-wide electricity, growing at a rate of more than 15% per year[13].

For example, it is estimated[14] that a complete search query requires 2 to 10 Wh, corresponding to a CO_2 footprint of 1 to 5 g of CO_2. Considering that hundreds of millions of searches are performed every day worldwide—and searches are only a small part of the worldwide ICT activities—it can be anticipated how the further expansion of ubiquitous cloud-based computing will increase the environmental impact of the ICT sector.

However, we can spot promising technological developments on the horizon that counteract this disturbing trend. The further miniaturization of electronic devices and the advent of multi-core systems on chips are leading to a dramatic improvement in the energy efficiency of computer systems. For example, according to Intel the 1996 design of the first *teraflop super computer*, consisting of 10000 Pentium Pro Processors, operated with an energy efficiency of 2 MegaFlops/Watt.sec. Ten years later, in 2006, a *teraflop research chip* of Intel containing 80 IP Cores on a single die connected by a Network-on-Chip achieved an energy efficiency of 16 000 MegaFlops/Watt.sec, a more than thousand-fold increase in the energy efficiency.

Further radical technological developments, such as the advent of *subtresh-hold logic*[15], promise to lead to a further significant improvement of the energy efficiency, particularly in the field of ultra-low power low-performance computing. This novel technology holds a high potential for the energy reduction in standby circuits, those that are used in billions of devices that are continuously draining power while waiting for a significant event to occur (e.g., a start command from a remote console). Even if only a 1 Watt reduction of the power requirement of a standby circuit is achieved (and the technology suggest a much higher potential), the energy savings amount to 10 kWh per year-and-device or a world-total of about 10 TWh, the equivalent of 5 million tons of CO_2 per year if only a billion of devices is considered.

The increasing growth of energy-aware and power-aware computing is driven by the following concerns:

- the widespread use of mobile devices where the available *time-for-use* depends on the lifetime of a battery load,
- the power dissipation within a large System-on-Chip that leads to high internal temperatures and hot spots that have a negative impact on the chip's reliability, possibly physically destroying the chip,
- the high cost of the energy for the operation and cooling of large data centres, and finally
- the general concern about the carbon footprint of the ICT industry.

We seem to be in the middle of a radical paradigm shift concerning the evaluation of computer system performance: While in the past fifty years *performance/unit_of_time* was an accepted performance measure, today *performance/unit_of-energy* is getting more important. This paradigm shift has far-

---

[13] Fettweiss, G. and E. Zimmermann, *ICT Energy Consumption--Trends and Challenges*, in *11th International Symposium on Wireless Personal Multimedia Communications (WPMC 2008)*. 2008

[14] Sunday Times *Revealed: the environmental impact of Google searches.* Times on Line, July 11, 2009, http://technology.timesonline.co.uk/tol/news/tech_and_web/article5489134.ece

[15] Intel, *Advancing Multi-core Technology into the Tera-Scale Area.* 2009 http://techresearch.intel.com/articles/Tera-Scale/1449.htm

reaching consequences on all levels of system design, and poses a number of deep research challenges, such as:

- *System architecture*: A proper architecture design can have a significant impact on the energy requirements. For example, providing an environment that supports power-*gating* has to be addressed at the architectural level.
- *Algorithm design*: For many software engineers it is new territory to consider the energy footprint of an algorithm as a relevant quality parameter of an algorithm.
- *Compiler design*: The object code, produced by a compiler, can have a decisive influence on the power consumption during execution.
- *Operating System design*: Energy-aware integrated resource management, such as voltage scaling and power gating, have to be supported by the operating system
- *Hardware design*: The miniaturization of the hardware with the associated reduction of the peak voltage has been the traditional method of improving the energy efficiency at the hardware level. Some new evolving trends in hardware design, such as the above mentioned *subtresh-hold logic* can further improve the energy efficiency

We are only at the beginning of this fundamental transition from a *performance/time* to a *performance/energy* focused information sector. This transition offers tremendous opportunities for new ideas, relevant research and innovative products and services. It is up to the framework program and the research community at large to be proactive in bringing about this indispensable transition that is crucial for establishing a sustainable information society.

ISTAG Recommendations

- Initiate a special research programme in energy-efficient computing and communication, adopting a holistic approach that considers energy efficiency at all levels of system design, such as: system architecture, algorithm design, protocol design, operating system design and hardware design.
- Ensure that energy-efficiency is considered and supported by all future design methodologies, tools and prototypes such that energy awareness becomes an important concern in any ICT development activity.
- Support the development of new hardware technologies that promise a significant reduction in the energy consumption of ICT devices.

8.4 Health and wellbeing

The opportunities offered by both technological and business breakthroughs will allow for major improvements in our societal environment and in particular to our quality of life.

By these breakthroughs we will see advances in areas that will impact us directly such as adaptive and life-long learning, domotics and home automation, and virtual spaces both for work and fun. However a major concern will be the ability to offer these services also in a secure and trust worthy manner taking into consideration the privacy of the citizen. This will also require an additional breakthrough in policy making and enforcement.

Due to the aging population and ever improving medical technology both the financial and workforce increases required will not be sustainable. Therefore major social and policy changes need to be introduced in areas such as healthy living, level and quality of care, reimbursement systems, chronic care management, etc in our society by all players in this field: citizens, care givers, insurers and governments. ICT will play a major role in keeping health and wellbeing sustainable while improving the quality of life.

