Celtic-Plus
Smart Connected World

Σ! 5828

Purple Book

Celtic-Plus Programme of
possible and recommended research items

Version 2012

This original issue of the Celtic-Plus Purple Book had been endorsed by the Public Authorities and the Celtic Core Group in April 2010. The updated version 2012 does not contain substantial changes in scope or research items from earlier version.

Celtic-Plus Core Group companies:

FOREWORD

This edition of the Purple Book is a very special one. It includes a first overview of the content of the future Celtic Programme that we suggest to launch from 2011 onwards and which we have decided to name "Celtic-Plus". It defines the main priorities on which the first Celtic-Plus projects should focus.

This Purple Book is issued to support the adoption of the Celtic-Plus programme by Eureka and the Public Authorities. It also provides project proposers with preliminary guidelines on the main priority research challenges envisaged for the first Celtic-Plus calls.

Since the launch of the Celtic Eureka Cluster, the main challenges have evolved. IMS was then the key word, now we are talking about "Future Internet". Projects have tackled the three main areas that constitute the core of Celtic up to now, i.e. Broadband Infrastructure, Services and Applications, and Security. Major achievements have been made in service platforms, new multimedia services, and new infrastructure solutions.

The main challenges that lie in front of us in the next few years may well be more and more centred on the user. Communication technologies are still essential to support such a new era where individuals, communities and businesses will see the frontier between the physical and the digital world progressively become more transparent. In order to achieve this evolution in a satisfactory manner, the border between network infrastructure and services will become more and more blurred. Business models will also need to evolve accordingly.

In addition, new challenges are appearing. Beyond end-to-end communications, an end-to-end system approach is required to go on with future communications-related solutions that are critical to the ICT industry but also to a number of other sectors. As an example, communications technologies and solutions will support environmental awareness by helping domains such as health or transport better manage and control the use of energy.

All of this explains why we decided to change Celtic's motto from "Telecommunications Solutions" into "Smart Connected World".

To achieve this evolution, we suggest in this Purple Book that Celtic-Plus should primarily focus on two key aspects, which we have respectively called "Get connected" and "While connected". "Get connected" mainly refers to adding new cheaper and more effective infrastructure, better suited to new services. "While connected" is about adding new value to networks, including extending service reach.

This document has been prepared by the Celtic "Core Group" (Alcatel-Lucent, British Telecom, Deutsche Telekom, Ericsson, Eurescom, France Telecom, Italtel, Nokia Siemens Networks, RAD, Telefonica, Thomson, Telenor and Turkcell). It has been edited by the Celtic Office.

EXECUTIVE SUMMARY[1]

CELTIC-PLUS, A FOLLOW-UP TO CELTIC

In 2003, the major European telecommunications vendors and operators decided to work together and create an ambitious European R&D programme providing the means to tackle issues related to end to end communications. This was to them the best option to address the roadblocks related to a "system view" of communications, in addition to designing and developing technological blocks. The Celtic Initiative, which was the outcome of their common effort, is now widely recognized in the European ICT R&D environment as a key enabler for ambitious and innovative projects dedicated to communications solutions.

Since then, the telecommunications technologies, services and applications have changed considerably. The number of Internet users has been multiplied by two in Europe and in the Americas, and by four in Asia. Broadband penetration has increased by a factor of four in the G7 countries, and the number of mobile line subscriptions has doubled in Europe. Individuals and organizations are not dealing any longer only with network connectivity and exchange of information, but more and more with social and business experiences where the frontier between physical and digital progressively becomes more transparent. All human activities and business sectors are evolving towards a "digital era". When the first Celtic projects started, Facebook, MySpace, YouTube and Twitter did not exist. Second Life and Google Earth neither[2]. Thanks to such innovative concepts that have turned into new economic and societal phenomena, the "system view" promoted by Celtic has continuously expanded its borders.

The focus of the Internet as a whole has evolved in parallel and is now on "people" and "things", and on transporting multimedia "content" and providing "services". Technologies and solutions are now more and more tackling *interdisciplinary* domains. Celtic has already paved the way to promote end-to-end communication solutions, but more expansion e.g. towards services and user-centred solutions, are needed. "Ambient intelligence" can not be understood any longer only in the sense of "always connected" or even "best connected", i.e. connected when required, but also as interdisciplinary and multidisciplinary service integration, e.g. automatic detection of appropriate services to be available on the more often mobile than fixed terminal, depending on the location of the user.

In addition, new societal challenges are appearing, with communication technologies likely to play a large role e.g. in environmental awareness. Technologies and solutions at *multidisciplinary* level are also required, to address such issues as developing new applications to reduce the need for travelling, and new technologies for reducing energy consumption, and moreover, to manage

[1] This Executive Summary is also available as a separate paper entitled "Celtic-Plus White Paper".

[2] Facebook was first launched in 2004, MySpace in 2003, YouTube in 2005, Twitter in 2006, Second Life in 2003, and Google Earth in 2005.

and control the best use of energy in other business or private sectors e.g. health, transport, energy, e-government, urbanisation, knowledge and culture.

All of this contributes to the need for more bandwidth, more reliable networks and more efficient and secure transport protocols and delivery mechanisms. Most new applications are demanding in terms of amount of data exchanged, more especially because they deal with video content. The development of Video on Demand and video streaming, the appearance of HDTV (whose first regular broadcasts had not yet started when Celtic was initiated), which will be more and more conveyed via the Internet, and then 3DTV, will continue and drive the demand for fixed networking. The explosion of smartphones drives users' requirements for having access to similar services on their mobile terminals, as well as additional specific mobile services (e.g. location based). Portable laptops have been continuously gaining ground against fixed PCs and contribute to the demand for nomadic access and services.

The Internet has become the global hub for information and communication where different actors, whether businesses, communities or individuals, connect with each other, share their contents, and want to be aware of their context. They are connected to social networks and virtual worlds, sharing knowledge within a given community. They want all those features to be accessible anywhere, anytime and on any device, but they also want to protect their privacy. Celtic-Plus positions itself at the heart of the upcoming digital era with its new "Smart Connected World" concept.

CELTIC-PLUS MAIN RESEARCH AREAS

Celtic-Plus promotes a "Smart Connected World". The traditional boundaries between networks, service platforms and applications have become increasingly blurring. This is why better suited views on the whole communications system are needed. In Celtic-Plus, the main research areas will be "Get connected" and "While connected". "Get connected" addresses the infrastructure and connectivity aspects. Key topics of Celtic-Plus projects will be related to network elements and infrastructures, like wireless, optics and energy efficiency, as well as network architecture and connectivity, like networking and autonomic networks. "While connected" tackles the end-to-end services and applications. Celtic-Plus projects will deal with future end-to-end services, like digital home, digital enterprise, digital city, digital school, digital transports, and e-health, as well as horizontal services, like security, public safety and identity, especially when it comes to protecting the user while keeping European values such as individual privacy and confidentiality. This aspect also includes business aspects, like evolution of value networks in telecommunication business focus area, forecasting the changes in value networks and business models, and user modelling.

Celtic-Plus projects, evidently, will also focus on the architecture and challenges of the Future Internet. Today's Internet protocol has been designed for fixed network applications, while the impact of the mobile radio channel has not been fully taken into account. Therefore, one major challenge is to further develop the network infrastructure, which makes mobile Internet with high Quality of Service happen in conjunction with a much higher flexibility, capacity (bandwidth) and mobility, so that future applications do not suffer from the current limitations of the Internet and that Quality of Experience stays at optimal level for each and every user.

Collaboration between existing Celtic participants coming mostly from the telecommunications sector, and players from other areas, will be encouraged, in order to promote a multidisciplinary approach to address topics such as smart energy networks, intelligent transport systems, and eHealth-related technologies and solutions.

As the Internet is evolving, efforts will also be made in regard to the development of new tools, allowing user profiling, recommendation systems, and new applications to enhance the creation of online content by professionals and amateurs. The development of novel multidirectional interfaces and interaction mechanisms, including multimodality and "presence", will be an integral part of Celtic-Plus priority research domains. Those new interfaces, technologies, methodologies and certification models should indeed be developed to ensure that the Future Internet does not exclude anyone and, furthermore, that it makes the Information Society more inclusive.

CELTIC-PLUS IN THE EUROPEAN ICT R&D LANDSCAPE

In addition to dealing with the new market and technological trends, Celtic-Plus shall also take into account the evolution of the European ICT R&D landscape and adapt accordingly. The evolution of the communications and more broadly of the whole digital world-related market has also been identified by other organisations at national and European level. New initiatives are appearing, and existing programmes change, especially to take into account a wider system and multidisciplinary perspective. The European Commission is considering "smart" application areas, i.e. Smart Health, Smart Transport, Smart Energy, Smart Enterprises, Smart Living, etc. as the main objectives behind the Future Internet developments, and is currently starting a new Future Internet Public-Private Partnership. Some national R&D programmes already place the "people" at the centre of the interaction and integration required between the society, the economy and technology, and the environment, promoting priorities related to health and wellbeing, digital world, and sustainable world, or emphasize the need for new generation networks to solve emerging social issues such as energy shortages, aging demographics, and natural disasters[3].

Celtic-Plus is dedicated to pursue the most appropriate relationship with a potential Joint Technology Initiative (JTI) or the Future Internet PPP to increase the impact of European research and to assure consistency and synergy of the research work, in order to build a most efficient European Research Area for the realization of a "Smart Connected World".

CONCLUSION

The high importance of the telecommunications sector for the European economy and the increasing technological challenges are the main drivers to carry out further market-oriented research in all areas related to a "Smart Connected World". Celtic-Plus will gradually expand its topical focus from the connection and service aspect to a "Get connected" and "While connected" view, taking into account the adjustments described in this white paper and in more details in the new Celtic-Plus Purple Book. Celtic-Plus will enrich its approach, in line with the evolution of

[3] Priorities mentioned by Tekes in Finland and NICT in Japan.

the marketplace and of the R&D environment. At the same time, to ensure further success, the involvement of additional countries, a better synchronisation of project funding, and a stronger commitment from supporting countries, are key elements that will be required in the coming years.

The Celtic-Plus Initiative is essential for securing and enhancing the market position of the European telecommunications industry, by continuing the successful work initiated by Celtic almost eight years ago.

TABLE OF CONTENTS

1. INTRODUCTION

This Purple Book is issued to support the adoption of the Celtic-Plus programme by Eureka and the Public Authorities. It also provides project proposers with preliminary guidelines on the main priority research challenges that will appear in the first Celtic-Plus calls. The idea behind the Celtic-Plus Purple Book is to define and describe the technical priorities and the research challenges that Celtic-Plus projects should focus on. We will also stress the main business and technological trends that will drive the evolution of the content of this new R&D programme, although they are described more at length in the associated document entitled "Celtic-Plus: why a follow-up of the Celtic programme is needed".

Section 2 describes the current evolving telecommunications market according to which the Celtic-Plus programme and projects priorities should be assessed.

Section 3 lists the main priority research areas that should be tackled by Celtic-Plus.

There are many available documents describing similar topics, more or less partially covering Celtic-Plus related areas. They have sometimes been drafted with contributions from more or less the same industry and academia players. The most relevant for Celtic-Plus are the "Strategic Research Agendas" (SRAs) coming from European Technology Platforms (ETPs). There are also documents issued from other initiatives supported by the European Commission, such as the Future Internet Assembly (FIA); one particularly important example is the so-called "cross-ETP" document. The Commission is also issuing very regularly new contributions from ISTAG, the Information Society Technology Advisory Group, or other more specific groups of experts, in addition to the top-down Work Programmes from FP7, which are updated every two years. There are also documents available at national level to support research priorities in various EU countries[4]. This is why a specific cross-reference table has been included in this version of the Purple Book. A summary table is to be found in section 4. The complete table is in a separate document which is annexed to this Purple Book.

References, abbreviations and acronyms, are at the end of the document.

As already stated, this is the first version of the Celtic-Plus Purple Book. In a similar manner to what has been done with Celtic, updated versions will be made available along the course of the Celtic-Plus programme.

[4] For a list of documents, please see the *References* section at the end of this document.

2. CELTIC-PLUS IN THE EVOLVING TELECOMMUNICATIONS MARKET

2.1. MAIN BUSINESS AND SOCIETAL TRENDS

The main challenges that lie in front of us in the next few years are likely to be increasingly centred on the user. Technology is there to support all these services that will be offered to individuals, groups and communities, businesses, and the society as a whole. This is mostly encompassed in the "Future Internet", which goes way beyond connectivity and exchange of information to start bridging the gap between the digital and the physical worlds. Communication technologies are essential to support a new era where individuals, communities and businesses will see the frontier between physical and digital experience progressively become more transparent. In order to achieve this evolution in a satisfactory manner, the border between network infrastructure and services will become more and more blurred. Business models will also need to evolve accordingly, beyond flat fee subscriptions.

All human activities and business sectors are evolving towards the digital era. New societal challenges are appearing, with communication technologies likely to play a large role e.g. in environmental awareness. Technologies and solutions at *multidisciplinary* level are more and more required to tackle such issues as developing new applications to reduce the need for travelling or new technologies for reducing energy consumption, and moreover, to manage and control the best use of energy in other business or private sectors e.g. health, transport, energy, e-government, urbanisation, knowledge and culture. This means that competence from communications, ICT, and other domains mentioned above need to be included.

The focus of the Internet as a whole has evolved and is now on "people" and "things", and on transporting multimedia "content" and providing "services". One of the keys might well be technologies and solutions tackling *interdisciplinary* domains. Celtic has already paved the way to promote end-to-end communication solutions, but more expansion e.g. towards services and user-centered solutions, will be needed.

Figure 1: Internet of Things, Content, People and Services

Not only people, but also enterprises will benefit from ICT as an enabler to transform the whole society in a number of ways, of which some are shown in Figure 2.

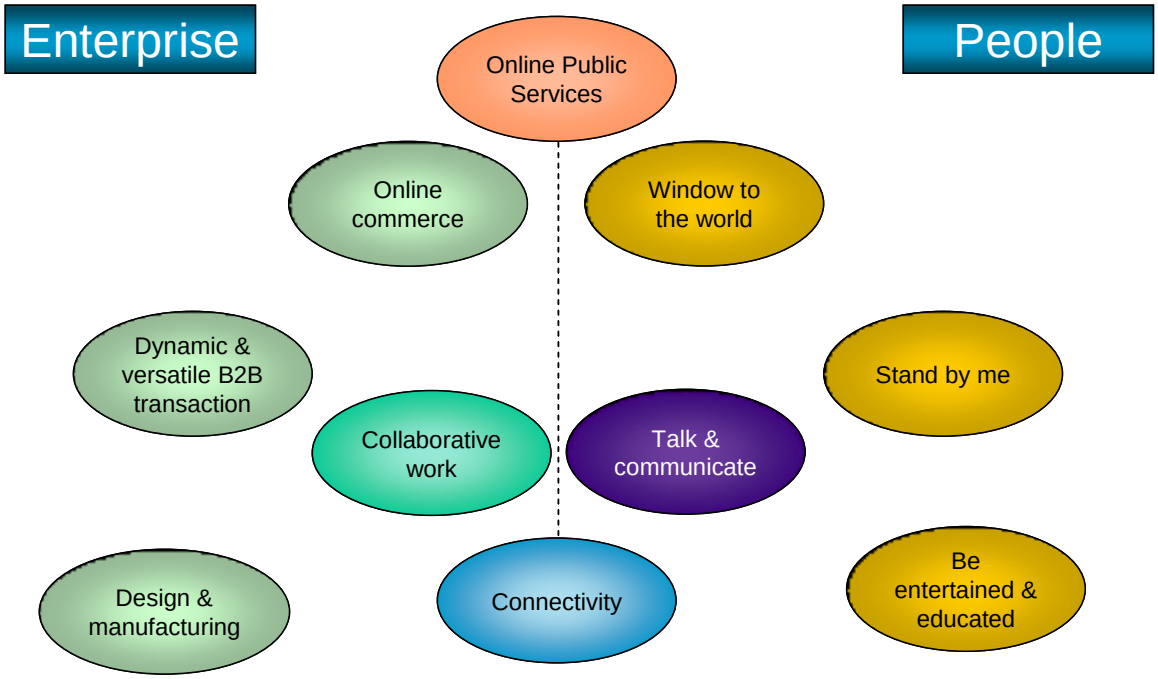


Figure 2: ICT as an enabler both for people and businesses

2.2. MAIN TECHNOLOGICAL TRENDS

The main characteristics of the current telecommunications market may be summarized as follow:

- The convergence of applications/services and infrastructure is really starting to happen;
- Networked/collaborative enterprises and digital manufacturing are emerging;
- New architectures are emerging which are facilitating convergence between infrastructure and services, as well as fixed and mobile solutions;
- End-users are becoming producers and actors of innovation ("prosumers"), due to business models and technologies that are more and more open for usage;
- We are in the middle of fibre and wireless development and deployment, which is likely to greatly impact the society as a whole.

The current main technological trends are:

- **The speed of technology development and deployment is getting faster**: e.g. the life-cycle of new end user device, like mobile phones or multimedia computers, is approximately 2-3 years only.
- **Moore's law will continue**: Continuous advancements of price/performance ratio of microelectronics drive low cost devices and highly integrated network components (flat networks)
- **Mainstream IT technologies are revolutionizing the telecommunications business**: Commodity hardware, Enterprise IT technologies (e.g. SOA, Utility Computing), and Open Source are enabling new product architectures.
- **User-Generated Content will grow on a massive scale:** Operators are keen on traffic growth according to Reed's law and lower cost of content. However problems of content control and community management need to be solved.
- **Location services are new enablers** for location information which will leverage all types of services and contents.
- **Converged services are expanding**, making the convergence with All-IP seamless and flat-fee. Value is shifting to the content/services and application side. New sustainable telecommunications business models are necessary. Consumer preferences in service adoption and context disclosure will strengthen identity and privacy issues.

In addition, **advancements in transmission transport technologies** (fibre optics, DSL and radio) drive high-speed broadband connectivity to the end user, enabling quadruple play and other emerging applications.

Operators are likely to be ready and support new emerging scenarios such as providing service enablers inside the Service Layer and making them available to other service providers throughout service exposure, or finding all the enablers outside the Service Layer with all services being built with a mash up of external elements. Thus, some potential key targets from their perspective are:

- New business by value added services, more independent of the network than today;

- A reduction in management effort, despite increasing network complexity;
- Cost optimization in access, transport and core, even when a higher capacity is available;
- Performance improvements, in terms of bit rate, coverage, QoS, security;
- Telco and IT convergence, for an easier and faster introduction of new applications. What does "use" mean exactly in this case? Is it "usage", but then why faster?

The services domain, although related to the network, will likely become a priority of its own with topics such as cloud computing, enterprise applications, open software, and user-generated content. Service adoption is mainly driven by Internet companies such as Google and Yahoo, followed by "community leaders" (Apple, MTV) and mobile operators. Such services coming from the web will imply the creation of enabling platforms, and will lead to "bandwidth hungry" applications like HD/SD video, P2P, webX.0. Unicast TV/video will also drive an exponential growth in traffic (a 100 fold increase is a likely outcome), while more and more powerful devices will drive data usage.

The network infrastructure will remain the foundation of all other pillars of the Future Internet.

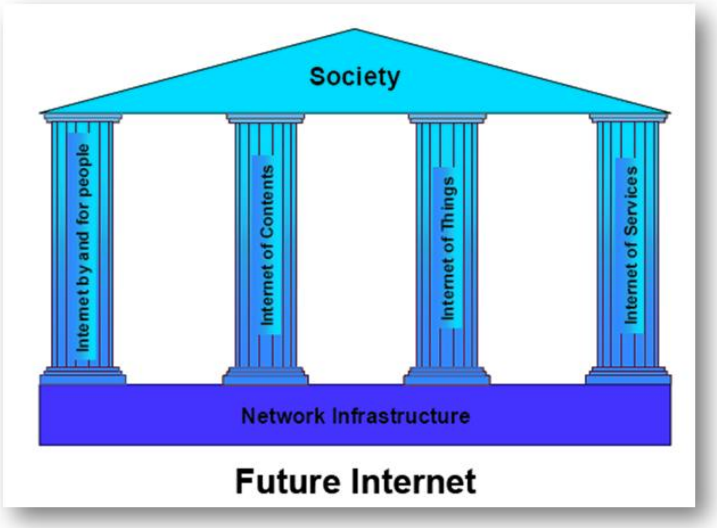


Figure 3: the pillars of the Future Internet[5]

[5] Extracted from the document *"Future Internet: the Cross-ETP Vision Document"*. See references at the end of the document.

2.3. OVERALL SCOPE OF CELTIC-PLUS

Celtic-Plus projects could heavily contribute to advances on such topics as economic fiber solution, LTE and beyond 4G. Ambient intelligence shall not be understood only in the sense of "always connected" (or rather "best connected", i.e. connected when required), but also in the sense of interdisciplinary and multidisciplinary service integration (e.g. automatic detection of appropriate services to be available on the mobile terminal depending on the location of the user). Progress on urban computing and identity management will be critical for mobile applications, as well as technology enablers such as new video features and security. Security topics such as beyond DRM, trust, and security, will remain at the core of the main research areas, especially when it comes to protecting the user while keeping European values such as individual privacy and confidentiality.

In order to respond to all these requirements, Celtic-Plus will primarily focus on two key aspects, which are called "Get connected" and "While connected".

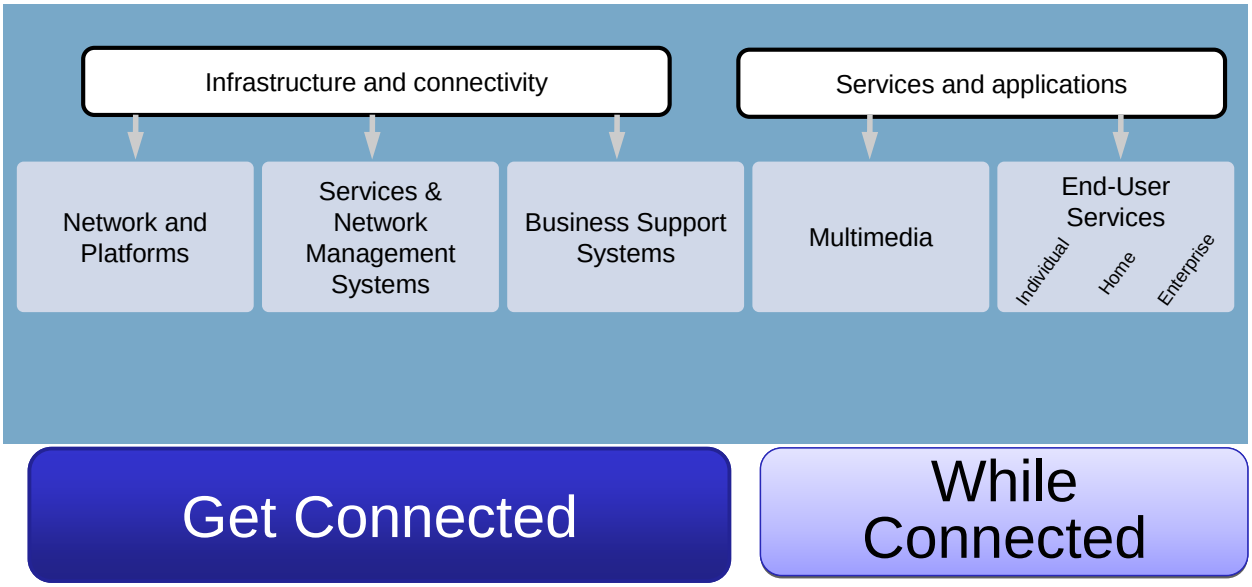


Figure 4: The two main research areas of Celtic-Plus

"Get connected" will tackle the infrastructure and connectivity aspects. Topics are related to network elements and infrastructures, like wireless, optics and energy efficiency, as well as network architecture and connectivity, like networking and autonomic networks.

"While connected" will tackle the end-to-end services and applications. The topical scope includes future end-to-end services, like digital citizen, digital home, digital enterprise, digital city, digital school, digital transports, e-health and games, as well as horizontal services, like security, public safety and identity. It also includes business aspects, like evolution of value networks in telecommunication business focus area, forecasting the changes in value networks and business models, and user modelling. New aspects related to the Future Internet will come into consideration, in particular for issues that are closer to the market.

If we look at the main technological trends behind "Get connected", we observe a similar evolution track between wireline and wireless networks (Figure 5a). However when looking at the market trend, it seems that the growth lies more with mobile broadband (Figure 5b).

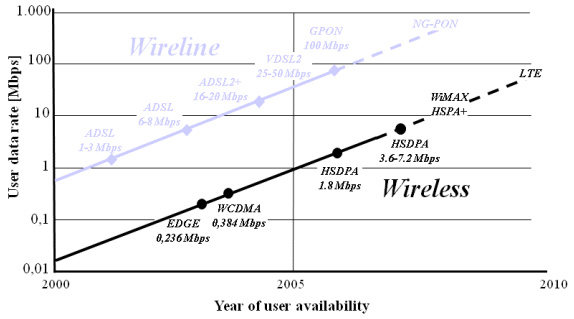


Figure 5a: track evolution in wireline and wireless networks

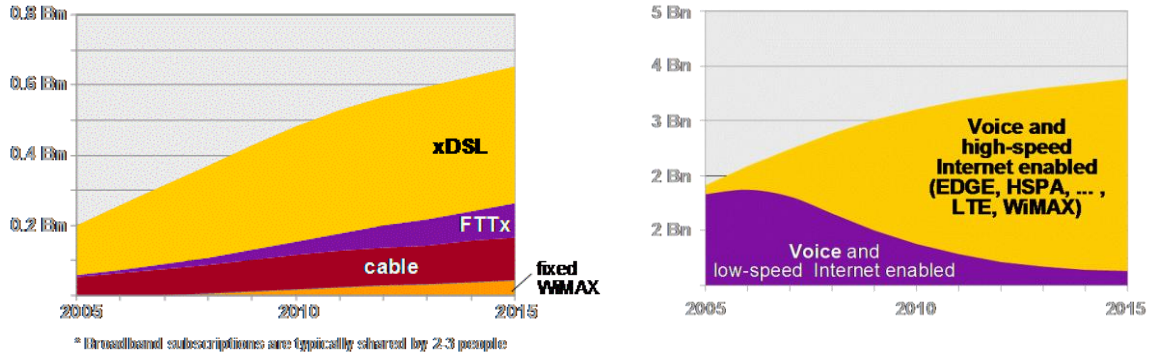


Figure 5b: market trends for fixed and mobile broadband subscriptions worldwide

An overall picture of the ICT market shows that the services area is bringing more growth than the infrastructure, making the "While connected" aspect all the more important.

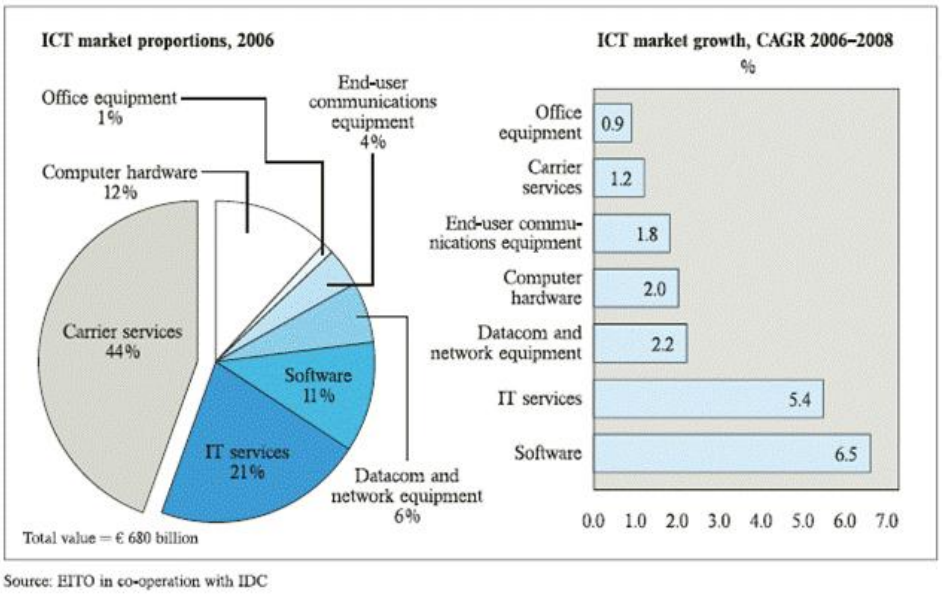


Figure 12
European ICT market, proportions by class of business, 2006 and market growth, 2006–2008

Figure 6: ICT market proportions 2006, and ICT market growth 2006-2008 (courtesy of EITO/IDC)

2.4. TRANSITION FROM CELTIC TO CELTIC-PLUS

Based on the outcomes of completed –but also currently active– projects, three major research lines have been identified:

- New personalized services by developing new service platforms;
- New income sources, like new multimedia services;
- Better operation by looking at new infrastructure solutions.

The transition phase from Celtic to Celtic-Plus, i.e. from 2009 to 2011, should therefore give a particular focus on these three research lines, and more specifically the following:

- **Service platforms** are facing a service revolution with web2.0 service extensions. Such topics as VoIP, video conferencing, "do-it-yourself" tools for SMEs, middleware, should be prioritized, with an emphasis on "looking at the customer".
- **New multimedia services** moving towards ambient intelligence in the new sense of the term[6]. The focus should be on video conferencing[7], telepresence, and home services.
- Solving the **infrastructure** dilemma towards a fully connected world. Fixed-mobile integration, along with low-cost broadband solutions, new OMA tools, integration of 3G-WLAN and development of new devices, should be tackled. **Security** plays a critical role in this domain.

[6] As already stated: *ambient intelligence shall not be understood only in the sense of "always connected" (or rather "best connected"), but also in the sense of interdisciplinary and multidisciplinary service integration (e.g. automatic detection of appropriate services to be available on the mobile terminal depending on the location of the user).*

[7] In this context, new video conferencing services will make use of enhanced network capabilities. Video quality will require network adaptation to assure adequate quality of experience. This feature is already possible in mobile networks and has to be extended to other domains.

3. CELTIC-PLUS MAIN RESEARCH CHALLENGES

3.1. GET CONNECTED

"Get connected" will tackle the infrastructure and connectivity aspects, with topics around network elements and infrastructures, like wireless, optics and energy efficiency; and around network architecture and connectivity, like networking and autonomic networks. Interdisciplinary between "Get connected" elements is more and more required.

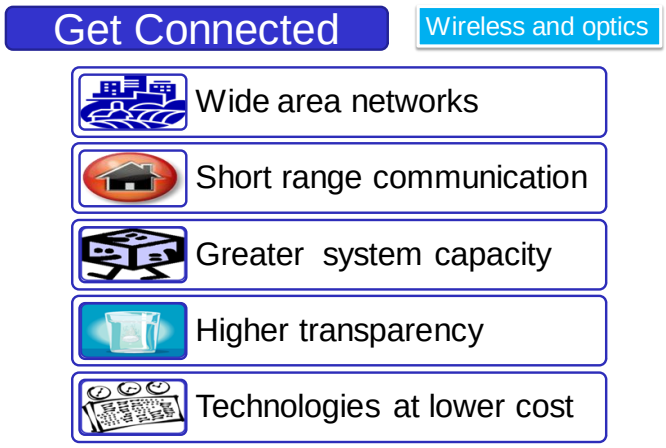


Figure 7: "Get connected" interdisciplinary approach

In addition, energy efficiency will become more and more a primary target for new communication systems and solutions. Therefore a multidisciplinary approach between "Get connected" and other areas such as energy efficiency is now needed.

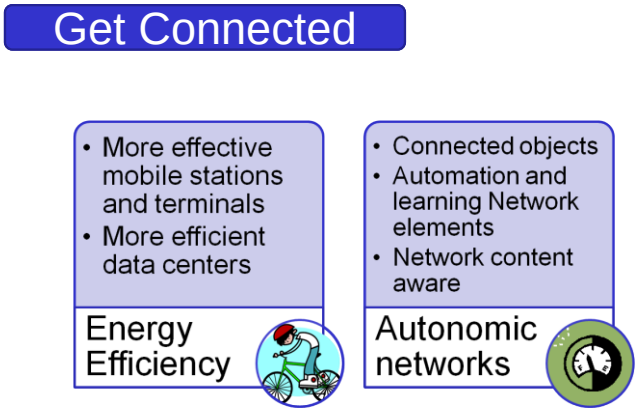


Figure 8: "Get connected" multidisciplinary approach

One of the main priority challenges in this area is of course to work on the architecture of the Future Internet. The reason for the need to further work on the architecture comes from the fact that today's Internet protocol has been designed for fixed network applications. The impact of

the mobile radio channel has not been taken into account. Therefore, one major challenge is the further development of the network infrastructure, which makes mobile Internet with high Quality of Service happen in conjunction with much higher flexibility, capacity (bandwidth) and mobility than today. These developments should support the requirements of the pillars of the Future Internet. Future applications will not suffer limitations in Quality of Service like in the today's Internet, if these technical requirements are fulfilled.

Besides, the mass market deployment of services and applications (like video streaming or the download of huge files) will require capabilities that today's infrastructure cannot offer.

Finally, Celtic-Plus should address the possible scenarios for a possible degradation of the Internet performance. Those scenarios are as follow[8]:

1. **Lack of investment.** The Internet is becoming a commodity. There are few, if any incentives to upgrade the infrastructure that supports the Internet experience of an ever increasing part of the population.
2. **Sudden meltdown.** Despite significant engineering efforts to produce stable protocol specifications, solid software and reliable hardware, the Internet is not as stable as one might wish. The Internet's history is scattered with examples of small scale "meltdowns" starting with the early congestion collapses, intended or accidental misconfigurations that disrupt Internet traffic significantly
3. **Increasing complexity.** The Internet can end up with a set of heterogeneous and incompatible protocols, algorithms and solutions that make it a chaotic machinery whose management becomes so complex that it gets out of control. This situation could be realistically reached if we continue deploying solutions that partially could seem beneficial, because each of these solutions in itself could contribute to solving specific problems that appear every day.
4. **Lack of innovation.** Driven by understandable short-term commercial interests, industrial and academic actors have partially failed to maintain a sustainable innovation rate for the Internet. This has led, at all levels of the Internet, to a short-term pragmatic but not scalable incremental feature/plug-in/add-on based approach dampening down progress, even if now the consensus seems to be that the Internet will bend but it will not break. The collapse of the Internet may be more a "soft degradation", meaning that the QoS is continuously slowly being reduced, if nothing happens. This may most probably not lead to a blackout. This would result in a reduction of the value of the infrastructure, and eventually in the lack of sustainability of the infrastructure, once costs are higher than benefits.

As a consequence, improvements in network infrastructure are mainly related to functionalities like:

- capacity (bandwidth),
- mobility,
- accountability,
- security/privacy/trust,

[8] As identified by the MANA (Management and service-Aware Networking Architectures) group of the Future Internet Assembly (FIA).

- network operation and management.

Furthermore, the basic elements related to network architecture like flexibility, future proofness, resiliency/survivability, and scalability of the routing system should be considered to support new applications like strict real-time transmission and reliable transmission without information loss in the industrial domain.

Those elements have to be developed taking into consideration issues related to:

- Cost efficiency
- Efficient use of resources such as spectrum
- Energy efficiency
- Easy operation and maintenance (including network interoperability)

At present, there are also some concerns related to operational and engineering issues that have to be solved:

1. **Operational**: lack of methods and processes to prevent e.g. mis-configurations, to improve diagnosability of e.g. bugs and configuration problems, automation of configuration and provisioning processes, better tools for monitoring and managing traffic,
2. **Architectural**: weaknesses in the design of routing protocols of the Internet (in terms of scalability, convergence, and stability properties) and transport protocols (in terms of performance, fairness, efficient usage of resources, etc), limitations in mobile IP (scalability problem (home agent and tunneling) as well as location, and triangulation problem), and also the IP address semantic overload (locator, host ID, user ID, etc) and address space assignment. Also related are inter-domain routing system (scalability and quality (stretch, convergence, and stability properties).

3.1.1. NETWORKS ELEMENTS AND INFRASTRUCTURES

3.1.1.1. Wireless

Driven by cellular mobile services, demand for capacity in wireless communication systems have been rapidly increasing worldwide. On the other hand, the available radio spectrum is limited and the communication capacity needs cannot be met without a significant increase in communication spectral efficiency. Several techniques are available to increase spectral efficiency in wireless communication systems, as listed below.

Adaptive Modulation and Coding

Adaptive modulation and coding (AMC) schemes adapt to channel variation by varying parameters such as modulation order and channel code rate based on channel status information leading to efficient spectrum utilization. Note that for systems with AMC, channel state information needs to be accurately estimated for proper implementation.

Multi-hop Architectures

Multi-hop radio networks are composed of radio nodes providing retransmission capabilities. These radio nodes can be mobile terminals with special relay functionality. This architecture is called “ad hoc”. The radio nodes can also fix installed extension points that operate exclusively as relays.

This kind of architecture is referred to as “structured”. These networks provide means to expand the coverage per base station and allow scalability of the radio network to match offered traffic capacity, leveraging fast deployment of wireless networks with low cost. Topics such as real-time requirements and routing need to be standardized. Cooperation between radio nodes can also help improve overall spectral efficiency.

Multi Antenna Systems

In order to overcome the impairments introduced by the nature of the wireless fading channel, multiple antennae are used on the transmitter and receiver. A multi-antenna system block diagram is shown in Figure 99. These systems can be classified into two groups: adaptive antenna systems and multiple input multiple output (MIMO) systems.

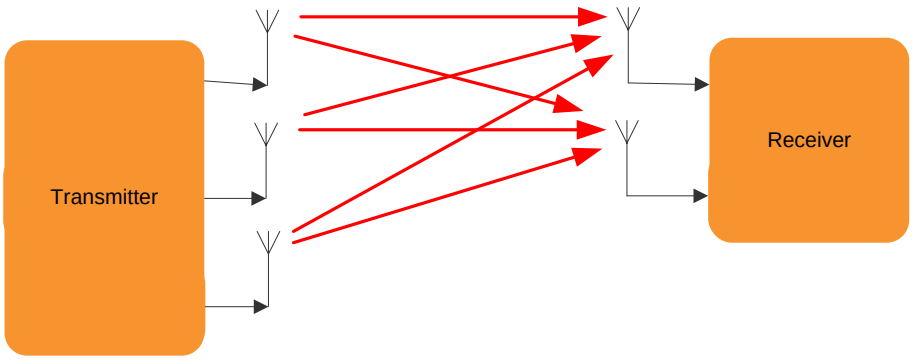


Figure 9: Multi-Antenna System Example

- Adaptive Antenna Systems

Adaptive, smart antenna technology uses antenna arrays, digital processing techniques and complex algorithms to modify transmit and receive signals at the base station and at the user terminal, leading to improved spectral efficiency of a radio channel, increased capacity and coverage. Form factor, due to relative antenna locations, is a critical design restriction in this technology.

- Multiple Input Multiple Output (MIMO) Systems

Multiple-input multiple-output (MIMO) techniques are based on establishing several parallel independent communication channels through the same space and frequency channel by using multiple antenna elements at both ends of the link. They can provide significant improvements in the radio-link capacity including data transmission rates by making positive use of the complex multipath propagation channels found in certain terrestrial mobile communications. Similar to adaptive antenna technology, the form factor is critical.

Cognitive Architectures

Flexible sharing of frequency carriers between different operators/bands/systems is a method to optimize the use of spectrum resources. However this will have serious implications on the regulatory side, and on the time required to scan the spectrum and locate a radio access technology carrier after the terminal has been powered on.

Standards

The methods above to increase spectral efficiency are currently being integrated to the wide area network (WAN) standards, in order to fulfill the recommendations provided by IMT-Advanced technologies. In this section, the requirements for IMT-Advanced technologies are summarized along with candidate standards.