In modern society we no longer just treat sick people but we take an active role in allowing them to manage their wellbeing (“nature”, eg genetic disposition and “nurture”). This can be managed at individual level by adjusting lifestyle but also at societal level by offering education, population vaccination and performing pre-screenings (dental, breast cancer, etc.). Also genetic information will be used more and more to predict risks for specific diseases for specific cohorts and tailor the prevention accordingly.

The treatment of diseases continues to improve dramatically with modern (imaging) technologies for diagnostics and with advanced minimal invasive procedures, ranging from reduced access approaches to robotic systems for therapy or surgery. Pharmaceuticals are improving as well and will become very specific for the treatment of particular diseases guided by additional biomarker information.

The after-care and the management of post-acute episodes and chronic care will see similar improvements hence reducing significantly the hospital stay, the need for re-hospitalization, and increasing the time for social and work re-integration.

None of these improvements will be possible without a major increase in the use of ICT and the products in which ICT is embedded such as robotics. However we expect that the role of ICT in the health domain will increase even further: in clinical research, in lifestyle guidance, in screening, in monitoring neuro-motor development and deterioration, in non invasive and pervasive treatment and in after-care and health management.

Below are a few areas where ICT breakthroughs will have a major impact on the quality and productivity of the health and healthcare industry:

Pharma

1. Development of new pharmaceuticals requires sophisticated computer modelling and simulation (see also section 9.2: FET Flagship initiative Understanding Life through future ICT).
2. Bringing pharmaceuticals to the market requires many years of clinical trials to collect and analyze data, much of which can be further automated. Also new possibilities to classify the target group based on genetic information will play an increasing role.

Care-cycle is a method to describe the continuum of care and identifies the following phases:

Prevention and screening

1. Life style assistance will become increasingly important. Due to non-intrusive sensors and cheap wireless technology it will be possible to collect continuously information that can [centrally] be stored in Personal Health Records and regularly be mined to detect specific deviations and to generate warnings and advise. Quantitative data on cognitive and motor behaviors can help monitoring neuro-motor development in infants and cognitive and neuro-motor deterioration in the elderly (due to neurological diseases or to the natural ageing process).
2. Population screening, not only for breast cancer but also for other wide-spread disease types, will require very sophisticated software to triage the information and present only exceptions to screening doctors [a radiologist can only read 50000 images/year]. Gastrointestinal screening has been made possible thanks to the advance of ICT technologies (e.g. endoscopic pill equipped with CMOS cameras) and now it requires additional resources for the effective take up by the healthcare system.

Diagnosis and treatment

1. Medical imaging technology is improving both in quality and in exposure time in a rapid pace, using the latest ICT capabilities. This includes new areas such as Computer Assisted Diagnosis and Clinical Decision Support.
2. Image guided interventions and treatment and a smart use of remote guiding techniques make it possible to perform localized surgery or treatment, greatly reducing recovery time. Besides image processing technology also robotic technology is having a major impact in this domain.
3. Current trend in minimally invasive surgery is to further reduce or eliminate the number of transcutaneous access ports. This approach would greatly benefit from a novel generation of smart robotic surgical tools, thus allowing a reduced trauma and a faster recovery time for the patient.
4. Robotic surgery is well established in minimally invasive surgical procedures, and the next frontier for biomedical robotics is the vascular district up to the brain. Intelligent and multifunctional miniature capsules and robotic systems navigating inside the blood vessels would pave the way to a broad diffusion of endoluminal robotic surgery.
5. Recovery of patients in Intensive Care Units (ICUs) or the ward is improving significantly due to innovation of patient monitoring equipment and the associated real-time analysis of the data from these monitors and other sources using Clinical Decision Support technologies.
6. Innovative ICT-based systems (e.g., robotic devices and wearable systems) can be used to carry out dedicated clinical trials for the improvement of motor function immediately after the onset of the disability. They can be also useful to provide more quantitative information to the cliniciansclinical to define more specific treatments.

After-care and chronic care

1. Not only the minimal invasive interventions but also the ability to keep an eye on the patient at home will make it possible to dismiss patients earlier and continue the surveillance at home using telemonitoring, telerehabilitation, and video surveillance technologies.
2. Similar technologies allow the surveillance and assistance of chronic care patients. It allows early detection of changes like weight that together with additional guidance may avoid other acute hospitalization episodes.
3. In this framework, the use of smart systems and robots (external and internal to the body) could greatly enhance the effectiveness of the current telemedicine approach.

Electronic Patient Records

The examples above highlight domains where ICT will help to improve. However in order to bring these benefits, all patient related information must always be available: complete, trusted, secure and with the right level of detail related to the particular phase.

1. Personal Health Record systems [Microsoft HealthVault, Google Health] allow the patient to collect all relevant information from the various other systems. It is typically a combination of own measurements and observations (eg weight, blood pressure) and professional information derived from various medical records. However a major concern is the business model (targeted advertisements) and the trust level: no physical verification to check if the record really belongs to a physical person.
2. Electronic Medical Records are quite often limited to a particular department in a hospital [Radiology Information Systems, Cardiology Information System] and support both the patient information related to that specialty and the associated workflow. However they lack the level of integration required to make information available in a holistic manner.
3. Electronic Health Records cross the specialties of an institution and are often also linked with the ambulatory care, GP's and local pharmacies. [iSoft, Agfa, Cerner, Epic] In particular these systems,

if implemented in an integrated fashion, may offer additional patient safety by reducing medication errors.

4. Electronic Health Exchanges are regional or national aggregation points of all health information of a resident. These systems either use a cross reference index to the place where the information is stored e.g. a doctors IT system (decentralized) such as the Dutch AORTA/LSP or contain all information at a central place such as the NHS SPINE in England.

Electronic Patient Records combine all this information by aggregation the data or by maintaining indexes to the various record systems. It is recognized by the industry and at political level that, in order to bring the improvements in productivity and quality of care desired, will also require major changes in the way of working and incentive structures of the medical profession.

ISTAG Recommendations

- Stimulate research and innovation in the domain of trustworthy and privacy-obedient products and (web-based) services for home health (in application domains such as PHR, robotics, ambient assisted living and wellbeing).
- Stimulate research and development for highly computing-intensive application domains such as synthetic life, clinical decision support, correlating genotype and phenotype information.
- Foster ICT research for the domain of robotic surgery and image guided interventions.
- Tele-health (monitoring & therapy) is the only economically viable way in an aging society. Enforce initiatives based on business models rather than on technology.
- In case of tele-health, the massive data volumes accumulated can be processed only in an automated way. Encourage ICT supported data evaluation and decision support system based on large volume or rather “fuzzy data” (e.g. time series of weight, pressure, age and anamnesis of an individual patient).

8.5 Media

The media landscape has changed during the last decade from the media industry’s linear value chain comprising the creation, modification, storage, delivery and presentation of content to a networked approach with the end users being an active and creative part of it. Today a tremendous amount of media data is available through the networks, whereas content has evolved and will further do so from purely textual information and low fidelity media to high fidelity media and 3D content in the near future. The further evolution of network bandwidths, the convergence of broadcast, PC and mobile networks, the availability of more powerful mobile platforms as well as emerging 3D display and interaction technologies are constituting a “*High Fidelity Internet”* with a huge potential for a number of innovative services and applications. Those services will include:

- Personalised services allowing ubiquitous and pervasive access to information on-the-move being capable to provide the right content at the right time while taking into account user preferences and context. This will include localised services where virtual information is seamlessly blended over real world projects.
- Advanced telecommunication services allowing people in distributed business units to remotely collaborate in a common “virtual” environment. Those services will help to gain further acceptance by the users for remote collaboration, with the positive effect of physical transportation avoidance thereby reducing costs and energy consumption.
- Efficient services for visual search and retrieval of 3D and other media content allowing queries based on sketch or example as well as object-oriented data search.

- Distributed media analysis and monitoring services allowing businesses to continuously assess their external business environment, including technologies for semantically enabled content fusion and visualisation
- Immersive media applications beyond HDTV that support the fusion of 3D video and interactive virtual reality content enabling users to consume and interact with 3D content at a new quality of experience.
- Intelligent and supportive tools for the creation, modification and exchange of audiovisual and 3D content, e.g. within social communities making the creation process as easy as editing text today.

To realize these services requires research at a significant level within a number of different areas. Future R&D activities within the domain should include:

- The realisation of open formats including suitable means for dynamic content adaptation over different distribution platform as well as the harmonisation of metadata models. The aim should be to facilitate translation and interoperability between different standards making it possible to search and retrieve traditional and 3D media documents over different networks and platforms in a common way.
- The advancement of automatic semantic analysis of media and 3D content capable to generate semantic metadata in a fast and reliable way. Further the development of search and retrieval technologies for 3D and other media objects in ontology-enabled databases.
- The preservation of archived media content and digitisation of cultural heritage artefacts through content based media enhancement or 3D object digitization technologies.
- The provision of effective recommendation systems, helping user to cope with the tremendous amount of available data as well as automatic content summarization technologies providing condensed versions for given audio-visual and 3D documents.
- The development of multimodal user interfaces enabling natural interaction via different channels as gestures, voice or touch. These should help non-expert or technological-illiterate users to access media content in an intuitive way helping to overcome the still existing “digital divide”. They should be capable to determine implicit user feedback as emotions, gaze, behaviour and intention as additional parameters for intelligent user centric content adaptation.
- Work towards an integrated 3D virtualization pipeline, from real-time 3D scene and object acquisition, modelling and transmission to visualisation of seamless photo-realistic 3D objects in mixed reality environments (i.e. 3D data consumption)
- The development of technologies for the efficient compression and transmission of dynamic and interactive 3D content at different levels of resolution and quality. As the available content becomes larger and more dynamic, 3D compression and transmission technology will be a key feature of future applications.
- The provision of means for securing privacy: The future internet has enormous possibilities to enrich our lives and indeed to change our society, however like all things of great power, the potential for misuse must be considered. History has shown that the great excitement and potential benefits of innovation have often caused technological advance to forge far ahead of the necessary security and privacy safeguards. The serious problems that inevitably occur lead to rushed ad-hoc and often non-standardised countermeasures that eventually frustrate further innovation and widespread exploitation.