- IMT-Advanced

As envisioned by the International Telecommunication Union (ITU), there will be a need for a new wireless access technology to be developed around the year 2010. This technology is named International Mobile Telecommunications - Advanced (IMT-Advanced).

IMT-Advanced systems are mobile systems that include the new capabilities of IMT that go beyond those of IMT-2000. Guided by Resolution ITU-R 57, ITU has started the process of developing recommendations for the terrestrial components of the IMT-Advanced radio interfaces.

These recommendations include:

- For cost efficiency, a high degree of common functionality worldwide and the flexibility to support a wide range of services and applications is required.
- Backward compatibility of existing services within IMT and with fixed networks is recommended.
- IMT-Advanced systems need to be able to interwork with other radio access systems.
- User-friendly applications, services and equipment are required, along with suitable user terminals for worldwide use.
- Worldwide roaming capability is recommended.
- Recommended peak data rates to support advanced services and applications are defined as:
  - 100 Mbit/s for high mobility use cases
  - 1 Gbit/s for low mobility use cases

The capabilities of IMT-Advanced systems are being continuously enhanced in line with user trends and technology developments to address evolving user demands.

- Standardization Efforts of IEEE

IEEE 802.16's 802.16 Task Group m (TGm) is chartered to develop an amendment to IEEE Standard 802.16 as an IMT-Advanced candidate. IEEE authorized development of the 802.16m standard entitled “Air Interface for Fixed and Mobile Broadband Wireless Access Systems – Advanced Air Interface” since December 2006.

The scope can be described as an amendment to the IEEE 802.16 Wireless Metropolitan Area Network – Orthogonal Frequency Division Multiple Access (WMAN-OFDMA) (also referred to as WiMAX) specification to provide an advanced air interface for operation in licensed bands. It is being designed to meet the cellular layer requirements of IMT-Advanced next generation mobile networks. This amendment provides continuing support for legacy WMAN-OFDMA equipment as recommended by ITU.

Other important topics include:

- LTE, WiMax, DVB-H, radio channel.
- Short range communication, with technologies such as Millimetre wave technologies, UWB, WLAN, ZigBee, Bluetooth
- Broadband terminals and base stations.
- Wireless Broadband, with such challenges as:
  - Designing and promoting innovative and cost-effective solutions
  - Technology transitions according to market needs and technology maturity
  - Regulatory aspects

- Identifying business opportunities for different markets and for different segments
- Handling convergence, e.g. fixed, mobile and broadcasting networks
- Femtocells
- Terminal architectures, multiradios, broadband antennas, smart antennas, HW- and SW-modules and components, filters, power amplifiers, software defined radio, Cognitive radio

- Architectural design, management of access network structure (self X…):
  - Wireless Broadband: Wireless broadband access will be the main enabler of ICT usage and Information Society, making life easier and efficient.
  - Backhaul of high data throughput: Bandwidth demand will continue to increase with migration to All-IP.
  - Last mile and in-building/home solutions: Digital home network with effective last mile access will increase service penetration in our daily lives. Cost and speed of establishment will be the main driving factors.
  - Regulation effects on converged access: Fast and effective standards and regulations will shape readiness of the EU ICT industry for global competition.
- Dynamic spectrum use: Spectrum Efficiency/fragmented spectrum
- Combined navigation and telecom services and applications, in cooperation with the Galileo program

3.1.1.2. Optics

Since their introduction thirty years ago, photonics technologies have largely contributed to the massive development of communication networks and it can be easily predicted they will serve as grounds for most of the network revolutions ahead, as unrivalled cost-efficient and power-efficient enablers of the new capacity-hungry applications. Rather than smooth migrations along a single path, step-wide, disruptive innovative changes have been setting the pace of photonics and will most likely continue to do so.

An analysis of the drivers of photonics suggests that its future expansion will be made along four paths:

- make networks faster
- make networks more transparent
- make networks more dynamic
- make networks greener

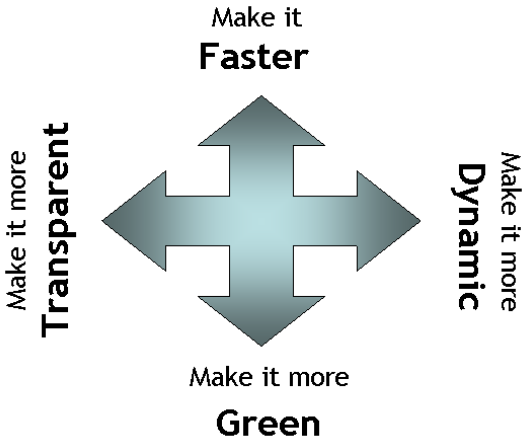


Figure 10: The four paths of expansion of future optical networks

These paths correspond to four market drivers that pull simultaneously, but cannot all win simultaneously. It is therefore important that the European industry benefits from research and development along all four paths in order to preserve its leadership.

More capacity optical networks

Since the beginning of the years 2000, the internet traffic is observed to grow at a rate of 60% per year, or equivalently at a factor of 10 over a 5 years period (ref: Minnesota Internet Traffic Studies). Up to now, the traffic increase is supported by optical networks providing the requested capacity thanks to the wavelength division multiplexing and transport of several high speed optical channels through a single fibre. The very key point is to still better exploit the available bandwidth of optical fibres; this is obtained by packing channels closer to each other while simultaneously increasing their individual bit rate. At a research level, WDM capacity transmission records beyond 10 Terabit/s have been reported, and the total capacity growth is still observed, even at a more modest pace since the recent years.

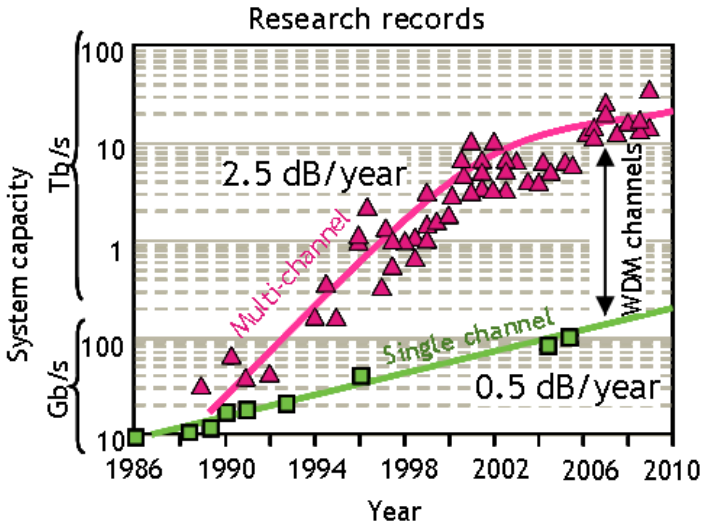


Figure 11: Evolution of the bit rate per optical channel and of the total capacity obtained thanks to WDM, transported through a single fibre (after S. Bigo, P. Winzer)

The capacity performance is characterized through the so-called information spectral efficiency, expressed in bit/s/Hz. Transmission systems under development will propose a 2 bits/s/Hz information spectral efficiency, achieved through 40 and 100Gbit/s advanced modulation formats and advanced detection techniques. Within the next five to ten years, advanced techniques and engineering must be identified and developed to prepare future networks with an information spectral density increased by a factor of ten. It must be underlined that the absence of solution will prevent ICT applications from their expected progress. This clear and challenging objective is mandatory, to cope with the traffic increase while maintaining the cost and energy of the transported bit at an acceptable level. The most relevant investigation directions will involve studies on theoretical analysis of nonlinear transmission limits, advanced new line and specialty fibres, high speed opto and opto-electronic devices, advanced engineering, modulation formats and receiving techniques.

More transparent optical networks

Many optical-electrical conversions are performed in today's optical networks, from transport to access networks. Increasing optical transparency is obtained by removing these conversions as much as possible. It will benefit to the transport but also to the access networks, by allowing several bit-rates, several modulation formats, or several radio standards to travel across the same generic fibre infrastructure. In particular, transparency will make possible the cost-effective convergence of some networks, e.g. radio and fixed access, or metro and access.

The ongoing introduction of transparency through optical cross-connects based on wavelength selective switches has already removed some limitations to the development of network capacity. In the ideal scenario, an optical data stream enters the network though the input node, possibly travel across several intermediate nodes, and reaches its destination node without conversion to electronics along the route. Numerous challenges remain to be solved in order to create fully meshed optically transparent networks or subnetworks. For example, longer distances will need to be bridged, across a greater variety of fibre type than today's. This will

require novel link designs, with appropriate dispersion maps, and to revisit all the performance estimators, that have already become obsolete. The interactions between signals at various bit-rates, travelling across a variety of fibre types will cause new propagation impairments (nonlinear effects, primarily) that have to be characterized and contained. The accurate assessment of the distortions stemming from transparent nodes in terms of cross-talk or filtering will need to be included in this picture as well. In order to contain the above spurious effects, coherent detection and massive digital signal processing will most likely be very helpful. They will deserve particular research focus. The all-optical processing techniques for signal regeneration (preferably of the entire wavelength multiplexed signals at once) or for wavelength conversion are also promising techniques. They could not only help to expand transparency further, but also to bring about wavelength agility and, hence, further save on the number of terminals.

The requirement for more transparency also spreads in optical access and home networks for a simple reason: the distribution of many heterogeneous data formats and communication applications will tend to convergent optical distribution network architectures characterized by a high level of transparency, so as to cope with all types of traffic in a cost-efficient and energy-efficient way. Radio over fibre techniques will be for example a key technique towards more transparency in optical access and home networks, leading to convergence of fixed and mobile networks. Long reach optical access networks (up to 100km) will allow convergence of metro and access networks, with WDM and cheap optical amplification as a common denominator and colourless customer modules as a pre-requisite. This trend towards more transparency may largely rely on the use of wavelength and/or sub-carrier multiplexing techniques, which can be combined with transparent optical or radio-frequency processing, alleviating the need to perform digital processing in all parts of the network. Hence, the convergence of metro and access could be eased if the aggregation and distribution of signals are performed by optical means. Similarly, the convergence of home and access networks would clearly benefit from the introduction of optically transparent home gateways, which remain to be developed. Transparency has the additional advantage of contributing to more energy-efficient networking without decreasing flexibility and agility. Overall, optical transparency is a useful feature for decreasing cost (cost/bit) and energy consumption (J/bit).

More dynamic optical networks

The increasing competition on leased-lines and Virtual Private Network services strongly encourages operators to offer quicker provisioning of connections, or even customer-controlled switched connections at the transport network level. The dynamicity of the optical network is thus related to the possibility for the network to automatically and dynamically control and manage connections, either for protection or restoration purposes in case of equipment failure, or for traffic engineering purposes, or at the customer's demand. In a longer term view, a truly agile network will require self-learning and auto-discovery of the available resources, making it really zero-touch. It will thus pave the way towards truly dynamic optical circuit switching or even optical flow switching (switching very large bursts of packets). The introduction of optical cross-connects is one of the first requirements for transport network dynamicity. But dynamicity also requires a control software (or plane) of the network. In each node, it should

drive the configuration of the optical cross-connects (which wavelength from an input fibre goes to which output fibre) but also force electronic regeneration of a given wavelength, that cannot be sent transparently all the way to its destination. This software has to be impairment-aware, i.e. aware of the feasibility of all optical paths before establishing connections: this is, by itself, a real challenge. In the routing process of optical channels, the control plane will also have to take into account energy consumption, thus allowing energy-aware optical networking. To be accurate, it needs to be fed with photonic components parameters, possibly from active monitoring, and should rely on dedicated fast routing algorithms.

The motivations for dynamicity can be partly addressed by remote wavelength management, thanks to cross-connects. However, other approaches deserve to be investigated as a complement or to go beyond. The most promising of them consist in automatically varying the bit-rate per wavelength, continuously or step-wise, or in varying the wavelength spacing. Dynamicity can also be obtained by adding or dropping sub-bands in/from a multicarrier signal e.g. an orthogonal frequency division multiplexed (OFDM) signal. All these approaches deserve deep investigation to assess their potential. Other strategies rely on optical switching with much finer granularity than the optical wavelength channel, whether at burst or packet level. These optical burst or packet switching techniques allow efficient aggregation of traffic coming from access networks, and will spread into metropolitan networks first, then into backbone networks. They will be in particular the cornerstone of convergent metropolitan and access networks.

As a matter of fact, the need for dynamicity will also be a key of future optical access networks, able to provide on-demand and bit-rate adjustable broadband access connections to the end users. Variable bit-rate transmitters and receivers will be one approach for this optical access network agility. Agile multiplexing and multiple access schemes will also be developed and tend towards fully wavelength-agile optical access networks. These advanced schemes will be combined with dynamic time-based, wavelength-based, or even sub-carrier-based bandwidth allocation mechanisms. In particular, agility provided by multi-carrier multiple access techniques (such as OFDMA – Orthogonal Frequency Division Multiple Access) is a promising solution towards future generations of PON (Passive Optical Networks). In a longer term view, optical burst or packet switching is considered as a solution towards convergent access and metropolitan networks, opening the way towards end-to-end all optical switching in the whole network.

Future usage of home area networks will also require a high level of dynamicity: as broadband and digital storage devices gain more success to the home every day, the trend is that it shall be possible to use all these devices everywhere at home with high flexibility, and with high data rate connectivity to transfer content either from remote servers or between end-devices sparsely distributed everywhere at home. This will require agile multi-format optical home networks based on multipoint to multipoint topologies. These advanced home network architectures will largely benefit from wavelength division multiplexing and/or sub-carrier multiplexing techniques, so as to easily manage multiple access to the network as well as various formats and services, including data, video, and wireless.

Greener infrastructure

This subject of energy efficiency is covered in the following paragraph. It is now widely accepted that optical technologies and engineering have a key role to play with this respect.

First, the routing function at the (electronic) layer-3 level is known as an energy consuming network function of the infrastructure, simply because it is the most flexible and processing intensive layer. In the frame of high traffic, studies have shown that it is less efficient to process all packets in all nodes. In effect, it is estimated that 80% of traffic entering a node is a pass-through traffic, with a destination located in another node. It is then particularly efficient to keep that part of the traffic in the optics domain, without electronic conversion or packet processing. This novel, not yet developed approach, requests a close relationship between the network layers (0, 1, 2 and 3) and intelligent cooperating management, control and data planes.

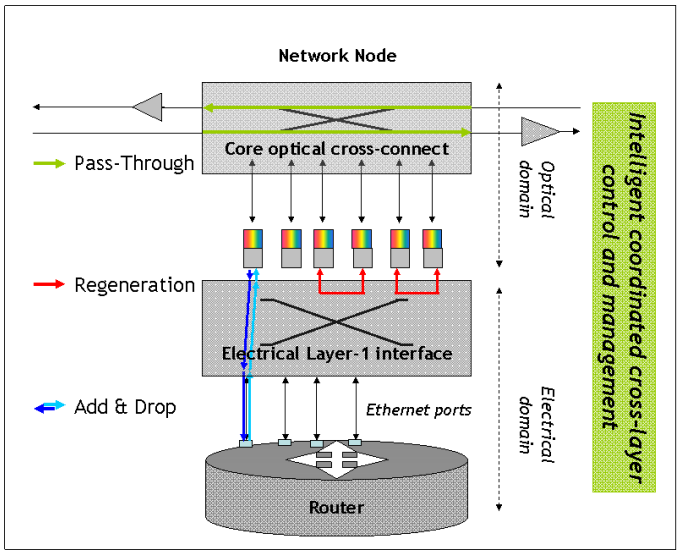


Figure 12: Intelligent cross-layer control and management for energy efficient network functions

Second, optical technologies could be envisaged to perform limited and optimized series of network operations, at a packet level, or more reasonably at a burst level. These operations could be realised at the layer 1 or 2 levels, without the ambition to replace the router technology, but more pragmatically to process large entities that would be more and more abundant in the frame of video services.

These two approaches, cross-layer cooperation and optical burst, request a strong research and design activity to really and actually focus on energy efficiency and energy consumption reduction.

3.1.1.3. Energy Efficiency

Since economic growth boosts the demand for energy, efficiency in the most energy-intensive sectors[9] is a must in order to maintain competitiveness on global markets and to minimize adverse impacts on people and the environment. EU leaders have pleaded in favor of an

[9] Buildings ~40 %, transport ~30% and industry ~30%.

integrated climate and energy policy by setting the well-known 20/20/20 targets[10], in whose achievement ICT will play a big role.

In today's background, being widely used in all aspects of life and transforming the way that people live and work, the contribution of Information and Communication Technology in energy efficiency and responsible growth is twofold, both as an instrument and as a subject.

As an instrument, ICT can be used for obtaining optimization of energy consumption in communication systems, thus stimulating new sustainable habits, uses and services (remote collaboration, e-learning, e-shopping, e-administration, e-healthcare, tele-working, etc.) that will be the key to improve people's quality of life and achieve sustainability. Further details regarding such instruments and services are addressed in the proper sections of this document.

ICT itself should be subject to an optimization process since its intrinsic energy demand is rising: figure 10 shows the distribution of CO_2 emissions caused by ICT[11].

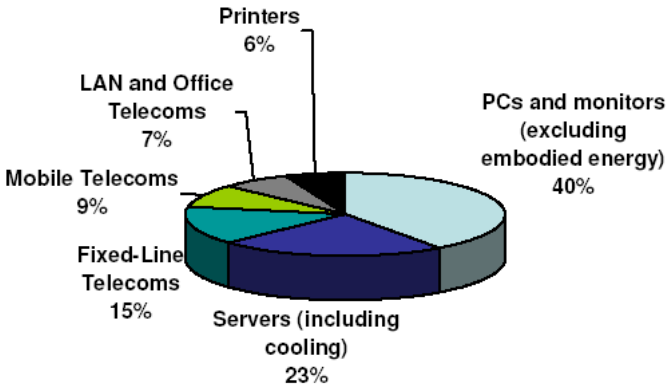


Figure 13: Estimated distribution of global CO_2 emissions attributed to ICTs.

Currently the ICT sector generates an estimated 2% of global CO_2 emissions. However, by year 2020, it is expected that approximately 4% of world energy consumption will be due to ICT activities (based on a 6% increase in consumer demand each year).

In telecommunications networks, which account for 0.5% of global CO_2 emissions and 24% of the emissions attributed to ICTs, some key improvements are needed in order to get better energy efficiency.

Improvements in broadband equipment for both fixed and mobile networks

It is worth mentioning that approximately 90% of the power consumption of mobile networks are produced by its own infrastructure on the network side (base stations and the switching centers), while the remaining 10% are generated by the subscribers' access devices (mobile phones, 3G modems, etc.). The main initiatives to reduce the power needs are therefore

[10] The European Council of 8-9 March 2007 set the combined targets of (i) reducing greenhouse gas emissions by 20% by 2020 (compared to 1990), (ii) increasing to 20 % the share of renewable energy sources by 2020 (compared to the present 6,5%) and (iii) saving 20 % of the EU's energy consumption (compared to projections for 2020).

[11] This analysis does not include radio broadcasters or devices for television viewing (from Gartner Research Paper No. G00150322).

addressed to improve the efficiency of the 2G and 3G equipment, to achieve optimal placements for antennas and active cooling reduction. Other predominant wireless technologies such as WiMAX and Wi-Fi should also be addressed. Regarding *terminals*, the increasing demand of electronic and electronically driven devices brings more power consumption, so it is important to consider their evolution roadmap in terms of batteries, processor and memory requirements, including weight and size.

On the other hand, in fixed-line networks, the percentage of energy consumption attributed to operator infrastructure drops to 70%. The remaining 30% is generated in the subscribers homes and it is therefore harder to act on. Energy efficiency can be achieved with the introduction of *multiple power modes* for broadband equipment, such as the modes defined in VDSL2 standard, when the equipment is inactive or carrying a low volume of traffic. Regarding *access technologies*, a substantial growth is expected in ADSL, VDSL and G-PON technologies, with a continuous advance in transmission capacity of these networks. The adoption of optical broadband access is an important factor to consider since in many countries traditional local loops (xDSL) are being replaced by strands of optic fibers, thus obtaining greater transmission capacity and also greater energy efficiency (for example, FTTH architectures are up to 6% more efficient than copper networks).