ISTAG Recommendations

- Foster the development of open media formats and harmonised metadata standards.
- Stimulate research on automatic media analysis, enhancement, content summarisation and effective content based recommendation.
- Foster the development of automatic 3D model digitization, segmentation and classification with their associated semantic meta-information and retrieval of 3D models as well as their semantic meta-information.
- Support research activities on end-to-end systems for 3D reality capturing, compression, transmission and reproduction.

9. FUTURE AND EMERGING TECHNOLOGIES (FET)

9.1 Developing a FET programme

FET plays within the framework programme for ICT a unique and seminal role. FET is an incubator for new ideas, and it explores new research themes that promise to be foundational and of long-term relevance for a sustainable future of ICTs in Europe. FET promotes high risk multidisciplinary research, offset by promising breakthrough with high scientific, technological or societal impact. The research promoted by FET has become a benchmark of excellence. FET initiatives, which attract and foster collaboration between top European researchers, have made substantial contributions in bringing the European research to the forefront of the state-of-the-art.

FET is not only supporting basic research for ICT, but also multidisciplinary foundational research. This raises the question of the role of ICT in FET: how far beyond ICT can FET go if ICT is just a tool helping research in other domains? The relation between ICT and FET is twofold: FET nurtures inspirations from other disciplines into future ICT's while ICT is equally important to other disciplines as an enabler and facilitator of multidisciplinary research. The synergetic multidisciplinary FET research provides new ways for ICT and other disciplines to progress.

Multidisciplinary research is a way to the future, and it needs to be handled properly especially in the evaluation phase. Multidisciplinary research works correctly only when all the disciplines participating to a proposal are considered equally important. Considering ICT as a service to other disciplines is counter-productive.

New ideas are important but FET should also be an authority on trends in research, including societal trends. Early detection of new trends is a first priority mission of FET. It would need its own actions to identify these trends in the broadest range of disciplines, which can be implemented as part of the FET Work programme using the CSA instrument. Such an analysis should also include an assessment of the degree of complexity from combination of disciplines, and the availability of talent in Europe.

Working with companies is not mandatory within FET, but is certainly a plus to test the interest of the research project and broadcast ideas. The implication of the company has to be analysed carefully with respect to its involvement in the project at the scientific and technological levels and the amount of resources and efforts that it can devote to. In many domains, high-tech SME are more innovative than large companies. However, their financial health is often very fragile. Hence, it is important that the amount of administrative burden be reduced. Moreover, recently created SME should be encouraged to develop their technologies since they are sometimes more a research entity than a market-oriented company. Increasing their support may be a good incentive to participate.

On the other hand, FET project objectives are often too far from product development to be attractive to engage SMEs. Instead, when FET projects achieve new technologies, further actions should be encouraged, like new projects, even outside FET, with the participation of industry.

Transfer of FET topics to the mainstream ICT programme is not effective if there is no pull from the mainstream side. FET should continuously inform and inspire stakeholders of the mainstream ICT programme on the findings and maturity of the FET topics. As an alternative transfer route a FET research topic can also be continued by leveraging funding from other programmes, e.g. in national programmes or through a cooperation of national programmes (ERANET, art. 169 of the Treaty).

Communicating on research goals and issues towards European citizens become of premier importance for acceptance and support in order to prevent resistance to acceptance of new technologies. Explaining the impact of new technologies for their life using various media may be a good way to reach this goal. Hence some investments in dissemination for non-expert should be done at the level of unit when preparing the calls, ask for such deliverables in all the funded projects and finally reporting in the same style the results obtained.

Currently, the amount of money for supporting a programme within FET is relatively small. For most programmes, this is a wise policy. However more complex programmes may need larger support. In that case, FET may launch prospective projects or team up with other Framework Programme themes or initiatives, or organizations to raise support.

The funding of FET has been of the order of 8 – 10 % of the IST/ICT Theme with a lowering tendency, in spite of the high-level high-impact research funded. This trend should be reversed, and FET funding should be raised to the 15 % level.

9.2 Launching Flagship initiatives

In a previous report, the ISTAG FET working group developed the definition of European flagships (FET-F) that address challenges in research and innovation requiring radical transformations of ICT for 2020 and beyond.

Such a FET Flagship is defined in a scientific and technological area where foundational research is strong in Europe, in the sense that essential competences and a range of dispersed initiatives exist that are mature to be brought together in order to achieve the next level of ambition. This will have a strong societal impact and evolve future markets in which Europe should play a prominent role. FET-Fs will present novel and ambitious goal-driven initiatives for developing and keeping this leadership and for transforming it into a significant competitive advantage for Europe. FET-Fs aim at unprecedented scientific discoveries and technological innovation from essential transdisciplinary research. It can only be achieved by a joint effort of the EU, its member states, and where appropriate, by including industry and international partners. Since the ambition is huge, a FET-F should be based on outstanding researchers and innovators, including world-wide partnerships.

Existing funding mechanisms may serve as building blocks in a cluster-based FET-F approach. Joint programming and alignment with national priorities are essential in an opt-in basis. To accomplish its scale of ambition, a single FET-F requires a strong support for at least 10 years. The required level of funding will be defined per flagship and is expected to be typically at least one hundred million Euros per flagship per year. It will be accomplished by combining existing and new European and national resources for creating critical mass and achieving integration and by leveraging additional resources from the EU, national governments and industry.