Improvements in network resource management

The use of remote management and maintenance of network equipment will help in minimizing travelling time and expenses. Besides that, instead of trying to optimize energy efficiency in each individual network device, it is worth to consider a *global approach* in which energy management is carried out by having knowledge of the overall infrastructure. The aim here is to investigate *integrated solutions* for management of networks and services spanning over different domains (transport, control and application layers). For example, taking into account traffic characteristics, distribution of fixed access customers, statistical distribution of mobile users, constraints from physical environments, and the energy consumption profile of the different network elements, both the number and the size of the access and routing nodes can be optimized to achieve an overall minimization of energy consumption while ensuring the quality of the services.

Migration towards unified network architecture

ITU-T Technology Watch Report no.7[12] describes how a significant contribution in the battle against global warming may spring from *Next Generation Networks (NGNs)* as a unique IP based network with a centralization of applications and services. One of the mentioned advantages should consist in enabling users to access all applications from a *smaller number* of *devices*: this could allow great CO_2 savings in manufacturing, power maintenance, battery recharging, and in addition the saving of scarce materials which in many cases are petroleum-based plastics. Another advantage will be to *reduce manufacturing complexity* and electronic waste (i.e. cables, installation space, etc.), while requiring also *fewer network premises* (against present PSTN, mobile, television, Internet). At the same time, high-speed high-capacity routing equipment for

[12] "NGNs and Energy Efficiency", August 2008

all media types will decrease the number of switching centers, and consequently the requirements for heat, light, and air conditioning.

The migration towards an all-IP network is expected to generate savings of approximately 30% to 40% in power consumption (compared to legacy telephone networks) as a result of the introduction of the IP transmission protocol to all network areas.

Efficient radio technologies for M2M feeder networks

To allow an efficient "Internet of Things", new radio access technologies and radio network architectures for massively scalable narrowband IP-based mobile communication systems with high spectrum efficiency, low cost and high energy efficiency for machine-to-machine communications (M2M) applications have to be developed. Such systems have to support a huge number of nodes opening an economically viable path towards the Internet of Things and should bridge the gap between existing short-range radio technologies and classical broadband cellular radio networks.

3.1.2. NETWORK ARCHITECTURE AND CONNECTIVITY

3.1.2.1. Networking

The network is the distinctive element for operators. It could be the base of vertically integrated services which other market players cannot offer.

Future Internet connectivity requirements will be based on:

- New traffic demands
- Reliability, ubiquity, security
- Flexibility, openness
- Neutrality, fairness
- Use of advanced network services

As far as traffic demands are concerned, there is currently a tendency towards higher streaming traffic. Furthermore, traffic is becoming again more asymmetric in comparison to the more symmetric P2P traffic.

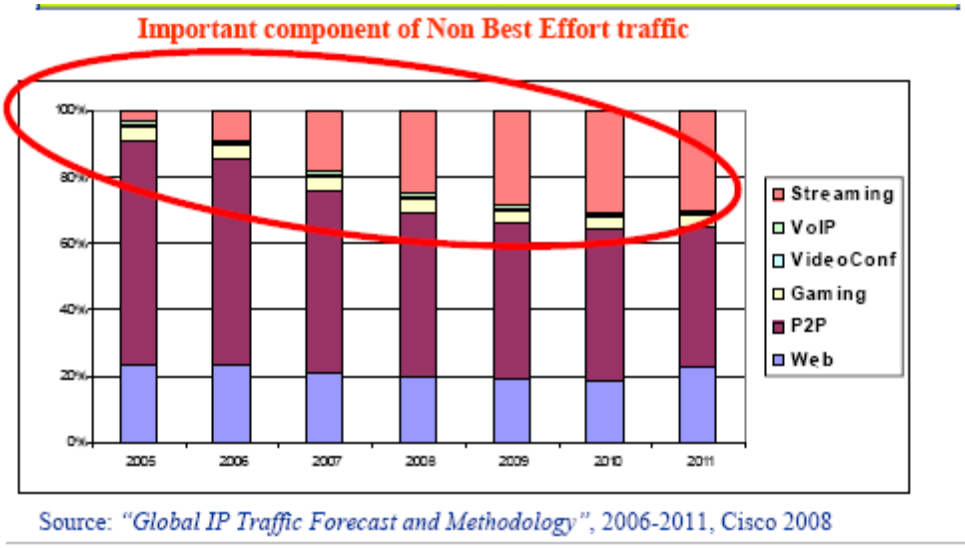


Figure 14: Evolution of traffic demands (courtesy of Cisco)

New requirements for the network are:

- Scalability
- Cost efficiency
- Quality of Service

Concerning this latest item, operator requirements for selling QoS are based essentially on the simplicity of the solution: easy to deploy, easy to manage, easy to charge, easy to sell, including support of wholesale/retail models and compatibility with existing solutions.

QoS must be built on new business models to be feasible, mainly based on the value of coordinating heterogeneous networks, which will be preserving the openness of the Internet model.

The current view is to link QoS to connectivity, not to the application, thus allowing the use of the system by any application.

Future network challenges include also:

- Evolution of Architecture Networking
- Internet of things and sensors
- Changes in the users demands and traffic patterns
- Network self-management
- Capacity and management flexibility
- Network virtualization. This area is strongly supported by a number of manufacturers and there are, at present, some promising proposals (X-bone …). It could lead to a meta-network, supporting a wide variety of virtual networking services, tailored to customer's needs and preferences.
- Another interesting research area relates to the investigation of some alternatives to IPv6, such as IPv4+4 in and Oxygen in 2004, or current extended-IP (xIP) work. Those alternatives have very low complexity and very good co-existence with IPv4, but without support it will be discontinued in IETF. This will include:

  - Virtualization of the access network (particularly using Software-Defined Radio concepts)
  - Software defined switching. Over the same hw switch element, different switching mechanisms are implemented.
- Info centric networks. The networks are adapted to the user information, optimizing the quality of experience and the utilization of network resources as a function of the application.

Other topics of interest include:

- Seamless Networking: management of heterogeneous networks, reliability, security, quality, mobility, cross-layer planning, seamless services and autonomous networks.
- Network support: testing, measurements, planning, optimization, operation, control, billing and security focusing on the whole life cycle of the network, as well as carrier services over IP/Internet with guaranteed Quality-of-Experience and application-awareness.
- Network performance and management.

3.1.2.2. Autonomic Networks

Network evolution

A general problem of today's networks is the ever-increasing complexity of their operation. This complexity is mainly driven by the heterogeneity and incremental nature of technologies. Furthermore, network operations are typically human driven and thus time-consuming, expensive, and error-prone. Complexity and cost are becoming important limiting factors to the evolution of networks and to the enriched services they are expected to deliver.

Autonomic network, an alternative

The purpose of autonomic networking is to provide solutions enabling to build a scalable and trustworthy operational environment while mastering complexity. Furthermore, it aims to ease and lighten the role of the human operator, which will, as a result, reduce the OPEX (Operational Expenditures). Distributed control, self-organization and knowledge sharing are the key characteristics to build collaborative processes that pursue high level objectives specified by the operator

A new architecture to face the autonomic network challenges

Proposing a clean-slate architecture faces deep scepticism from network operators, who are reluctant to give complete control of their networks to some novel autonomic processes without strong guarantees. Moreover, such clean-slate approaches run the risk of being seen as unrelated to real network operation and management issues and tasks. Thus, an evolutionary approach to the problem, which integrates both top-down and bottom-up designs, is preferable. First, a general framework, functional planes and objectives should be defined for autonomic networking. Then, concrete use cases, involving every-day network operation and management issues, should be identified. Resolving each issue, within the aforementioned autonomic framework, aims to progressively enrich the design of a global autonomic solution, to provide simple examples of the relevance and efficiency of such solutions, and hence to ease the acceptance of future autonomic systems by network operators.

Standardization: something that needs to be done

Undeniably, a definitive architecture for autonomic networks and systems can only emerge from a sustained work in standardization. The scope and content of self-management are intrinsically too large and intertwined for individual initiatives to succeed. In the meantime, applied research must be performed on the key building blocks and concrete developments must be achieved to demonstrate the feasibility and relevance to migrate towards autonomic networking.

Core elements to succeed

Among these key building blocks, the usage and management of "network" knowledge is a crucial element to achieve an autonomic behaviour. This knowledge comes from the transformation of raw information into valuable and meaningful knowledge. In a first step, various information is collected, aggregated, filtered, analyzed and correlated. This first step is called network mining. Then, a second step is required to achieve the genuine transformation into knowledge: the confrontation of this information with a model on system behaviour. This confrontation can produce important statements on the equipments, or traffic, states and on the trends, which are of great help to the decision processes: a complementary key building block of autonomic networking.

Technical Challenges to tackle

Based on these concepts, research in autonomic networking spans different activities and should address several technical objectives:

- Managing information/knowledge (aka knowledge/awareness plane), network mining;
- Building trust in autonomic/autonomous systems;
- Visualizing complexity: new ways to represent systems/networks for management purpose, new man-machine interface/user interface and controls;
- Architectures/Interfaces --> Standardization is key;
- Closing loops: service and network, low-level loop;
- Relationship between application/services and the network (e.g. service-driven networking, application-aware VPN);
- Common approach for mobile and fixed networks;
- Modelling;
- Cognition;
- etc.

3.1.2.3. Other network infrastructure aspects

Network virtualization & exposure

Service platforms in Future Internet shall be targeted at overcoming the current fragmentation in Web and telecommunications services, often developed and deployed as *ad-hoc silos*, by sharing and integrating a number of disparate network resources and backend management systems.

At present, many of the capabilities required for building new services are already implemented within the network, but are scattered across various data repositories and different service execution environments. For example, solutions may already be in place for location and presence information, group list management, calling capabilities, file streaming, content management, real-time payment and others, but these capabilities are often only used and accessible from a so-called stove-pipe service solution.

The challenge is to leverage distributed information and expose these assets from different service execution environments, in a uniform way through open interfaces. This will enable the creation and mash up of new and compelling services quickly and cost-efficiently, leveraging common IT technologies, methodologies and best practices.

Service Oriented Architecture technologies may provide integration frameworks, suitable for rapid discovery, creation, composition and deployment of services, integrating disparate telecommunication domains in a coherent environment, thus helping to shorten time to market. Network abstraction shall be achieved through simple and easy to use APIs based on Web Services technologies, which can be used remotely by third-party domains and service providers.

Service platforms evolution in the Future Internet has a twofold perspective, from the telecommunications infrastructure side, and from the web side.

Regarding the telecoms network, an important factor enabling a successful deployment of NGN services will be the transition towards an all-IP network infrastructure. The IP Multimedia Subsystem (IMS), now in a deployment phase, can be considered today as the unifying architectural framework for the provision of seamless IP-based services on top of converging fixed and mobile networks. Its access-agnostic framework is key to enabling the rapid deployment of services, since its overlay architecture is widely abstracted from the outer interfaces and ensures that the access is network, technology and vendor independent.

Such an architecture model allows and leads to the so called *network virtualization*, for which we refer to the adoption of an "encapsulation" approach to hide the complexity of the telecom core services and to provide an easy-to-use interface for applications. The upper layer of the telecoms network, on top of its core control functions, provides the ground on which service enablers are defined and used for the implementation of composite services.

At the same time the evolution of the Internet should be considered, where the new era of Web 2.0 services has emerged, leveraging the collective intelligence of users as active contributors, adopting a light-weight model enabled by loosely coupled systems that are simple to use and creating valuable data pools that are difficult to recreate. Popular services like social networking, blogging, mash-ups, social tagging and community-based music services can take advantage of the telecoms framework for further advancement. Telecom network assets may allow evolving Future Internet services while adopting the Web 2.0 principles.

The disrupting use of Web service technologies can now be seen as the candidate for opening up the networks and exposing capabilities to third-party service providers and enterprises. Service exposure capability may be extended, beyond traditional voice and messaging services, also to

the abstraction of user authentication and authorization, identity management, policy enforcement, service level agreement, accounting, provisioning and management. The reuse of an extensible set of existing service components to create rapidly new market-driven applications has been a key aspect of telecommunications platforms for many years and gains a new momentum with the definition of dedicated application enablers for NGNs.

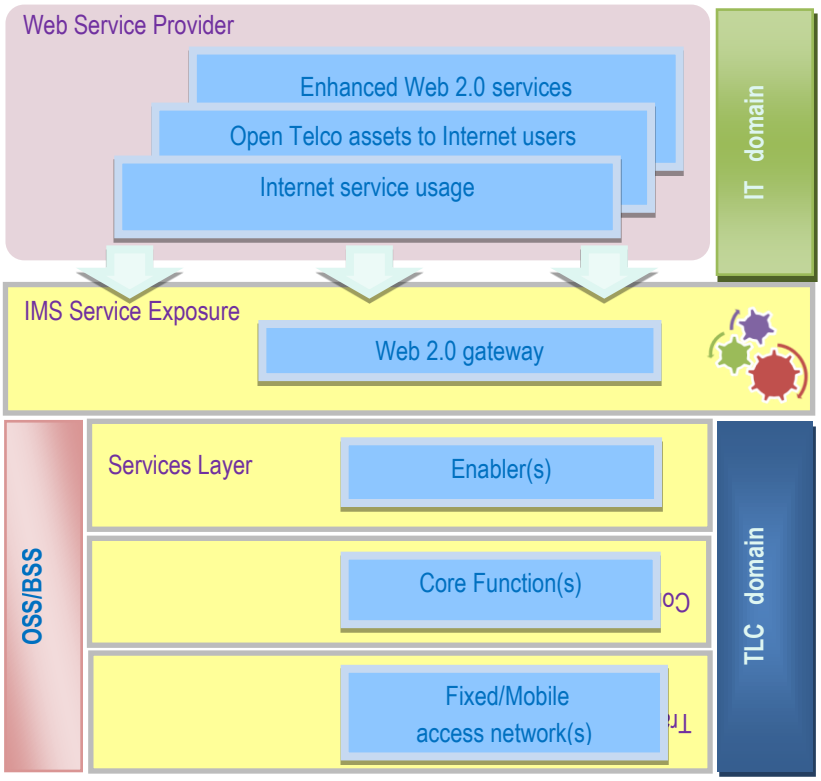


Figure 15: Platform architecture for NGN/IMS/web 2.0 service building.

The Service Layer exposure is the nerve center of the scenario: it is the level through which network intelligence assets can be spread for the benefit of users. The convergence of IT and telecoms shall result in an open service platform architecture, capable of supporting and optimizing management and delivery of telephone services and innovative multimedia services, suitable for all types of users. This is a conceptual leap, representing a real evolution towards the integration and convergence of traditional telecommunication networks, innovative multimedia telecommunication networks, like NGN and IMS, and Internet, IT, Web2.0 and "web-of-objects" environments.

Increasing network resilience

There are essentially two possible approaches to increasing network resilience: increasing network protection and enabling network restoration mechanisms.

The first approach essentially implies increasing the number of back-up elements. It is very safe but not very cost effective. The use of restoration solutions is much more promising but existing algorithms are not good enough and the resulting network is not fully optimized.

There is a clear need for mechanisms that assure the re-optimization of the network. Those mechanisms should be controllable but automatic.

This problem is particularly acute when managing heterogeneous networks and multiple network layers, where a unified control plane may be required to assure resource optimization. Those solutions have to be standardized to be fully applicable to different networks and to solve the interconnectivity issues.

Femtocells

Due to higher frequency use with introduction of 3G/WCDMA mobile networks and in order to provide better coverage inside the buildings, small access points, called Femtocells, are needed. Solutions based on Femtocells have been developed by many industry players and the technology has already gained a lot of attention among operators. Femtocells provide good signal quality and help accelerate the adoption of 3G services. As basic features and capabilities of Femtocells are already in place, Celtic Plus should focus on Advanced Femto concepts and encourage the ideas placed among this core. Those advanced applications of Femto could be grouped as follows:

- **Next-gen Femto:** In many countries, 3G/WCDMA mobile networks have been in operation since 2000/2001 Nowadays, these pioneers have already started to trial and evaluate 4G or LTE mobile networks and the spectrum allocated for the technology is higher than the one for 3G. In some countries this will be around the 2.6 Ghz spectrum which will make it quite difficult to penetrate the inside of buildings. In that sense, studies around LTE Femto should be supported. These studies should also incorporate “Self Organizing Networks”, “Cognitive Radio” and also “Software Defined Radio” concepts to advance LTE Femto solutions in the future.
- **Services and Smart Home:** As basic features of Femtocells will be provided soon after its launch, further studies would be based around value-added services and the incorporation of Femtocell into the Smart Home concept. Social network applications such as Facebook, Myspace, Bebo, and Twitter are becoming a natural part of mobility, and increasingly people tend to use these applications and innovative services based on them. Service architectures and API mechanisms would be studied, and useful examples of applications should be given, such as education, e-health, security, and entertainment. Those should also be integrated with existing Smart Home architecture solutions so that end-user adoption is accelerated and a “seamless” user experience is achieved.
- **Enterprise Femto:** Initially, Femtocell solutions were planned for residential markets but later most of the operators and manufacturers noticed that there is also a market for enterprise applications. High-capacity Femto solutions would be studied including considerations of potential health concerns. Many femtocells used in an Enterprise environment would clearly need for seamless hand-over functionality, and this also should be considered in studies.

Femtocells will favour a disruptive “micro mobile” scenario.

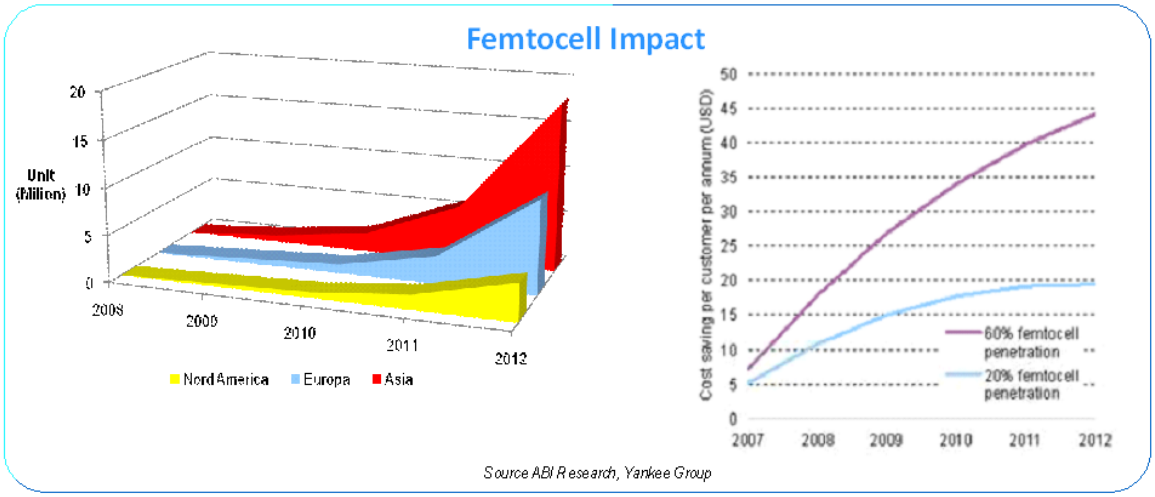


Figure 16: Femtocell impact

Public safety and future communication networks

Public safety involves "the prevention of and protection from events that could endanger the safety of the general public from significant danger, injury/harm, or damage, such as crimes or disasters"[13]. ICT is clearly capable of giving support in all phases of disaster management, e.g. in preparation, mitigation, response, or recovery. Although all phases are important, the phase of preparation has a key role, as it enables protective measures like, e.g., evacuation. Advanced ICT technologies allow to forecast the route of a tornado, it can listen to seismic activities and interpret them. Supercomputers are helpful tools for analysis and simulation. While it is challenging enough to coordinate counteractions once a warning was given well in advance, it gets much more complicated if the warning is rather a notification of an event that has already started, leaving practically no time for preventive actions. Modern and robust communication networks that help in spreading information and coordinating activities have an important role at such events. The power blackouts in the US and Italy are specific examples, as these are cases that impact also the systems used for warning and recovery. There are a number of aspects which need closer attention in order to improve use and availability of ICT for public safety. This includes cross-border aspects – important for incidents that affect more than one country. Further progress on standardised solutions is a basic requirement to enable interworking of systems. Inhomogeneous systems are by far not overcome. Finally, there are security issues related to convergence toward IP-based networks and Next Generation Networks.