The structure of society and the role of the state will undergo major changes towards 2020 and beyond in order to build the future sustainable society. It is widely recognized that ICT is a major enabler for these changes. However, incremental innovation is not enough, radical innovation is necessary. The emergence of new markets has to be deeply intertwined with the development of radically new innovations based on interdisciplinary and solution-oriented approaches. The role of the state (for example pre-commercial public procurements, creation of economic incentives), the role of the market (going from the single market concept to a more contextualized and individualized value model) and the role of public infrastructures have to be evaluated with respect to future challenges. And the capacity to cooperate among sectors, break the barriers, and create new markets has to be radically developed.

Research quality and capacity are excellent in Europe. However, it is mostly driven at national level (member states) which results in fragmentation of competing initiatives. Competition is essential in research but it should be at a world wide scale and more coordination at the European scale is crucial in order to obtain critical mass, define strategic priorities, launch ambitious research-based and goal-driven initiatives, speed-up the take-up of results and enable scale of economy for industry.

Five candidate European Challenges and Flagships in Research and Innovation and motivates the selection have been selected:

- Understanding Life through future ICT
- Anticipation by simulation – Managing complex systems with future ICT
- Future Information Processing Technologies
- The team player - Future Problem Solving Technologies
- Robot Companion for Citizens

Obviously a closer analysis has still to be done, the selection has to be confronted to experts of the fields and the SWOT analysis has to be performed in order to assess the importance and respective merits of each of these FET-F candidates. Eight criteria have been defined: Goal, Impact, Novelty, Ambition, Interdisciplinary research, Resources, Plausibility and Sustainability.

ISTAG Recommendation

- The Work programme 2011-2013 should consolidate the FET-Flagship Initiative, provide the support for the analysis, selection and further definition of the FET-Flagship candidates and launch preliminary programmes.

ANNEX A. MAJOR INITIATIVES

A.1 Knowledge and Innovation Community (KIC) in ICT

The European Institute of Innovation and Technology (EIT) is to be a key driver of sustainable European growth and competitiveness through the stimulation of world-leading innovations with a positive impact on economy and society. It is moving towards getting fully operational and the first Knowledge and Innovation Communities (KICs) are to be implemented during 2010, having ICT as one of its first areas selected. The mission is to grow and capitalise on the innovation capacity and capability of actors from higher education, research, business and entrepreneurship from the EU and beyond, bringing together all the three dimensions of the knowledge triangle. It will be the first instrument addressing education, research and innovation all together within the same instrument having.

Strength: The possibility to move towards open innovation networking at a European , addressing research and innovation at the same time addressing our future competence needs in Europe. The EIT KICs will address key areas for Europe, which will strengthen our future competitiveness at a global level.

Opportunity: Through its thematic areas the KICs will be able to drive open innovation in cross-sector areas providing new business opportunities for Europe’s industry. By involving innovation already in early phases it will address by exploiting an environments

Weakness: There is a need to define roles between the EIT KICs and other ongoing instruments, both at EU-level and national level. The process for this is today not defined.

ISTAG Recommendation

- Support selected ICT KICs and align the Work programme with their strategic innovation programmes, thereby strengthening the overall research and innovation process in Europe.

A.2 Future Internet PPP

There has been much activity at the European level through the last year to motivate and align research activities in the domain of the Future Internet, with the intention of catalyzing coordinated action. This activity has included the formation of the Future Internet Forum, the Bled Declaration and discussions among several European Technology Platforms on synergy and alignment of their Strategic Research Agendas. More recently, various groups of companies have issued a Call for Action, advocating a European Future Internet Initiative in the form of a Public-Private-Partnership.

We recognise that the Future Internet is a challenging area in which to set up an initiative of this kind. The scopes of each of the existing JTIs, though broad, do cover a specific research domain with a well defined strategic research agenda. The scope for the Future Internet Initiative must cover a much wider domain. The capability and architecture of the evolving Internet will be based on technology and principles that will be created by a number of existing ETPs. A set of emerging and compelling Visions of potentially disruptive transformation (Internet of Services, Internet of Things etc) can form the basis of a roadmap for the required capabilities of the Future Internet Infrastructure. On the other hand, the enormous investments required for new capabilities and infrastructure will be driven by the marketplace, and by new opportunities for wealth creation. This is a challenging landscape for any initiative.

ISTAG believes that Europe urgently needs an initiative to drive the development of the Future Internet. It is concerned that the scope outlined in the Call for Action is not sufficiently ambitious or well enough focussed to put Europe in a leadership position (as discussed in section 3 above).

ISTAG Recommendation

- If Europe wants to drive the mega trend of Future Internet as envisioned, there is an urgent need for the formation of an industry-led Future Internet PPP, in order to drive the midterm research agenda and the related standardization issues as well as providing an infrastructure of rapid deployment of applications and services.

A.3 Joint Technology Initiatives (JTI)

The current JTIs in the ICT area, Artemis and ENIAC, are industry driven Public-Private Partnerships involving hundreds of European R&D actors and the majority of EU member states, in collaboration with the EC.

After almost two years of operation, a first assessment on their achievements and outlook can be provided. A formal evaluation is planned to be carried out in 2010.
The following positive results can be highlighted:

- Focus on the strategically most important topics, through the shared development of their Strategic Research Agendas
- Focussing on close-to-market R&D activities
- Bundling of forces and efforts instead of fragmentation of research activities
- Pre-committed, harmonized and synchronized national funding
- Single common evaluation and monitoring process
- Relatively short time from proposal to contract and project start
- Big footprint in Europe, involving companies, institutions and universities in many countries
- Good participation of Small and Medium Enterprises (SMEs).