Unfortunately, ICT nowadays is not fully exploited to the extent state of the art technologies would allow. Attitudes of ignorance at political level like "it can't happen in my country", debates about how to finance or distribute the costs, or lengthy disputes about the right implementation strategy are some of the non-technical barriers. But extended use of ICT going along with automated control and management could even help to keep costs low, and also to improve speed of reaction.

[13] According to Wikipedia.

The usability of future networks for public safety applications will require specific consideration of their design. While many users are nowadays happy to enjoy lower cost for VoIP calls over the Internet, this goes along with a lower guarantee of service. This is critical, if this medium is needed in emergency situations. If a disaster goes along with power outage, then users of today's Internet telephony could not make phone calls as both their PC and WLAN router would not work. Other issues are network congestion, which can easily occur at larger disasters causing peaks in communication, the missing capability of locating the caller origin, or the ease of faking the identity of the caller or called.

3.2. WHILE CONNECTED

"While connected" will tackle the end-to-end services and applications, with topics related to future end-to-end services, like digital citizen, digital home, digital enterprise, digital city, digital school, digital transports, e-health and games; horizontal services, like security and identity; and business aspects, like evolution of value networks in telecommunication business focus area, forecasting the changes in value networks and business models, and user modelling. New aspects related to the Future Internet will come into consideration, in particular for issues that are closer to the market.

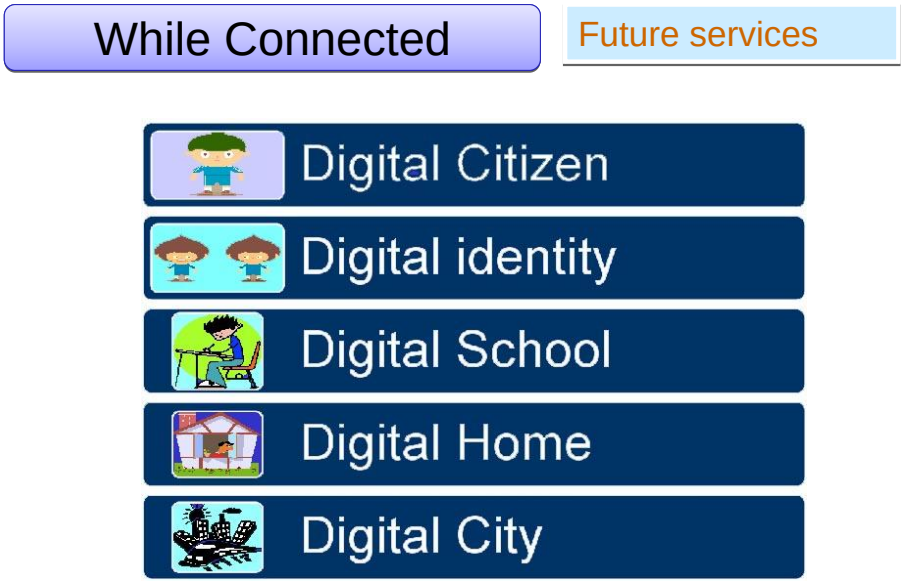


Figure 17: Future services of "While Connected"

The main objective is to evolve from "just connectivity" into:

- Connectivity;
- Storage;
- Processing.

The activities are split between:

- Future end-to-end services;
- Future business models.

3.2.1. FUTURE END TO END SERVICES

The Internet is the global hub for information and communication where different actors, including citizens, share their contents and connect with each other. They are connected to social networks and virtual worlds, sharing knowledge within a given community. They want all

those features to be accessible anywhere, anytime and on any device. The network is becoming less relevant and now a new definition of the Internet is emerging: “Internet is the people”.

As the Internet is evolving, efforts should be made in regard to new tools, which allow user profiling, recommendation systems, and new applications to enhance the creation of online content by professionals and amateurs.

It will also become necessary to develop novel multidirectional interfaces and interaction mechanisms, including multimodality and "presence”. Those new interfaces, technologies, methodologies and certification models should be developed to ensure the Future Internet does not exclude anyone and, furthermore, that it makes the Information Society more inclusive.

The list of applications is large; here are some examples:

- **The smart city concept.** The objective is the provisioning of all elements in the city, ranging from security for people´s life and goods, management of waste disposals, entertainment in the city, new ways of getting information, and advertisements.
- **Intelligent transport.** Design of intelligent, adaptive, context-aware and self-healing transport systems, including monitoring and management of transportation networks to get a better distribution. It also includes gathering and distribution of reliable, real-time traffic information.
- **E-health.** This is a wide area including, among others, the interoperability of computer-based medical systems, management of electronic patient record, and the interconnection of hospitals and medical team remotely.
- It also includes more specific applications such as enhancement in remote care of patients while at home (especially for chronic diseases) or in hospital, robotic based solutions.
- **Development of energy-friendly solutions.** This is motivated by two facts. On the one hand, there is a wide consensus that networks should actively contribute to reduce the carbon footprint of the industrialized society. On the other, many devices to integrate the so-called Internet of Things will be severely constrained in what concerns energy consumption, computational complexity and storage capacity. In addition, a pervasive use of efficient Internet networks and services will have to assist to other sectors (transport …) to reduce their own energy consumption.
- **E-government** It will cover the globalization of public services including the accessibility by any telematic means; the optimization of public services information databases and processes.

The main difficulties lie in solving interoperability issues to address the heterogeneity of administrative procedures and systems.

Some services are listed and explicated further in this section.

3.2.1.1. Digital/ Smart Home

The objective of this activity is to develop technologies and software that will improve home networking and enhance end-user experience through personalization and interactivity. The main objectives are to:

- Enable seamless consumption of different kinds of media irrespective of the source (broadcast, broadband or home network)
- Assist the consumers in navigating within the huge amount of content through discovery based on preferences and personalization while maintaining privacy
- Bridge the entertainment-information gap by integrating Internet-based information with entertainment
- Improve home networking technologies especially for video distribution.

In order to achieve these objectives, the following priorities have to be addressed:

- Personalization technologies (content recommendation, user profiling and complementary information retrieval)
- Enhanced and simplified connections within the home using new protocols, mechanisms, and techniques (with wireless, wired or hybrid wired-non-wired solutions)
- Optimisation of home content storage (management of content storage and access on distributed devices within the home)
- Management of several rendering devices (audio, video etc) into aggregated services.

It is indubitable that the Digital Home concept is undergoing a complete transformation along with the network and device technologies that have appeared in recent years. The problem is how to enable those new technologies with appealing features in the digital home scenario without affecting the available infrastructures and imposing a substantial economical effort on the users for replacing already available equipment. A key capacity of the offering for the Digital Home must lie on reuse.

Personalization

Mobile terminals allow users to make individual choices according to their preferences. It is in the interest of all providers to consider the individual needs and preferences of users and offer them a set of services well adapted to their respective way of life and personal habits. To do this, it becomes necessary for the service provider to develop and implement service enablers that insure for all new services customization of the customer experience, adaptation to use contexts (service continuity) and their integration into a set of customer loyalty services (service interoperability). Through open interfaces, these basic building blocks will allow carriers to choose and establish richer partnerships with third party service suppliers.

In the context of user personalization, what is of the utmost importance to be sure to get the best offer is to utilise the good knowledge of users, their contexts, their respective equipment, and their habits. To this purpose, a great cooperation between all suppliers is needed as well as a clear definition of the way to exchange information of interest. Once the information has been gathered, a rule engine will permit to treat this set of information according to occurring events in order to react as wished by the user.

In the Digital Home concept now the family services have to be open to the personalised profile handling of all members of the family. Now every member of the family has his or her own mobile device and profile in social groups on the Internet at Facebook, keteke or similar providers.

Global Network Integration

What we mean by "global network" is the combination of all network technologies that surround the user and permit global interconnectivity: Fixed, mobile, WiFi and similar technologies that allow users in different contexts to be connected.

Here the challenges are:

- The end-user should be allowed to access the services important to them from any appropriate terminal, from any network regardless if they are at home, connected to their home mobile network, visiting someone with a broadband connection or roaming in another operators mobile network.
- A set of enablers have to be developed that allow services delivery to the end-user based on the network connection that is available at any given time. It is true that the industry has worked on many solutions around roaming, but yet there is no standardized solution.
- Enablers are also needed for continuous adoption of services when the connections or status of the end user changes.
- For the Digital Home, the integration of the mobile terminal is still not consolidated via the Femtocell approach. Marketing plans do not show at the moment exciting perspectives. Nevertheless it should be always remembered that now most home users have a mobile terminal that still is used in the home. Therefore we should work on scenarios where the mobile terminal of the user will hold an important role to access or control services at home. Technologies such as Near Field Communication (NFC) and RFID can enable interesting service scenarios (if Femtocells are not available) as soon as we can "communicate" to the mobile phone via for example the residential gateway.
- To be able to deliver services anywhere, a single end-user-identifier and uniform authentication and authorization mechanisms are needed. The single-user-identifier could possibly be biometrics parameters in combination with the SIM of the end-user's mobile terminal. The latter info can be sent to other devices via NFC. Technologies are available now, but no universal solution has been adopted yet.
- The user needs a transparent security solution, easy to use and being visibly present in the background in order to increase the confidence of the user to be always connected while being away from home but still accessing his content and home based services.

Content Management and Provisioning

The consolidation of broadband and 3G/4G in the mobile domain means that genuine on-demand multi-media services will soon be a reality. This now can be possible because of the advent of very attractive devices such as the iPhone or the new HTC, Nokia or Samsung devices with smooth and wider touch screens. The potential is for the user to access personally relevant multimedia content wherever he is, and on the appropriate device for their current context.

The architecture for content management provisioning has to be designed to provide both push and pull multimedia services, which are personalized to the user interests, and adapted to their current context and end access device. In addition, the combination of broadband services, home networks and large home storage means that multi-media content which is stored at home can be accessed from outside the home. The architecture, therefore, also should allow for this second

novel type of service where the user provides the content for consumption by themselves or their friends and family.

It should be very easy to push the user content onto the internet, e.g. Youtube, Flickr, or Facebook.

Therefore more advanced and distributed search engines have to be designed and distributed at the edge of the networks to allow real content-aware networking. The knowledge of the content at the edges will increase the reach ability and speed of streaming for example. P2P and P4P will see explosive growth, and they must be combined with content filtering and adaptation algorithms to swiftly serve the users in whatever terminal and context they may be.

Digital Home Platform

Broadband is successful worldwide, and its penetration rate is growing fast in basically all member states of the European Union. This increase is related to home networks, because families are using more than one PC at home, and other types of Ethernet-enabled equipment are being bought: play stations or consoles, multimedia/DVD players, recorders, and digital Hifi systems. Content like music, films, or photos are increasingly available in digital format and stored on hard disks. This has permitted the distribution of this content via the Web. Moreover, the Web allows the distribution of such content within Home Area Networks, using wired or wireless technologies.

WiFi access points are now combined with the broadband routers, permitting the user to access their data anywhere in the home using multiple devices, not only PCs. The wireless world is getting acceptance and dissemination from the fact that also hotspots are being successful and accessible almost everywhere now: you turn on your computer anywhere, and several wireless networks are within your reach.

Moreover, Powerline solutions are more and more reliable allowing, home backbones at very high speeds (more than 100 Mb/s).

In the sensor area ZWave and Zigbee solutions are being commercialized and can be easily integrated in all kinds of homes. They are very well suited for control-based services such as home automation and parameter reading.

These usage and demand facts are leading to a reduction in the cost of broadband equipment, and a networking niche for the home oriented consumer market. Also important is the

appearance of various outlets serving directly this market even at global level in Europe and America. Examples are Carrefour, Mediamarket, and Office Depot.

Having defined very rapidly the environment laying behind the DH platforms and broadband worlds, the challenges that need to be addressed to realise the Digital Home are:

- Plug and Play interoperability is still not a reality for the home equipment, even if DLNA is now being implemented in more and more equipment. Different user intervention is needed in order to connect and handle the services offered.
- The cost of customer support is an important issue for the vendors, service providers and Telcos. TRXXX protocols defined at the Broadband Forum are very important in order to configure automatically the terminals. The latter will have to be made available to most commercial products for the DH.
- The management of services can now be achieved via OSGI, but the problem still lies in the fact that the language used, Java, imposes strong processing and memory requirements for the Residential Gateways (RG) raising the costs. So the question that needs an urgent answer is: should we wait for more powerful RGs, or should we develop new service management technologies?
- Services are now key if we want to see new sources of revenue for telcos. For that we have to follow the Web2.0 paradigm, meaning that users have to participate more in the creation of services. They should have tools in order to implement Mashups oriented to the DH environment.

Device Middleware

Consumer electronic appliances such as set-top boxes, PVRs, and DVD players are sophisticated and expensive digital processing systems now able to handle multiple tasks. By connecting these information appliances to home networks, it is possible to share processing and storage resources between members of the family. Central to the fabric of all home networks is a software system called “middleware”. This software system allows connected information appliances to exchange both control information and streaming multimedia content.

Therefore the DH faces the implementation of middleware platforms for devices that should have the following properties that are needed in order to create “device communities” that can effectively interoperate to:

- Enable the plug and play operation in order to integrate enhanced devices without new configuration settings.
- Update new software and run multiple versions of it.
- Allow interoperability of services across a network of devices.

Broad industrial support for devices available in the market is needed. The problem is that the device market is so diverse that the task of implementing middleware is not trivial. Thus new Digital Home architectures should be investigated.

As a summary, access to services is currently limited. Most consumer devices support a pre-defined set of services, which limits the exploitation of the features offered by the device.

Furthermore, access to services depends on the location of the user requesting the service.

Two main functionalities will have to be realized to allow seamless service access:

- Terminal independence
- Location independence

Device independence consists of allowing to receive a service on a particular device and optionally to transfer the service onto another device, in a seamless and secure manner. The Digital Home platform will be able to adapt the content sent to the device onto different devices. For example, transferring a movie clip from a desktop PC onto a PDA should consider the device capabilities such as display size, resolution and the network capabilities (broadband, cables, etc).

Location independence consists of allowing users to access the same services they are registered to without any dependence on their location.

The concept behind this aim is to hold a certain number of "bubbles". Each bubble encompasses a user island where a user can consume the services he is registered for.

For example, one of the main bubbles in the service space is the Home Bubble, i.e. services which can be accessed by devices at home. An additional bubble is "On the Move", which is a bubble available on a user's device such as mobile/PDA while he is outside the home.

3.2.1.2. Digital Enterprise

There were almost 20 million enterprises active within the EU-27 in 2005 in the non-financial business economy. The overwhelming majority of these (99.8 %) were SMEs, with less than 250 persons employed. SMEs in the EU-27 employed, on average, 4.3 persons. This figure varied considerably between Member States from 12 persons per SME in Slovakia and 7 or more in Estonia, Ireland, Latvia and Germany, down to less than 3 in the Czech Republic or Greece.

67.1 % of the non-financial business economy workforce in the EU-27 was employed in an SME, while 57.6 % of the non-financial business economy's value added was generated by SMEs (see figure 15).

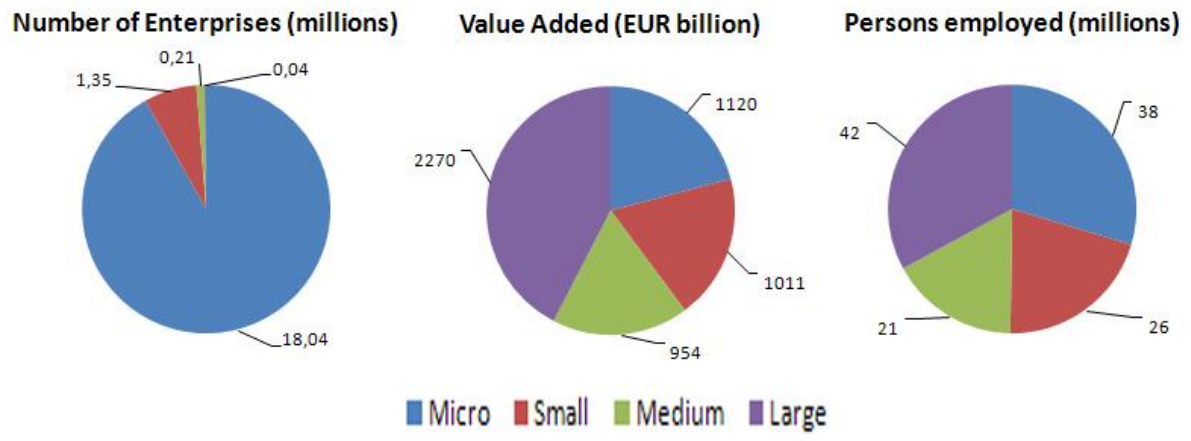


Figure 18: key indicators for enterprises in the non-financial business economy, EU-27, 2005

In order to improve these figures, more electronic information and business processes should be envisaged. Most SMEs, even micro companies, are using the Internet, but mostly still for communication and search of information, but not yet sufficiently for their business processes. For medium-to-large or large enterprises this is an easier to solve issue, but for SMEs, and especially for micro companies, this is still a critical challenge, which is not easy to solve. SMEs are very cost sensitive and are, therefore, often reluctant to buy adequate software or hardware or hire IT staff. Software-as-a-Service (SaaS) could be a perfect solution for them.

IT hardware and software developments are changing the business environment and concepts frequently and Software-as-a-Service (SaaS) is a new approach for providing IT capabilities, merging software and services. With SaaS, all the software and IT capabilities are hosted by a provider at a center, and subscribers do not bother with software, maintenance, licenses and other things. They do not even need to hire IT staff. They only need thin clients (regular PCs) and Internet connection. Once logged in, they can use all the services and programmes remotely.

The three main differences between the current, traditional, model and the SaaS model is licensing, location and management.

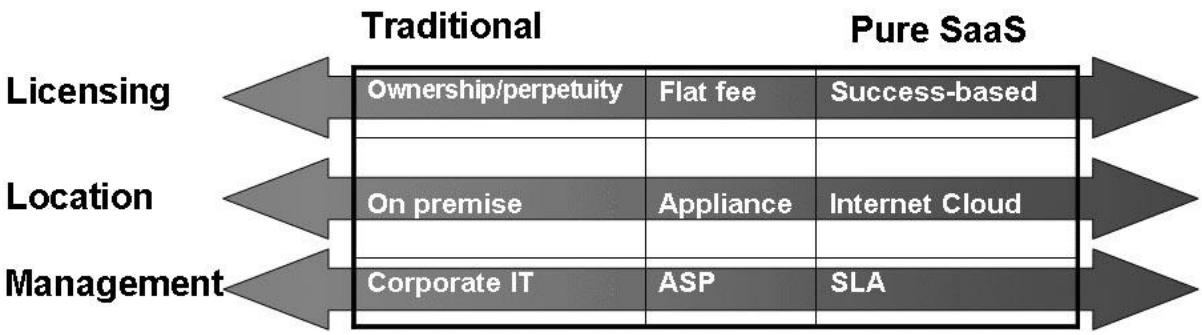


Figure 19: Traditional Software vs. SaaS

- **Licensing:** Metered licensing, the customer is only billed for the number of transactions used, which is called usage-based or success based licensing.
- **Location:** Everything is installed at a remote hosting location; the customer only needs an Internet connection and a Web browser to use the service.
- **Management:** Applications are completely managed (upgrade, security, performance, etc) by the SaaS vendor, customers do not need any internal IT staff.

All these features decrease the cost and workforce needed for IT software and services.