At the same time, a number of weaknesses have been identified:

- Community bodies with complex rules and procedures, compounded by the constrains resulting from the presence of national public authorities
- At the moment, too low funding from member states, potentially leading to sensibly lower program budgets, possibly limiting the exploitation of available private R&D investments
- Time to contract still too long, due to extended procedures in some member states
- No funding available for activities non strictly related to R&D but innovation supportive, like promotion of standardization, establishment of Centres of Innovation Excellence in MSs, etc.

In essence therefore, JTIs have shown the keen interest of the private sector in participating in research scheme supporting innovation, through the collective development of SRAs, the coordination and pooling of resources and the use of dedicated, efficient management structures. ITo facilitate long-term commitment by Member States, new implementation rules need to be explored in order to create early awareness of the funding requirements and provide input for the Public Authorities for budget allocation.

This experience could be translated in other fields in ICT research, namely the Future Internet. However, the implementation of future PPPs should be accomplished avoiding the negative aspects of JTIs, particularly the strict adherence to complex legal procedures resulting from being community bodies.

In addition, attention should be paid on the possible overlap among SRAs of PPPs, as the Internet of Things, a key component of the Future Internet is already largely included within the envelope of ARTEMIS.

ISTAG Recommendations

- Regarding the existing JTIs, the Commission should build upon their strengths and correct their weak points. This might require even the amendment of the Council Regulations, as part of their mid-term review.
- For the future, ISTAG recommends that PPPs should be real PPPs, rather than Community bodies. The use of article 171 proved to be too cumbersome and time consuming.
- ISTAG believes that PPPs should be used also as instruments to support innovation. Therefore, they should not limit themselves to R&D activities, but should be allowed to focus on the entire associated value chain as well.

A.4 EUREKA

EUREKA is a pan-European network for market-oriented, industrial R&D. Created as an intergovernmental initiative in 1985, EUREKA aims to enhance European competitiveness through its support to businesses, research centres and universities (often organised at regional level in Pôles de Compétitivité) who carry out pan-European projects to develop innovative products, processes and services.

The two largest Eureka clusters are directly aimed at ICT domains: Catrene and ITEA2. They use roadmaps to reflect on the vision of future uses of ICT and ICT-based services upon which regular calls are placed. Pan-European consortia of industry, SME and academia submit project proposals of which the winners are labelled. The funding for these labelled projects takes place at member state level.

Strength: The Eureka clusters have proved to be very efficient tools to foster the cooperation between European players and create critical mass. The Eureka clusters are complementary to the JTIs at political, organizational and content level.

Weakness: The process is a two-step approach: first obtaining a label and secondly obtaining national funding. This makes the process to obtain funding for each consortium partner long and uncertain.

Opportunity: Through their inter-governmental nature and their flexibility the EUREKA clusters are the ideal platform to enlarge the European innovation instruments in concerted actions with Public Authorities, the EIT KIC ICT (see Annex A, section A.1) and the regional innovation clusters. Examples of concerted actions are:

- Strategic network of PdCs at European level
- More support to deploy R&D results in the market
- Support the creation of ecosystems such as Open Innovation
- Support Business Model Innovation
- Business driven expansion of the geographic scope of European R&D initiatives

The current roadmaps of Catrene and ITEA:

- Focus on strategic markets such as health, energy, transport, knowledge and education;
- Address greater sustainability, efficient use of scarce resources such as energy, water, frequencies
- Address alternative (nano-)devices and systems based on alternative technologies such as organic electronics;
- Respond to the generalization of connectivity (massive scalability);
- Provide end-to-end solutions including products and services

ISTAG Recommendations

- Align the Framework Programme and the JTIs/PPPs with EUREKA clusters, thereby strengthening the complementarities of EUREKA clusters and JTIs.
- Investigate the feasibility for top-up funding schemes for EUREKA projects, while maintaining the EUREKA governance.

A.5 Joint Programming

Joint Programming is a product of the Ljubljana Process launched in May 2008 by the Council, which endeavours to develop a common European vision for the European Research Area and to improve its governance. It was the subject of a communication from the commission in July 2008. As a consequence, at the end of 2008, the Council created a High Level Group on Joint Programming which is responsible for identifying themes for potential joint programming initiatives. The Commission has just (August 2009) launched its first initiative (on Alzheimer's) with 20 states participating.

Joint programming is about establishing a common vision and research agenda that is shared by a number of Member States and, about achieving structuring effects in order to increase the efficiency and impact of public research funding. It is about public-public cooperation rather than public-private cooperation which has been the target of JTIs (although the ICT JTIs do have an element of public-public cooperation). Currently 85% of the public R&D expenditure is through national programmes with little collaboration or coordination between countries. Europe cannot compete with our major international partners if this fragmentation is allowed to continue. The purpose of the Joint Programming Initiatives is to identify areas where there is the potential for major societal impact from better integrated and coordinated publically-funded research programmes.

Much of the language used in the communication and subsequent press releases resonates very strongly with the thinking behind the FET Flagships recommendations. Other topics for the first call for EIT KIC proposals have also been specifically identified as potential candidates for Joint Programming Initiatives.