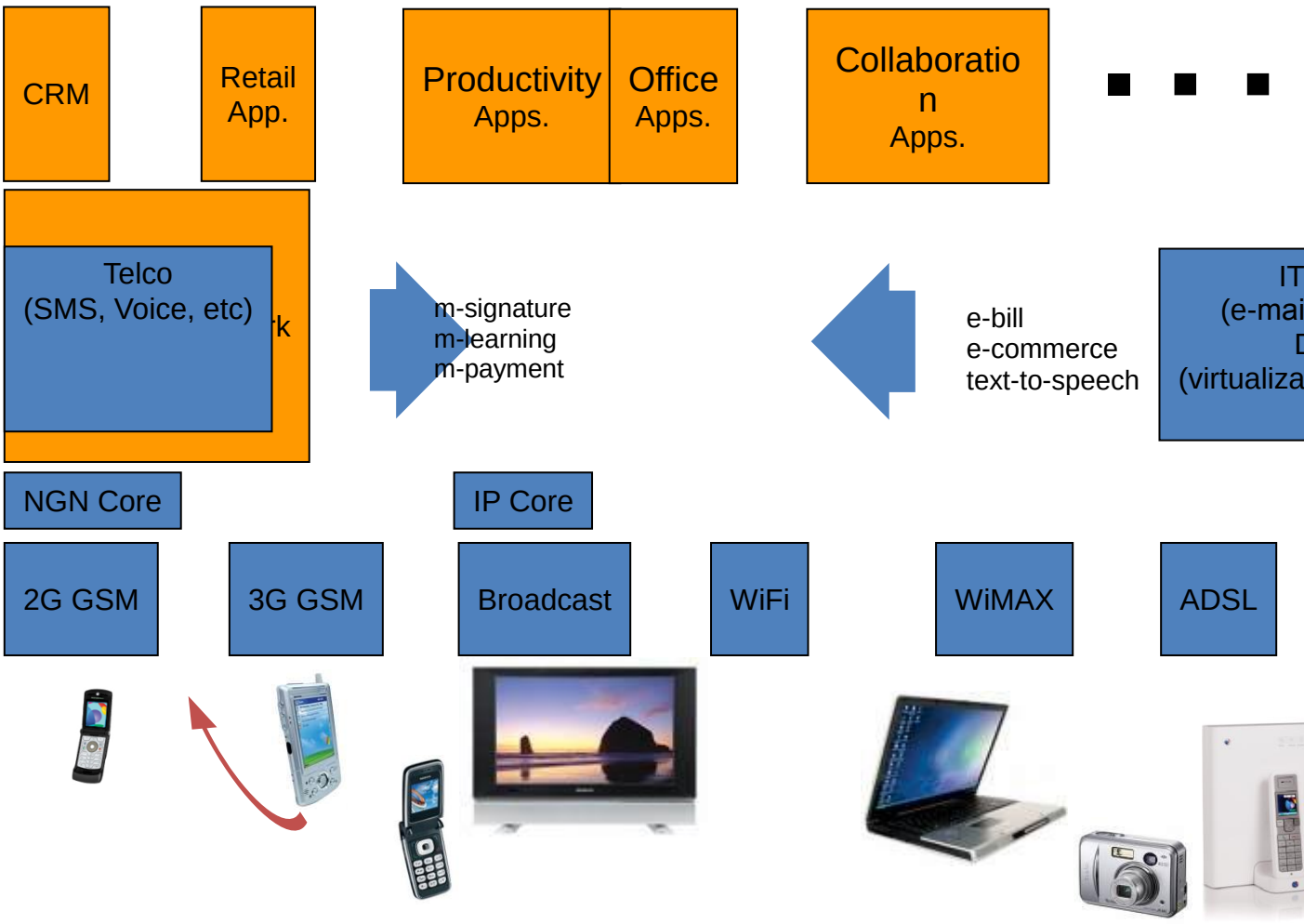


Figure 20: Vertical applications on top of IT-Telco framework

We believe that all the IT and telecoms services for SMEs should be provided as a single, cheap and pay-as-you-go package. With this package, SMEs will have a standard telephony solution, office programmes, basic CRM, mail, a Web site and also programmes specific to their working area. For example a pharmacy could have access to pharmacy programmes which can query drugs or drug stores; it could order with e-signed forms or send bulk SMS to its customers. And all these services are hosted services, so they do not need hardware or software investment or even IT staff. SME would just need a regular PC and Internet connection and pay for these services as much as they use these services.

3.2.1.3. Digital/ Smart City

3.2.1.3.1. Context Statement

Modern cities are places for interaction and commerce between people and places of aggregations and concentration of people, services and production of goods and ideas. ICT

technologies have started to profoundly modify the way cities are evolving or are being created. Future cities of the 21st century will be evolving towards vastly enhanced sustainable areas such as Smart buildings, Smart infrastructures (water, energy, heat, and transportation) and Smart services (health, Entertainment, etc.) for city dwellers and city travellers.

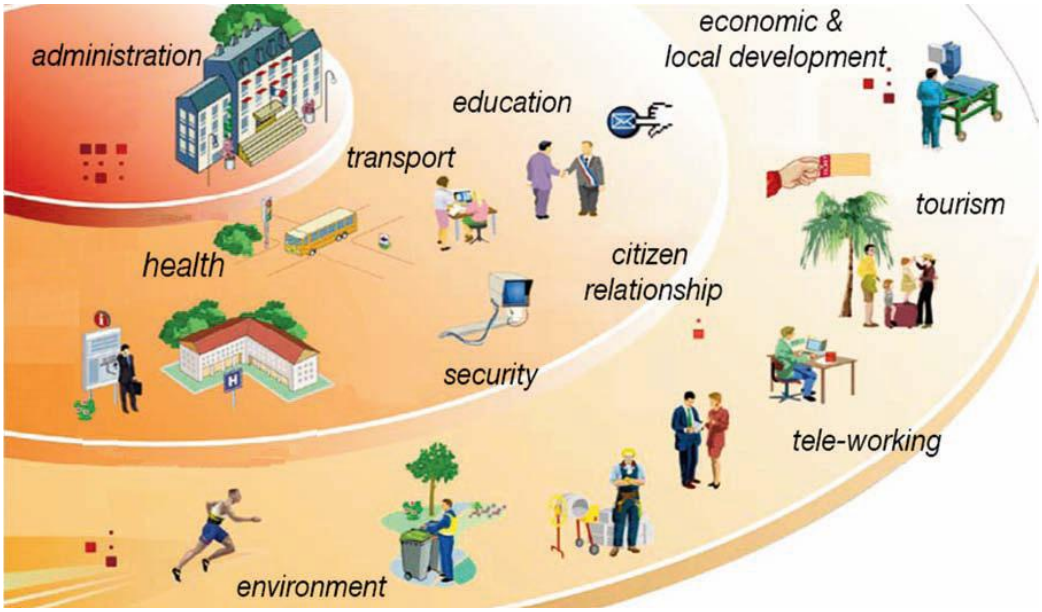


Figure 21: Future cities schematics

Future Cities will be immersed in a multitude of ICT technologies, ranging from ubiquitous communication and computing facilities over various kinds of actors and sensors to new modalities of user interaction like haptics, speech, lighting, smart materials and ubiquitous displays embedded into the environment.

All systems mentioned before are complex systems by their own, with huge challenges regarding their deployment, operation and maintenance. The full potential of smart cities however is only exploited by integrating the various domains. The major challenges include:

- Use-cases and business models across domains
- Standardization for integrating systems, services, actors and sensors
- Architecture and platforms addressing non-functional requirements like reliability, robustness and scalability
- User requirements, user-acceptance as well as privacy and security
- Deployment, operation and maintenance of highly distributed urban ICT infrastructures.

3.2.1.3.2. The way forward: smartness by degrees

If the potential to increase property efficiency and value seems overwhelming, it's important to understand that the Digital City can be created in easy progressive stages. There are four levels of 'smartness' in Digital Cities that can be introduced incrementally.

- **Network infrastructure**: the infrastructure for the single IP network must be considered during the planning stage and should be a part of the master development plan for maximum impact. The fibres should be installed during construction as an integral element of the building that can, at a later stage, control all the other utilities with the addition of active components (switches, routers and others) of the infrastructure.

- **Content & communications**: then at the next level the network lights up services for the city, delivering telephony, broadband internet access and video-on-demand over a single network. This includes such concepts as Smart homes, Smart hotel, and Smart Business.
- **Building intelligence**: next, intelligent infrastructure (buildings, public space, road, parking ...) come into place. Wireless sensors automatically control pollution, lighting, cleaning, waste… optimizing carbon footprint and reducing energy bills. Examples are City commodities and environment management, Mobility and transport, Smart building, and Smart energy grid.
- **E-services to citizen**: the final level is the public domain. The community is made safe by closed circuit television integrated with a communications system. Families can use WiFi services at Internet cafes or portals in shopping malls or civic buildings for information or transactions. During a day in the city a resident or visitor can buy movie tickets, pay for parking, place a bet, vote for a democratic representative, use a telemedicine facility, call up an intelligent transportation system – or just order a pizza online. This level includes such aspects as Information, Health (remote medical care and ambient assisted living), Education, Entertainment and Culture (museum, cultural activities), and Commerce and exchange (micro-payment et micro-commerce).

More details on content & communications, building intelligence and e-services to citizen are provided in the next paragraphs.

3.2.1.3.3. Building intelligence

City commodities and Environment management

A living city requires a lot of urban services such as cleaning and waste disposal, city light control, water and electricity network management, parking survey,….1000 sensors by km2 is the average for any big and middle European cities. Today, all this services are based on proprietary dedicated networks and technologies provided by different sectors and actors. This co-location and superposition of heterogeneous services and networks increases the complexity of management and is not optimal nor energy efficient.

Each service induces a few of traffic, mainly data exchange for tele-measurement and tele-control. But they have to be flexible and adaptable to the environment by being autonomous (ex: battery) or by using existing infrastructure (ex :city light).

Solutions offered to the cities have to be improved in terms of genericity and flexibility, scalability and efficiency, security and simplicity but also in term of energy efficiency of the solution:

- Development of unified network of heterogeneous sensors

- Optimized relations between physical networks (water, electricity, road, rails, parking, billboards, city walls, …), sensors networks and telecommunication networks
- Services towards users (guidance, alerting, ..) such as parking guidance
- Applications towards operators for control, supervision, maintenance and planning such as road traffic optimization, city light management, air control…)

Open thematic – challenges include:

- Standardized framework for M2M services deployment and management
- Open communication standard for any kind of sensors/actuators
- Unified network of heterogeneous sensors
- Open Mediation between sensors, actuators and applications,
- Optimization of cost position, energy consumption, size and installation effort.
- Control and processes optimization
- Efficient data handling

Mobility and transport

Future Internet paradigm might make truly possible the design of intelligent, adaptive, transport systems where a continuous gathering and distribution of reliable, real-time traffic information allows the management of the transportation networks.

This will not only allow for the transmission of critical information instantly to remote locations, but also and very importantly for the use of computers' crunching capabilities to turn masses of data into information.

This will be use for better routing planning and to avoid delays caused by traffic jams. Furthermore, this monitoring and processing of traffic information can foster the optimal coordination of the totality of transport modes following the principle of co-modality; applicable to both individual transport means and fleets as well.

This information shall be seamless around Europe, in the sense that multi-modal travel planners shall allow seamless travel in and between cities and towns and across borders.

There is a huge amount of information about the movement of goods and materials that could be better exploited to intelligently meet additional goals and requirements, such as quality and safety of food, security of locations, optimization of routes, business analysis and improvement, and so forth.

Open thematic – challenges include:

- Design and optimisation
- Circulation, communication, management, exploitation, performance indicators
- Load monitoring on multimodal systems, interoperability of networks and transport modes, supply chain, transport infrastructure performance

For a complementary analysis, please refer to section 3.2.1.5 on "Digital Car".

Shopping malls

Malls and markets can use multiple VoIP phones and business application on corporate intranets to check stock availability. They can stream video feeds on to in-store display screens and security cameras as well as chip-and-pin machines and electronic payment terminals.

Smart buildings

Office buildings already contain a number of networks: fire alarms, security alarms, door access controls, utilities monitoring, lighting systems, lifts, the heating and ventilation – a complex environment with high installation costs and limited automation. These services can all be run over the same network, delivering better performance for less cost. Accurate information gives owners the ability to save energy by offsetting peak loads. Intelligent buildings know when to turn off lights or turn down the cooling system and even before they are completed, developers are able to adjust internal temperatures for the comfort of building workers.

Converged networks increase capabilities and reduce costs. Many buildings that are currently being constructed have proprietary networks for communications, heating, lighting and air conditioning (HVAC) and security. In the Smart City, one network and one control centre can manage an entire campus.

The advantage of a converged scalable IP network is that new locations can be added easily, bandwidth can be rapidly increased, advanced technologies can be introduced without massive capital expenditure and new services can be added incrementally.

In the Digital City, individual buildings will not need to have individual controls systems – which save money through lower maintenance and easier upgrade. Shared communications reduces costs for tenants and negates the need to deploy their own services platforms:

- **Communications:** voice, data and video share one high-bandwidth network throughout the building and campus, enabling telepresence, collaboration, unified communications, video-on-demand and other rich media.
- **Flexible working and living:** conference room booking, "hotdesking", managing deliveries.
- **Security and safety:** building security will also share the network enabling video surveillance, access control and visitor management and fire safety. Parking and elevator control can also be integrated.
- **Environmental services:** heating, lighting and air conditioning (HVAC) will be automated, controlled by RFID sensors. Fire and smoke detection, lighting controls and energy management can feed into a unified campus control system over the converged IP network.

3.2.1.3.4. Content and Communication

Smart homes

In the Digital City, residents are able to connect to the network instantly, accessing millions of games, films, music tracks and countless other services. They can turn on the air conditioning from their mobile phones or check the family is safe by remotely accessing a home set-top camera. Assistive technology can give greater independence to the elderly or disabled. A home hub could wirelessly link multiple PCs and PDAs to high definition television, video and radio, with multimedia services like online gaming and music downloading available on demand. The

Smart City extends all of the home automation capabilities to outside of the home and your profile can follow you to any terminal within the Smart City.

Smart business

In a Digital City, multisite businesses can network voice, video and business critical enterprise applications. With the help of an international carrier, these can run seamlessly across corporate wide-area networks on different continents for intranets and secure collaboration, email and voice mail, conference calls and instant messaging. Unified communications makes it easy for employees to hot desk or work remotely. Managed firewalls, antivirus, storage area networking, remote access, messaging, and web hosting can all be added. Branches of multinational businesses will have all of the powerful communications tools that offices in London, New York or Tokyo have.

Smart hotels

Hotels in a Digital City can offer guests video-on-demand and IPTV as well as office services like video-conferencing, which can be billed on a per-use or monthly basis. In the public spaces plasma/LCD televisions, wireless access, digital signage and virtual reception can be provided. Add to these point-of-sale terminals in bars and restaurants, a front office booking suite, automated check-in and smart-card room locks. Room comfort settings can be delivered over IP phones and smart bathrooms let management know when supplies run short.

3.2.1.3.5. E-Services to citizen

The need for physical human resources and dedicated resources for the management of offices can all be optimised by providing online access to voting, birth certificate applications, tax payments and so on. On-campus hospitals can be created with telemedicine in mind – outpatients can have their heart rates, blood pressure, insulin levels monitored and recorded remotely with the vital statistics fed into telemedicine control systems. Schools and universities in the Smart City support distance learning and rich media and lectures with professors around the world can be conducted via telepresence. In a Future City, smart government and public services mean the pubic are healthier, better educated and disasters can be prevented or mitigated. The crime rate can even be reduced.

E-Services to Citizen addresses all the web services that could be offered to the citizen, such as

- Information
- Health : remote medical care and ambient assisted living
- Education
- Entertainment and Culture (museum, cultural activities)
- Commerce and exchange (micro-payement et micro-commerce)

Other areas of interest are as follow:

- **Digital identities**: a single identity for all services? On-line citizenship (e.g. : on line municipalities meeting), eMunicipality : web based services for urbanism, taxes, school, …; Unified Pass for transport, sport (access to training and events,..), culture (access to museum, access to training, events,…); eVoting.

- **Paperless information**: City-Wall including contextual information (localisation and time related), Paperless local and regional newspaper and municipalities' information, User generated newspapers.
- **Ambient Assisted living (distinct from at home hospital)**: home communicating objects based AAL services (activity monitoring, guidance, instruction, agenda...), robotics based services for AAL (aging or disabled population), eInclusion services: telephony, TV, web, dedicated communities.
- **Remote medical care – at home hospital**: tele monitoring modular remote illness management tool, hosted on the Internet, Semantic interoperability of medical information and services
- **Commerce and exchange (micro-payement et micro-commerce)**
- **Tele- working**
- **Education**
- **Entertainment and Culture (museum, cultural activities)**

3.2.1.4. Digital School

Educational approaches are always influenced by advances in technology. Web technologies have made profound impacts on distance education due to their accessibility to both the end users and content creators. The Web has eased the delivery and consumption of educational material by breaking the physical and temporal barriers present in traditional educational contexts. Distance and asynchronous models of education became affordable and convenient.

The global proliferation of mobile devices presents many new opportunities for information and communication (ICT) applications. Mobile phones are of specific interest in that they are increasingly powerful and pervasive in modern life. Mobile phones are treated as highly personal devices that travel with individuals. This is in contrast to other information devices that are more likely to be shared. These characteristics suggest that these devices may be well suited for educational purposes. Their accessibility allows educational activities to take place anywhere when it is convenient. Their personal nature allows tracking customization and tracking progress. There are several challenges, such as their limited screen real estate, bandwidth and power capacity. These constraints call for appropriate approaches suitable for the mobile support for blended learning.

For digital schools and mobile supported learning, the following issues should be handled in the future:

M-LMS (Mobile Learning Management System)

LMS is a commonly used standard e-learning platform utilized in many schools, universities and corporations for the aim of e-learning. LMS enables the responsible parties (school, university) learning contents to employees and to keep track of the progress. Once the content is decided to use, it is assigned to selected employees/students. For the M-learning case M-LMS or LMS integration shall be necessary reporting for the tracking the progress of m-Learning.

Data Charging and Operator Independence

Appropriate charging policies are essential for successful products and common use. M-Learning can be exploited on the mass market if the data costs can be set accordingly. This enables corporations to provide free m-Learning content not only to their employees but also to their customers. This could be an important lever for achieving widespread acceptance of m-Learning by large audiences.

Multimedia and Client Architectures

Adobe Flash™, XHTML and Java can provide the media of educational content. This design decision needs justification. There are a number of choices of media for content in m-Learning platforms. One possibility is to use a client that is downloaded and installed to the phone to view the content. For example a Java Micro Edition-based system would work this way. The disadvantage of this approach would be clear if one considers the case that a user wants to use m-Learning content from a number of m-Learning providers. Every provider asks the user to download its own viewer client. Another problem with the client approach is to get a client working virtually on all phones consistently. It is unfortunate that even well-known stable platforms, such as Java Micro Edition, have differences from phone brand to brand. It is not a surprise that the same client has different behaviours on two different phones of the same brand. This is the reason why many Java games have different versions for different phones.

Due to these considerations, an approach that avoids installation may be preferred. The content should be prepared in such a way that it can be viewed in some horizontal viewers that the phone comes with them as in the case of Java runtime environment. One such viewer is HTML browsers. Recently Adobe Flash™ has become widely available on mobile phones. XHTML is an open standard whose viewer comes with virtually every phone. Although XHTML is very suitable media for m-Learning, it is limited in terms of animation and interaction. For contents that requires rich interactivity and animation, Flash is the preferred platform. Huge success of Flash on the web and a big number of Flash developers are advantages. On the other hand, a Flash player is not as common as HTML browsers in phones.

User-Generated M-Learning Content Development

Horizontal subjects, such as time management, are relatively easy to obtain from third party content providers. Sector-specific subjects, such as credit card application procedures of the banking sector, are not so readily available. Company-specific content is highly vertical and virtually unavailable from third parties. The latter type of content is of real interest in the corporate context. Consider a pharmaceutical company that wants to train its sales force regarding its new drug. The relevant information to convey would consist of the specifications of the new drug, its positioning, its competitive advantage, and its pricing. The speciality of this information and confidentiality concerns would motivate the company to prepare their training material internally. There is a need for suitable tools to assist the development and management of such educational packages. Such a tool must provide suitable assistance for the creation of user-generated content. It must be easy and accessible for it to be effective.