ISTAG Recommendations

- Should a proposal for the creation of an ICT KIC be successful, the High Level Group on Joint Programming should be invited to consider the Strategic Research Agenda of the successful KIC as a candidate for Joint Programming.
- ISTAG recommends that the High Level Group should consider the FET Flagships as potential candidates for future Joint Programming initiatives.

A.6 Joint initiatives with the PEOPLE programme

Although recognized as very important, Education and Training were not an explicit priority for funding within previous ICT Work programmes. In fact, only very few topics about education are currently included within the Cooperation Programme and initiatives on this topic are mainly generated and funded in the PEOPLE Programme, but only in a “bottom-up” way. However, education and training of innovators (of processes but above all of products) in ICT are a priority (now more than ever) to address the urgency of current challenges for Europe.

Innovators have a key role to play in addressing new challenges: ICT innovation represents the crucial factor to let Europe grow and Industry strongly and urgently need innovators. High level and multi-disciplinary scientific Education and Training, based on mobility (trans-European and university-industry), is needed to stimulate a sustainable ICT-based economy.

As knowledge and innovation are the EU's most highly valued resources and assets, Education and Training should became a priority, in the next decade. In particular, specific priorities in the area of Education and Training in ICT should be identified, new and more effective ways to educate and train innovators should be designed, and twinning initiatives with the PEOPLE Programme should be explored to implement this strategy. These dedicated "top-down" initiatives will promote collaboration between university and industry and speed up the training and the inclusion in the industrial environment of a new generation of inventors.

ISTAG Recommendations

- Promote the preparation of a joint ICT-PEOPLE Communication document addressing the future needs of ICT skills in Europe.
- Launch initiatives with the PEOPLE Programme to define specific calls in the area of education and training in ICT.

ANNEX B. SUMMARY OF RECOMMENDATIONS

Future Internet

- Focus on a few selectively chosen European lighthouse projects with soon available solutions as implementation examples in real business services and smart applications, particularly in services directed at urgent societal challenges. These lighthouse projects may be set up as extra large integrated projects (XL IPs) to allow for significant impact and worldwide visibility. They should serve for the preparation of a larger FI PPP initiative that was announced recently.
- Facilitate a European wide dialogue between the network research community and the application and service research community for a joint effort as the Future Internet will be driven both "bottom up" and "top down" at the same time.
- Stimulate extensive use of research outcome following the rapidly emerging deployment strategies of the new web-based application and services through real living lab infrastructures available to consumers and application industry sectors.
- Facilitate a European wide research dialogue about the architecture, frameworks, and platforms to serve the needs of the applications and services provided via the Future Internet. An open innovation based approach allows for rapid adoption while avoiding single proprietary solutions leading to unintentional dependencies.
- Invite for an international dialogue to promote a European way of establishing standards of the Future Internet, particularly with the emerging and developing countries.

Cloud Computing

- Initiate the guidelines (standards, interoperability) for a pre-commercial procurement of European cloud services to enable European industry to establish a European-based cloud environment.
- Assure the identification of new trustworthy cloud computing solutions and approaches, simultaneously addressing technology, standardization, policy, law and socio-economics. Technology wise, the EC should stimulate RTD in areas like: cloud threat modelling, identity management platform, interoperable encryption and key management, assurance of security in storage and processing, physical security of the core network and the critical nodes, incident response.
- Stimulate easy consumption of cloud-based services to European enterprises to explore business opportunities quickly. Easy and trustworthy consumption will be key for the global competiveness of European enterprises.

Web-based Service Industry

- Research, development and innovation initiatives should focus on tools for service development, federation and deployment on top of the horizontal services offered by the infrastructure (Future Internet and Cloud Computing) in order to facilitate a wide variety of end user solutions & services both in the professional and consumer space.
- Capitalize on the new capabilities offered by wide-area and in-building location-based services and stimulate a dedicated Work programme objective.
- Stimulate barrier-free access to European based cloud resources to deploy new products and services both in the ICT sector and industry and service sectors where innovation capabilities rely on ICT, particularly the Future Internet. Special emphasis should be given to small and medium enterprises as well as governmental and non-governmental organisations as prime user community.
- Define the appropriate instruments focused on commercial acceptance of these web-based services and their effectiveness beyond the level of wide-scale testing and behavioural analysis.

Smart Environments

- Stimulate special research focus on smart environment "by design" including the development of new paradigms of human-environment cooperation (interfaces, cognitive and physical models).

Embedded systems

- Consider the multi-core systems on Chips (*MPSoC challenge*) as a major opportunity to strengthen the European lead in the embedded system domain. Focus related objectives onto research and developments that tackles this paradigm change, considering all levels of system design and architecture in a holistic manner.
- Support research and development in the area of self-organizing embedded systems and autonomic diagnosis to provide the infrastructure for new applications in the coming *Internet-of-Things*.

Socially Aware Ambient Intelligence

- Stimulate research on Socially Aware Ambient Intelligence systems that understand social signalling and social context and 'keep the human in the loop'.
- Address the conflict of ubiquitous and unobtrusive data collection/provision with human control and attention in an open fashion.