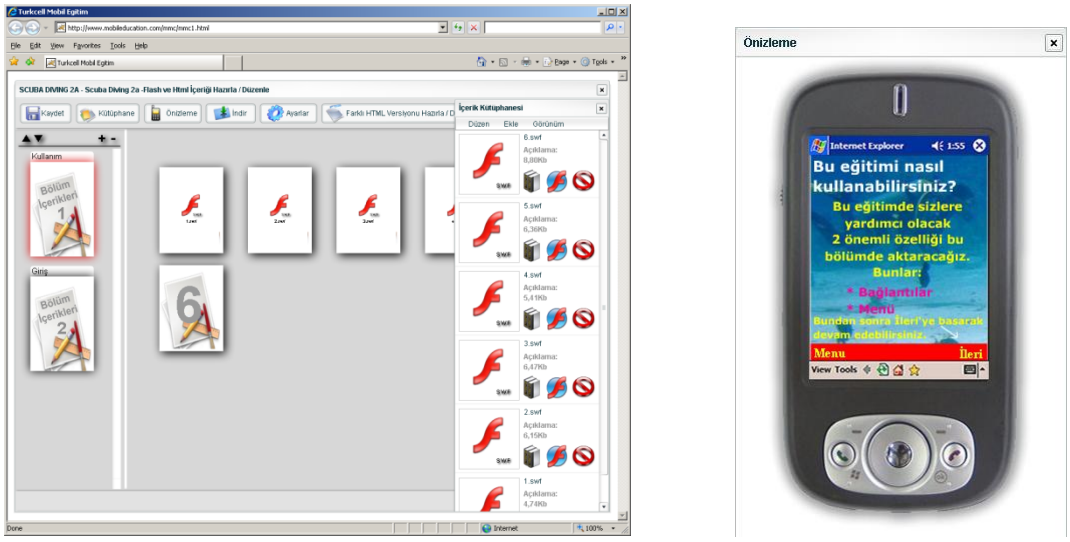


Figure 22: EduMob content development tool and content on a phone

The advanced solutions should support mobile content creation, lesson management, lesson distribution in a context that combines the advantages of the Web and a mobile network operator. The mere availability of platforms is insufficient for obtaining sufficient quantity of high-quality educational material. For that, an ecosystem of content providers, good mobile educational content practices, and m-learning standards are needed. As applications of m-Learning are in their infancy, the market cannot support content providers, yet. Therefore, until the market becomes mature enough, support for early content providers is necessary.

The media types supported by this platform are the ones that are immersive and successfully being used on mobile phones.

- **Text.** Text is the minimum requirement for learning.
- **Audio, Images and Videos.** Well designed multimedia presentations can increase enjoyment and comprehension. Well chosen media can be more interesting. Various media types can reinforce each other.
- **Flash Movies.** Flash can be used to animate temporal or sequential concepts. It can also be used for high quality user interactivity.
- **Quizzes and Surveys.** Quizzes and surveys can be designed in order to measure learner comprehension. The results of quizzes and surveys can be reported to the developers to assess the success of the educational package.

E/m-learning platforms

Educational approaches are always influenced by advances in technology. Web technologies have made profound impacts on distance education due to their accessibility to both the end users and content creators. The Web has eased the delivery and consumption of educational material by breaking the physical and temporal barriers present in traditional educational contexts. Distance and asynchronous models of education became affordable and convenient.

E-learning has been defined as "pedagogy empowered by digital technology". In some instances, no face- to- face interaction takes place. *E-learning* is used interchangeably in a wide variety of

contexts. In companies, it refers to the strategies that use the company network to deliver training courses to employees.

The economic crisis will complete e-learning's transition into a standard venue for course work. In 1999, 12% of instructors used some form of e-learning technology to support teaching and learning. The Gartner 2008 e-learning survey showed that more than 55% of all courses offered were fully online or hybrid courses. According to the survey, the top motive that respondents cited for using e-learning was "meeting student demand," followed by "providing pedagogical advantages" and "meeting faculty demand."

Many universities will want each instructor to offer at least one course completely online per semester. Ten years ago, such a request would have sparked protests, but instructors have several reasons to accept it now:

- In some situations, the university's viability is at stake, and the faculty won't want to jeopardize it.
- A growing percentage of faculties are less suspicious of technology; rather, they see more of the value.
- Technology can make life easier for teachers. For example, e-learning will enable them to avoid teaching classes on late Friday afternoons, when students' energy and attention are low.

Most CIOs can do a better job of implementing and supporting e-learning. According to the Gartner 2008 survey, at least 80% of institutions have adopted a single, standard, campuswide elearning platform (mostly because it's easier for faculties and students to use). However, university IT organizations can improve in other ways:

- Only 22% of universities that use commercial e-learning software as their primary platform for course delivery use external service providers to implement and upgrade the software.
- Fifteen percent of institutions don't provide any instructions or training for students on how to use the e-learning platform (and 3% of institutions still offer no training for faculties).

Figure 1. Current Percentage of Courses Taught as Purely Remote, Hybrid or Traditional, Face-to-Face

Source: Gartner (March 2008)

Much effort has been put into the technical reuse of electronically-based teaching materials and in particular creating or re-using Learning Objects. These are self contained units that are properly tagged with keywords, or other metadata and often stored in an XML file format. A common standard format for e-learning content is SCORM whilst other specifications allow for the transporting of learning objects.

Advances in mobile devices and new media are fuelling explorations for more effective methods for education. M-Learning is still a new research field requiring much research. There are few widely accepted results thus far. The global proliferation of mobile devices presents many new opportunities for information and communication (ICT) applications. Mobile phones are of specific interest in that they are increasingly powerful and pervasive in modern life. Mobile phones are treated as highly personal devices that travel with individuals. This is in contrast to other information devices that are more likely to be shared. These characteristics suggest that these devices may be well suited for educational purposes. Their accessibility allows educational activities to take place anywhere and when it is convenient. Their personal nature also allows customization and tracking progress. Naturally there are several challenges, such as their limited screen real estate, bandwidth and power capacity.

Explore M-Learning: Educators have been experimenting with m-learning for some time, but several factors combine to make this a good time for corporations to explore its potential. These include:

- Device economics and capability
- M-learning maturity is increasing
- Mobile and teleworking trends
- Efficiency and cultural alignment

Opportunities and Examples: M-learning is a broad concept best illustrated by examples. The following list is by no means a complete taxonomy of m-learning but is intended to illustrate the breadth of the opportunity:

- Low-cost mass learning
- Low-cost education as a service
- Contextual and exploratory learning
- Media delivery
- Surveys, exams, questionnaires, data gathering and feedback
- Storage and delivery of reference documents
- Time-sensitive learning
- Information feeds and fragments
- Web and portal content
- Creating learning material
- Community collaboration and communication
- Learning support and administration

With opportunities of mobility, despite its immaturity, m-learning offers a wide range of ways to deliver education, training, testing and documentation. It also enables most organizations to find some m-learning techniques relevant to their needs.

3.2.1.5. Digital Car

Context and Problem Statement

Worldwide, the transport sector is facing three major challenges: safety, efficiency and sustainable mobility. Concerning safety, in Europe alone, road accidents accounted for over a million automobile accidents, with 40,000 dead persons per year (figures of 2005), 1,700,000 casualties and 160 billion euros in economic damage.

In this context, Intelligent Transport Systems and Services (ITS) are very strong candidates to help make transport safer, more efficient and competitive, more sustainable and more secure.

Two key issues must be accomplished for Europe to take advantage of the benefits offered by ITS. First, cars and roads shall be connected. Second, a pan-European ITS system must be built from current local, regional or national systems. The first issue deals mainly with vehicle-to-vehicle and vehicle-to-infrastructure communications, as well as with the pan-European emergency system (eCall), with a strong focus on safety and efficiency, which are part of the current Action Plan for the Deployment of Intelligent Transport Systems in Europe [AP08]. The second issue encompasses the interworking of legacy systems and local services, such as traffic and travel information, as well as the provision of real-time information to foster transport co-modality and allow for the improvement of efficiency and sustainable mobility.

Celtic/Celtic-Plus involvement

The future ITS systems and services, that is, the future Intelligent Transport, will be intelligent, adaptive, context-aware and self-healing. All the road transport elements – vehicles, roads, drivers, passengers and road/traffic/transportation managers – will form a 'network' that will combine loads of information, and various technologies, such as communications, data mining

and ambient intelligence, with the common goal of building tailored ITS services for the different users of this 'network'.

- Safety: pan-European interoperability and vehicle compatibility of advanced emergency/assistance ITS systems and services, including contextual information.
- Efficiency: application of pay-per-use concepts to road transport, ranging from on-the-fly parking management to adaptive road management.
- Sustainable mobility: seamless co-modal transport for freight and passengers.

The introduction of an electronic system in the vehicle to automatically call emergency services in the event of an accident is one of the key applications being promoted. This pan-European ITS service shall come into force in the short term (2010-2011). Intelligent Transport will in the short term strive to make eCall a reality, complementing the activities of the eSafety Forum. In the mid- to long-term, Intelligent Transport will aim to provide more advanced safety services, by boosting the evolution of eCall and bCall (breakdown call) services based on novel technologies, such as advanced vehicle-to-vehicle communications or context information.

Another big issue in future ITS applications and services is the concept of pay-per-use applied to transport, which shall lead to sustainable mobility with transportation intelligence.

Furthermore, European enterprises increasingly require optimal logistics to ensure their resources are used as efficiently as possible. These optimal logistics rely on seamless co-modal transport networks where all modes complement each other.

3.2.1.6. eHealth

European trends show that populations are getting older, and there are an increasing number of illnesses, especially chronic illnesses. This fact has produced increasing health expenditure.

In addition, patients are not passive actors in the healthcare loop; they require better information about their diseases. It is mandatory to empower patient role in treatments and improve relations with the health professionals.

The introduction of ICT in healthcare (eHealth) has and will continue having a great impact in the medical field. These services and technologies have already allowed a reinforcement of patient monitoring and acquisition of medical data, a more personalized treatment, an empowerment of patients in the medical loop, and an improvement in the follow-up and treatment of elderly people and chronically ill patients.

A secure and trusted communication environment must connect monitoring devices or sensors with hospital information systems. Information systems will collect and integrate patient information, providing a more personalized treatment. Medical professionals and patients will have real-time communication and access to the information.

eHealth solutions might provide with tools and solutions to tackle these challenges. Among the key issues that must to be overcome:

- Management and interoperability of Electronic Health Records (EHR)
- Interconnection of hospitals and medical team remotely
- Extreme guarantee of privacy and confidentiality of data

- Enhancement of remote care of patients (specially for chronic diseases and elderly people)

In order to foster the introduction of ICT in the health system, the following areas must be explored and developed:

- **Enhancement in the healthcare processes and operations**. ICT must be used to improve the physicians' daily work when in the hospital. That should be achieved by:
  - Designing collaborative tools.
  - Improving medical image management (3D)
  - Protecting asset sharing
  - Sharing multimedia content in real time
  - Handling smart data storage – trend analysis
  - Using e-prescriptions
  - Electronically tracking of medical devices
  - Enhancing Interoperability and standardization of computer-based medical systems.
- **Management of monitoring and treatment of chronic diseases by means of Telecare-Teleassistance**. Adaptable and customizable services must be developed, improving and personalizing the treatment and management in this kind of diseases. The developed solutions will be based on "smart environments" (ambient assisting living, specific communication tools, alarm systems, etc) where the patient becomes an active part in the medical loop.

  Telecare service will be obtained by adding mobile communications which also enables coverage outside the home, mobility, location, security, fall detection for the elder and family, eliminates the shortcomings of "in home" Telecare.

  Improved in-home Telecare and tele-hospitalization will be provisioned by adding broadband and video allowing real-time visual communication and interaction, including remote interaction. This service might be enhanced by adding features such as vital signs monitoring (automatic monitoring with established thresholds that trigger alarms), alerts, telepresence of health care professionals, remote medical administration monitoring, medication reminders, appointment reminders, location tracking, etc.

  To respond to the aforementioned needs, the following technical issues (enablers) must be tackled:

  - Ontology development and semantic application of medical information systems
  - Interoperability of data
  - High definition images for better diagnosis (3D)
  - Machine to Machine communications. Use of sensors for remote monitoring
  - High capacity networks to transfer huge amount of medical data (images) between different locations, reliability of networks
  - Security and privacy
  - Use of RFid for identification purposes (equipment, devices, etc)

3.2.2. FUTURE SERVICE ENABLERS

3.2.2.1. Future Service Platforms

Open Platforms SOA (Service-Oriented Architecture)

Service Delivery Platforms. The present concept of global service delivery platform should go beyond the client/provider service model to support mechanisms of global service supply where third parties or even the user will have the capability to aggregate services, act as intermediaries for service delivery and provide new channels. Under the Telco2.0 model, some operator capabilities can be accessed by the user by means of common web2.0 technologies (Ajax, JavaScript, PHP, etc.) to create a variety of mixed services involving communications, social networks, MM content sharing, etc. Besides, Telco2.0 approach can take advantage of the transformation of most operators' network towards NGN, and benefit of IMS technology bringing new capabilities to the network, and empowering it into a new dimension.

In fact, Service Delivery Platforms should evolve to become Service Delivery Frameworks (SDF) and services should evolve to become Managed Services. Managed Services provide not only functional but also management interfaces which allow their management across domains. SDFs provide the framework to manage end to end the service lifecycle across domains. SDFs extend management processes across SDPs of different service providers. SDFs and Managed Services enable the birth of open markets of services on the Internet (where a service provider can syndicate its services to the SDFs of other service providers to be reused or resold withouth loss of control of the customer experience).

The open platform concept has to be extended to include SOA for value added services. Semantics is a very good tool to enhance service descriptions allowing automatic composition.

EDA (Even Driven Architecture) will complement SOA in customized complex services, creating complex added-value services for sensing and reacting to situations typical of compliance, logistics and finance services.

This tendency of incorporating new functionalities as required by the applications will lead to the new SOA/Web 3.0 that will include new features that have to be fully developed and used:

- SOA for things
- Indexing of internal applications
- Semantic services
- Automatic behavior

The above-mentioned vast amount of information, coupled with the incorporation of data coming from the huge amount of sensors being deployed (the "sensor web") will preclude human processing; therefore in the application space, it is increasingly becoming a matter of machine-to-machine communication. A large share of the future Web will consist of systems talking to systems, not to humans.

Semantics is widely thought to be the "unifying glue" that will put together all the bits and create the overall intelligent interconnected network, hence the vision of the Semantic Web. However, the development and application of semantics is facing challenges such as those

related to scalability (semantics must adapt to extend its scope and deal with data that is of increasing complexity) and the problem of generating useful, selected information from the huge amount of existing information.

Internet computing. This area includes the virtualization of infrastructures through more flexible and granular optimization of computing and storage resources. Those "on the net" resources shall also be used by enterprises, using on demand models, that would allow dynamic and intelligent accounting.

Platforms for sensors and actuators

Sensor and Actuator Networks (SAN) will play a key role as a horizontal technology for delivering information about and enabling interactions with the physical world for the next generations of highly autonomous and adaptive Internet services and applications. Current SAN deployments are still low in numbers and represent heterogeneous, vertically closed solutions. Tomorrow's ubiquitous world of tags, sensors, connected objects and smart systems can only be achieved, if existing and future SANs can be integrated into a scalable real-world information and interaction fabric, connecting the current Internet with the physical world.

SANs will play an important role at the edges representing an inexhaustible resource for real world information. True real-world awareness can only be achieved if information concerning the physical world can be captured in an automated fashion, ideally in real time with respect to arising demands. Moreover, recent advances in research on ambient intelligence and semantic technologies will enable more autonomous ways of interaction of computer systems with each other, with humans or with their environment. By integrating semantic capabilities, context-awareness and reasoning mechanisms into the service layer of the Future Internet, the autonomy of computer systems or networked services can be greatly enhanced. These technologies will serve as building blocks for a new generation of highly distributed services based on efficient information and autonomous machine-to-machine (M2M) interactions, reducing the need of human input.

The current development of Short Radio Wireless Network, among which Wireless Sensor Networks represent the most popular ones, envisions a myriad of future innovative applications based on the interaction between physical (sensors/actuators) and digital worlds. New Sensor and Actuator Network (SAN) capabilities and progress in sensor miniaturization, enabled by advanced nanotechnology, will allow sensing enriched user contexts, providing a huge potential for developing revolutionary context-aware services. Recent economical forecasts reveal an increasing number of business opportunities expected for a wide range of industries: medicine, agriculture, energy, utilities, environmental, telecommunications and defense, among others.

As Sensor & Actuator Networks (SAN) mature and are increasingly deployed, more and more SAN-based services require a paradigm shift from current application-specific sensor networks towards more complex infrastructures and platforms, built on highly interconnected heterogeneous, dynamic and geographically dispersed nodes. In that sense, the ITU vision of the Ubiquitous Sensor Network (USN) depicts an innovative framework for ambient sensor networks "not as simple sets of interconnected networks but as intelligent information infrastructures".

In this challenging technological environment, as a myriad of innovative services are being conceived, major telecom network operators are committed to design and develop a new generation of architectures to support real ubiquitous services over Next Generation Networks (NGN). Therefore, important technological innovation efforts should be devoted to define new Service Platforms for Future Internet approaches that enable both telcos and third-party service providers to deploy applications related with physical world interaction, with homogeneous access to USN infrastructures.

Finally, it must be pointed out that although SAN applications are being increasingly developed (consider, for example, M2M applications), the market growth-rate is slower than expected due to the lack of standardization in this field dominated by vertical solutions, and/or proprietary solutions. Therefore, an important issue in this area should be to promote new standardization initiatives such as the recent ETSI Technical Committee on M2M Communications. Beyond current individual vertical solutions, standardization is required to provide economies of scale in order to reduce the cost of deploying future value-added end-to-end solutions.

Services should be available to interact with t 'smart objects' over the Internet, query and change their state and any information associated with them, taking into account security and privacy issues. Through the development of a Global Ubiquitous Sensor Network Platform, services will be embedded in the operation environment, and objects will become gateways to services. Physical world data from SANs will be properly processed and annotated so each particular service could link it to its specific service-dependent semantic or context framework. The aim will be to provide semantic and logical abstractions for any physical or virtual entity that can provide directly or indirectly information related to the real world or enable interaction with it; for example, entities that may combine information (e.g. aggregation, fusion, inference) from multiple resources; examples: sensors to deliver some high level context of the real world, or resources that realize control loops by means of other sensors and actuators.

3.2.2.2. Future interfaces

Key priority challenges in this area include:

- Intuitive interfaces
- New immersive 3D experiences at the frontier between real and virtual worlds: 3D World Tools
- Widget gadgets mush ups

Among the future interfaces, a specific place has to be contemplated for the 3D approach. This covers intuitive interfaces, new immersive experiences at the frontier between real and virtual worlds, and 3D world tools.

Solutions are now considered to introduce 3DTV services. The starting point will be stereo TV (2 views, with glasses), but technologies without glasses will follow. The field related to mixing real and virtual contents, known as Mixed Reality, encompasses various domains such as video games, augmented reality and advertisement. As computers become omnipresent in our everyday life (workstations, laptops, SmartPhones …) and tend to have permanent access to

each other through various networks (ADSL, WiFi, 3G …), an emerging yet promising trend relies upon the concept of massive multi-user online mixed reality worlds.

The priority challenges in this area include:

- Solutions to render 3D stereo and Multiview on 3D Displays,
- Optimization of the visualization experience by understanding 3D human factors,
- Rendering algorithms to adapt the incoming content to the display performances
- Enhancement of the HDMI standard to take into account 3D content.
- Novel 3D user interfaces to support new 3D rich media content and 3D interactivity.
- Large sceneries, realistic avatars and intuitive interaction systems for a unique immersive experience.
- A method for efficient delivery of 3D objects (3D content compression and encoding).
- Innovative online QoE monitoring solutions that address the end user's experience.

3.2.2.3. Multimedia enablers

Audio/Video/Image Processing

Among the various technologies that will shape multimedia in the coming years, 3D will play an important role. The increase of computing power makes it now possible to process the very content of images, either in order to display it differently from various viewing angles (this leads to stereoscopic multi-viewing), or even to interact with the content (virtual reality, mixed reality).