Robots in Smart Environments

- Address specifically the problem of data explosion and management of data complementing management of smart robots in action.
- Stimulate socio-economic research to ensure uptake of smart robots beyond traditional (industrial) environments, such as environments in health and wellbeing.
- Stimulate a cross disciplinary dialogue about the legal consequences of robotics and new human-machine relationship.

Business Model Innovation

- Stimulate research on business models (mathematical modelling) and tools (simulation based) to allow for rapid deployment on the Future Internet. This certainly should be done using a multidisciplinary dialogue including economists, domain experts, and ICT experts.
- Add business model research as a topic to Living Labs and furthermore to all ICT research projects where the business model is essential for the market impact of the results. Make this a priority within the proposals evaluation process for proposals submitted to this Work programme.
- Ensure that Public procurement regulations encourage business model innovation.

Supporting Mobility

- Stimulate research and innovation initiatives on usability and context aware applications and services including rapid innovation and deployment of mobile devices into their focus.
- Stimulate R&D instruments to focus on the next generation of users, particularly taking into account cultural and IT skills diversity.
- Stimulate all digital technologies supporting spectrum conservation and efficiency to continue a rapid uptake of mobile Internet infrastructures, particularly in rural and remote areas.

Sustainability

- Address ICT for sustainability in three domains: a) Society; b) products and services c) natural environment.
- Stimulate research for a sustainable ICT sector including societal aspects such as inclusion or ambient living, sustainable ICT products and services including efficient production processes, as well as environmental issues including energy consumption as design principle.
- Stimulate cross-domain research on ICT technologies and applications to allow key European industry sectors to implement more sustainable solution and services.
- Promote adequate ICT tools for ensuring transparency and compliance in real economy towards a sustainable growth.

Energy efficiency of the ICT sector

- Initiate a special research programme in energy-efficient computing and communication, adopting a holistic approach that considers energy efficiency at all levels of system design, such as: system architecture, algorithm design, protocol design, operating system design and hardware design.
- Ensure that energy-efficiency is considered and supported by all future design methodologies, tools and prototypes such that energy awareness becomes an important concern in any ICT development activity.
- Support the development of new hardware technologies that promise significant reduction in the energy consumption of ICT devices.

Health and wellbeing

- Stimulate research and innovation in the domain of trustworthy and privacy-obedient products and (web-based) services for home health (in application domains such as PHR, robotics, ambient assisted living and wellbeing).
- Stimulate research and development for highly computing-intensive application domains such as synthetic life, clinical decision support, correlating genotype and phenotype information.
- Foster ICT research for the domain of robotic surgery and image guided interventions.
- Tele-health (monitoring & therapy) is the only economically viable way in an aging society. Enforce initiatives based on business models rather than on technology.
- In case of tele-health, the massive data volumes accumulated can be processed only in an automated way. Encourage ICT supported data evaluation and decision support system based on large volume or rather “fuzzy data” (e.g. time series of weight, pressure, age and anamnesis of an individual patient)

Media

- Foster the development of open media formats and harmonised metadata standards.
- Stimulate research on automatic media analysis, enhancement, content summarisation and effective content based recommendation.
- Foster the development of automatic 3D model digitization, segmentation and classification with their associated semantic meta-information and retrieval of 3D models as well as their semantic meta-information.
- Support research activities on end-to-end systems for 3D reality capturing, compression, transmission and reproduction.

Future and emerging technologies (FET)

- The Work programme 2011-2013 should consolidate the FET-Flagship Initiative, provide the support for the analysis, selection and further definition of the FET-Flagship candidates and launch preliminary programmes.

Knowledge and Innovation Community (KIC) in ICT

- Support selected ICT KICs and align the Work programme with their strategic innovation programmes, thereby strengthening the overall research and innovation process in Europe.

Future Internet PPP

- If Europe wants to drive the mega trend of Future Internet as envisioned, there is an urgent need for the formation of an industry-led Future Internet PPP, in order to drive the midterm research agenda and the related standardization issues as well as providing an infrastructure of rapid deployment of applications and services.

Joint Technology initiatives (JTI)

- Regarding the existing JTIs, the Commission should build upon their strengths and correct their weak points. This might require even the amendment of the Council Regulations, as part of their mid-term review.
- For the future, ISTAG recommends that PPPs should be real PPPs, rather than Community bodies. The use of article 171 proved to be too cumbersome and time consuming.
- ISTAG believes that PPPs should be used also as instruments to support innovation. Therefore, they should not limit themselves to R&D activities, but should be allowed to focus on the entire associated value chain as well.

EUREKA

- Align the Framework Programme and the JTIs/PPPs with EUREKA clusters, thereby strengthening the complementarities of EUREKA clusters and JTIs.
- Investigate the feasibility for top-up funding schemes for EUREKA projects, while maintaining the EUREKA governance.

Joint Programming

- Should a proposal for the creation of an ICT KIC be successful, the High Level Group on Joint Programming should be invited to consider the Strategic Research Agenda of the successful KIC as a candidate for Joint Programming.
- ISTAG recommends that the High Level Group should consider the FET Flagships as potential candidates for future Joint Programming initiatives.

Joint initiatives with the PEOPLE programme

- Promote the preparation of a joint ICT-PEOPLE Communication document addressing the future needs of ICT skills in Europe.
- Launch initiatives with the PEOPLE Programme to define specific calls in the area of education and training in ICT.