Much has still to be designed in order to make that 3D technology popular especially when "natural" scenes are contemplated. As a matter of fact, the creation of 3D content is still in its infancy and must be developed in order to supply the various 3D TV systems with relevant material at an affordable cost.

The priorities to be considered within this activity concern:

- the design of innovative 3DTV solutions (with and without glasses) for TV and cinema applications
- systems to acquire 3D contents from several cameras and relevant post-processing
- Processing (mixing, switching, special effects etc) of 3D TV material
- Coding, Storage and Distribution of 3D materials

Multimedia Search

The Internet is globally becoming the common access mechanism to information anywhere, anytime. Web 2.0 services like blogs, podcasts, YouTube and Flickr show that more and more individuals are also becoming content providers. In addition to this, a high amount of digital video and audio content (increasingly due to user generated content) became publicly available over the years. By having more and more digital content available, the ability to deliver rich information to customers has increased.

But at the same time, the problems of management, delivery and retrieval of these audiovisual contents are rising. We require smarter, faster and more powerful search engines. Furthermore the amount of rich media prepared to be delivered to mobile devices is rising every day. As

mobile phones offer more and more information – news, photos, video clips, music downloads – finding what you are seeking can be a big challenge. A few percent of wireless users download some type of multimedia content, and it is believed that is because people can't find easily the content they are looking for. So Google, Yahoo and startups are developing search tools in order to optimize search results. But smaller screens, tiny keypads, limited memory, processing power, high bandwidth cost and the user's impatience to wait for downloads and scroll through pages of search results still pose technical challenges. Finally, search technologies and services play a significant key role in the mobile area in order to boost content download and create new growth momentum across the European mobile communications market. Mobile search facilities will become an indispensable instrument for end-users to access information that suits their needs in a specific context (e.g. date, place, mood) or provide content by taking into account our current situation, preferences, search history and intentions. According to eMarketer, the number of mobile search users is expected to grow to 55.8 million in 2011 in correlation to the increase in mobile Internet users (see figure 23).

US Mobile Internet Users, Mobile Search Users and Mobile Search Advertising Revenues, 2006-2011 (millions)

	2006	2007	2008	2009	2010	2011
Mobile Internet users	27.0	31.1	36.0	42.9	52.3	64.8
Mobile search users	20.3	23.3	28.8	35.1	43.9	55.8
Mobile search ad revenues*	$2.1	$13.5	$48.1	$155.7	$307.4	$713.7

*Note: *earned from sale of display or text listings alongside mobile search results*
Source: eMarketer, July 2007

085441 www.eMarketer.com

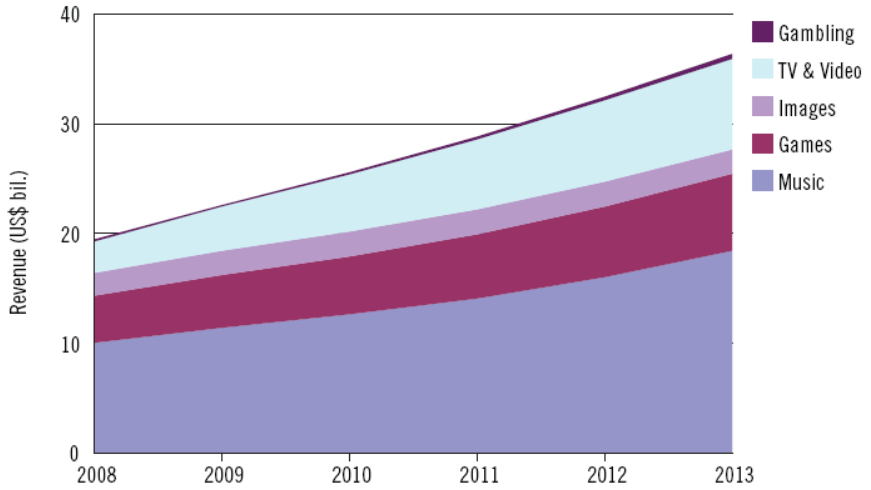
Figure 24: mobile search evolution (courtesy of eMarketer)

The increasing penetration of 3G/HSPA mobile networks across many European countries and the interest of major mobile operators in investing in next generation mobile networks like LTE in Europe will boost the adoption of multimedia and user-generated content in the mobile market.

3G/3G+ devices are critical for the consumption growth of rich mobile content and multimedia services. 3G devices provide advanced functionality to deliver a richer media experience. In addition, users download, stream or browse via their mobile phones and through mobile broadband networks. The mobile phone is becoming crucial for contents and services designed to enhance daily life of mobile consumers in a practical or entertaining way, with services such as Mobile Internet, TV & video, games and music. Finally multimedia content will become more and more important. This content will be accessed from different types of devices, including the MID, mobile PCs, phones, cameras, etc. Some analysis results give us an indication of future trends. For example Informa Telecoms & Media forecasts that the global total revenues of mobile

entertainment services will increase from US$19.5 billion in 2008 to US$36.3 billion in 2013 as shown in figure 25. Mobile music will get the largest portion of revenue among entertainment categories.

However, te strongest growth is expected in mobile TV and video services, which will grow from a smaller base of US$2.9 billion in 2008 to US$ 8.3 billion in 2013, a compound annual growth rate (CAGR) of 23.7%. Informa Telecoms & Media estimates that total mobile video download will grow from 1.3 billion in 2008 to 8.4 billion by 2013. The highest CAGR (82.1%) in this period is expected to be in India which will grow from 26.6 million mobile video downloads in 2008 to around 532.9 million downloads by 2013. Global users for mobile video downloads are expected to grow from 46.8 million at the end of 2008 to over 207.5 million users by the end of 2013. China, India, Japan, the US and the Western European markets are expected to account for around two thirds of the total number of users throughout the forecast period.



Source: Informa Telecoms & Media

Figure 26: total revenues of mobile entertainment services evolution (courtesy of Informa Telecoms & Media)

Downloads (mil.)	2008	2009	2010	2011	2012	2013	CAGR (%)
US	229,9	319,3	421,1	582,4	847,2	1255,7	40,4%
Canada	11,6	15,6	21,9	34,3	55,9	87,3	49,8%
Brazil	24,4	32,7	43,7	62,1	94,9	153,4	44,4%
Rest of Latin America	46,9	64,5	84,9	116,5	171,5	273,9	42,4%
Japan	185,0	253,7	339,3	466,8	623,4	785,5	33,5%
South Korea	91,9	123,3	154,4	200,0	257,6	320,2	28,4%
Rest of Asia Pacific	40,3	58,1	82,0	122,2	184,1	264,5	45,7%

(Developed)							
China	135,6	202,3	294,1	432,6	666,6	1.068,3	51,1%
India	26,6	48,4	84,9	148,0	272,6	532,9	82,1%
Rest of Asia Pacific (Other)	60,8	105,8	167,9	259,8	402,6	624,1	59,3%
France	41,6	55,3	74,2	112,0	182,6	292,1	47,7%
Germany	44,7	71,2	114,7	200,6	334,3	483,6	61,0%
Italy	41,6	56,8	77,7	116,3	176,8	255,5	43,7%
Spain	33,2	47,7	66,6	99,0	148,6	212,2	44,9%
UK	51,3	71,4	100,2	152,8	239,2	350,8	46,9%
Rest of Western Europe	81,9	108,6	143,3	206,3	306,4	438,9	39,9%
Russia	18,6	27,9	40,0	58,8	93,1	156,7	53,1%
Rest of Eastern Europe	49,0	73,5	105,9	155,6	236,6	361,8	49,1%
Africa	15,6	27,5	46,1	77,6	131,5	224,9	70,6%
Middle East	31,9	53,7	80,7	121,2	186,6	291,3	55,6%
Total	1.262,4	1.817,2	2.543,7	3.724,7	5.612,3	8.433,8	46,2%

Figure 27: global mobile video downloads, by country, 2008-2013 (courtesy of Informa Telecoms & Media)

Most network operators act as a walled garden by offering only their own or branded content to their subscribers. They do not permit subscribers to leave their contents and let them search via their mobile phone for other contents. Some operators are more open to accommodate the users' content. Mobile market dynamics are changing, and mobile search will play a critical key role in this environment, as mobile search can help providers increase their revenue.

Finding an appropriate business model for the mobile operators is the biggest challenge to focus on. Mobile search advertising, data traffic or premium content revenue are the possible ways. Advertising opportunities within mobile search are expected to increase rapidly over the next few years. eMarketer estimates that mobile search ad revenues in the United States will hit the $714 million mark in 2011 (up from $48 million in 2008). The same forecast anticipates that global mobile search marketing ad revenues will reach $2.3 billion by 2011 (16.6% of the total mobile advertising spend). In addition, the forecast said that the mobile advertising market should reach over $13.8 billion worldwide by 2011. Regarding revenue sharing models, novel approaches on positioning value chain players should be worked on. The development of innovative business models should be a critical area for mobile search.

The concepts and features Celtic-Plus should focus on in the multimedia search domain include:

- Research and Development of multimedia search engines and platforms that have strong modelling, capturing, transferring and retrieving of n-dimensional digital multimedia data objects. This includes such features as cross-media (audio/speech, video, image, text)

indexing and retrieval, multimodal and multilingual search, Contextual Rich Media Search based on Semantic Analysis, etc.

- Identification of the semantic gaps for a true multimedia search (market and user expectance, research and innovation gaps, operational gaps or legal and business models gaps).
- Video/Audio Compression Algorithms
- Multimedia security and content protection: watermark, encryption, Privacy, digital rights management (DRM), Authentication and access control
- Framework, architecture for 3D search
- Personalisation (including e.g. semantic reasoning and personalization tools for automatic annotation and generation of Multimedia Content metadata, context awareness, user
- Ease of use by mobile
- Other search input types (image, video, face, etc.)
- Etc.

R&D effort in the search domain is fundamental for the growth of European ICT. It strengthens the leading role of Europe in introducing novel media technologies. In addition, the big players like Yahoo, Google, Microsoft will threaten European industrial position in media technologies in the long run, if the Networked Media sector in Europe is not reinforced through more collaborative research projects in order to ensure its economic, scientific and technological competitiveness.

3.2.2.4. Security, trust and identity

Security issues are related to three main causes:

- Cybercrime. This is the major problem at present both for network operators and for applications and service providers. It has a clear economic motivation and it is becoming much professionalized.

Current Rank	Previous Rank	Goods and Services	Current Percentage	Previous Percentage	Range of Prices
1	2	Bank accounts	22%	21%	$10–$1000
2	1	Credit cards	13%	22%	$0.40–$20
3	7	Full identities	9%	6%	$1–$15
4	N/A	Online auction site accounts	7%	N/A	$1–$8
5	8	Scams	7%	6%	$2.50/week–$50/week for hosting, $25 for design
6	4	Mailers	6%	8%	$1–$10
7	5	Email addresses	5%	6%	$0.83/MB–$10/MB
8	3	Email passwords	5%	8%	$4–$30
9	N/A	Drop (request or offer)	5%	N/A	10%–50% of total drop amount
10	6	Proxies	5%	6%	$1.50–$30

Table 1. Breakdown of goods and services available for sale on underground economy servers
Source: Symantec Corporation

- Cyber war. This area is also relevant even if it is not considered extremely urgent and although it is within the responsibility of national governments and defence organizations.

There has been considerable talk about the possible origin of the attacks on the network of the Republic of Estonia and the Titan *rain attack* on US institutions. As a consequence of the concerns the US government has established a specific cyber war unit (http://www.afcyber.af.mil).

- Cyber terrorism. This aspect is related to the previous one.

New scenarios (enhanced home environment, virtualization at different levels, larger penetration of mobile workers, pervasive applications regardless of the access method, etc.) will open new breaches for cyber-attacks. Increased criminalization of malware and security threats, and larger exposure of personal and enterprise data to attacks will force users to increase their awareness and spending on enforcing security and privacy. Providing security solutions to end customers will only be possible if done from the network, so that adequate scale is achieved, information aggregation is possible, and non-breakable mechanisms can be implemented.

The objective is to develop a proactive, holistic approach towards security and trust capacities and services, which can be flexibly used in a scalable way both to secure trust reputation and to provide tools for new advanced services.

Higher security is also a key element for developing and lowering barriers for electronic transactions, allowing the deployment of services that require irrefutable proof of identity, which will lead to a reduction of fraud.

Main research challenges in these areas include the following topics:

The network as a security guarantee: advanced network access control for trusted services over public networks

The network is a key element for providing real security, since all transactions and communications go through it. A networked application scenario where security only relies on the end nodes will never be sufficient and will put too much burden on the users, hindering the development of new applications. Any rational approach requires a common action between all interested parties: network operators, service providers and end users.

There are several security levels that can be applied: from an intrinsically secure network where all traffic is fully identified, to more lax approaches, where privacy is also taken into account. However, modern security approaches can combine security and privacy leaving a tradeoff that the user will have to decide upon.

There are several possibilities to assure a greater security in the network:

- Introducing new software elements in existing or planned network nodes to assure an adequate PCRF (Policy Control Resource Functions)
- Defining new PCRF using open standards.

Any approach will need collaboration of several network elements from several operators, transmitting information and sharing information.

This can be implemented as a security service for users based on multi factors security, including elements such as identity, user behavior, and device status. The systems should be able to correlate different attack patterns and to adopt countermeasures in collaboration with other networks

Advanced DPI (Deep Packet Inspection) elements can also be used to assure transaction security.

Security reputation

The general objective is to assure the reliability of users and transactions through the communication of trusted information between network nodes, application providers and final users.

Interoperability between security information stakeholders, trust, simpler processes, and usability will be essential for success. New techniques for advanced white-box security evaluation and ethical hacking must be incorporated.

Privacy and identity

In order to improve privacy it is necessary to use open identity frameworks including third parties' services integration, including storage technologies of client identity. This area is related to the security usability and includes identity federation. The main objective is to fight against botnets federation using AI solutions, such as behavioural analysis and neural networks.

Complementary to that would be the use of enhanced biometric algorithms (e.g. iris, fingerprint, veins, signature). Those elements should be used to provide a strong authentication that could be assured by the network.

Privacy and trust

Digital Identity Management frameworks are a convenience for users' Single-Sign-On, and they support the federation of business relations among different sites of interest to the user. Nevertheless, the SIM can play an important role in identity management systems.

Security of content – beyond DRM

Special attention has to be paid to the security of contents. Beyond "classical" content security addressing intellectual property rights, new security issues concern the protection of privacy when the user becomes an actor of the content. This can be found in services like Second Life. The priorities of this activity will include the following topics:

- protection of (on-line) games
- protection of metaverse (referring to Internet services like Second Life)
- 3D watermarking
- fingerprinting
- selective encryption
- forensics
- software protection

- identity management
- interoperable security
- user-understandable security
- renewable long-term security

Future U/SIM (Universal/Subscriber Identity Module)

A specific security solution that should be investigated further by Celtic-Plus is the future of the SIM card, including general issues such as, e.g. "everything on the SIM". There is a broad range of new opportunities with the SIM card: Payment, ID management and privacy, M2M, Radio on SIM, simplified authentication, pushed personalized and innovative services. These might be key to new services with high business impact in mature and emerging markets.

U/SIM is one of the key assets of network operators in mobile telecommunications. It has many and quite important functionalities, and so far these are enlarged rapidly. As its capacity and capabilities are increased, it can host a Web server, or it can easily run a Java application as it stores a Java VM (Virtual Machine). In order to increase penetration of most of the mobile applications among the users, it should be terminal-independent, and if an application can be provided on a U/SIM, there will be no hassle such as which OS it requires or which specific mobile handset is required. Average memory size has been increased and nowadays 256k, 512K U/SIM solutions are available.

Some operators are also providing 1MB U/SIM to their customers with increased functionalities such as multimedia, mobile payment, mobile signature and M2M (Machine-to-Machine) communications. As these applications have become important revenue opportunities for mobile network operators, solutions or applications based on U/SIM will be quite important for Celtic-Plus. These solutions and applications need to be developed with high inherent security; this is the fundamental task of U/SIM. In the future U/SIM roadmap, location information, payment capabilities, embedded Web server and M2M concepts will have significant impact on mobile telecommunications industry. Leased memory areas on U/SIM for companies' loyalty cards would be another application area on U/SIM.

Other security research challenges

Possible solutions to fight against security issues cannot be limited to technology solutions. Legal requirements, such as the possibility of making ISPs partially responsible for the abuse of IP addresses or making the declaration of incidents compulsory, will have a significant impact. Furthermore, in some countries the new electronic identification cards will produce new applications.

The appearance of critical new solutions is unlikely, so we expect rather a smooth technology evolution. Some of the new technological measures will be based on biometry, coding or specific solutions using USB keys or similar equipment.

A significant new possibility is incorporating identity into service provisioning.

Some promising research areas include new software elements that will stop browsing when certificates are not confirmed. This could lead to specific browsers developed for electronic banking.

Other research areas include hash algorithms which have, at present, some vulnerability.

Some of the new technologies to be explored may include:

- Use of Open ID for services without a very high security requirement
- Use of virtual identification cards
- Use of Higgins. Higgins is a framework that enables users and applications to integrate identity, profile, and relationship information across multiple data sources and protocols.
- Development of solutions to allow the interchange and portability of certified data to the application level (such as U-prove of Microsoft)

3.2.3. DATA MINING, REALITY MINING, USER MODELING

With people using more and more ICT to communicate with each other, and to access online services, increasingly more usage data becomes available. This data is a goldmine for service providers because it enables them to know their customers much better than before and thus be able to serve them better. It is a key enabler for high-quality personalization. However, service providers are allowed to take advantage of this information only if privacy concerns are adequately taken into account. Looking at the data from an aggregated point of view, instead of looking at individual users, enables the detection of global patterns, which can be key enablers for improving monitoring and management in diverse areas such as traffic management, migration monitoring, urban planning, disaster management, etc. The latter point is the subject of reality mining, where communities of people using mobile phones with several sensors (GPS, movement, cameras, Bluetooth, etc) generate large volumes of data which then are mined for patterns, and to make predictions. As MIT puts it: “Reality Mining defines the collection of machine-sensed environmental data pertaining to human social behavior”.

Research in technologies for new ways of user modeling, data mining and reality mining are needed in order to cope with the increasingly growing amount of user data, while at the same time guarantee the privacy of people in a transparent and user-controlled way.

Key challenges of user modeling are user social graphs, and user experience. Topics related to user experience to be addressed include customer entry points and Quality of Experience (QoE).

QoS (Quality of Service) can be defined as the collective effect of service performance that helps to pinpoint the degree of satisfaction of a service user, including any performance issue. However, this is only the quality from the network operator or service provider point of view. Nevertheless customers may have a different perception of quality. This new concept of quality is known as Quality of Experience (QoE) or Quality of Perception (QoP, pQoS) and is focused on the subscribers. QoE (Quality of Experience) is a concept that can be applied to different topics. It means “Level of satisfaction with a service from the perspective of that customer, based on their needs, wants and expectations”.

The evolution of quality management from the customer point of view shifts end-to-end quality services from subscriber perspective. This new outlook will allow identifying network degradation and performance results before affecting the customer, since QoS is just a technical concept that it is measured and understood in terms of networks. So it is a subset inside the QoE scope and must be noted that one of the goals of Quality Assurance will be delivering QoS through the user experience.

Quality of Experience is the new business focus for most actors in this rapidly changing multi-service world. Since the monitoring of services is increasingly complex and are composed of many components, the Telco companies are trying to measure the experience of customers and users in the best way they can afford, being involved in main QoE standardization groups.

Furthermore, in order to lead the growing market of new generation services, the different Telco actors must offer the best possible quality to the customers. In addition brand new services are being supported on NGN (Next Generation Networks), which are even more complex to quantify.

Nevertheless it is not trivial to determine what quality is perceived by the clients, because it depends on a great variety of factors. The quality experienced by the customer depends on many factors: the components that set up the service, the business processes related to the service, the resources on which the processes are supported and the performance of the underlying network.

Important topics in this context include how to measure quality of experience from quality of service, and how to act on the network or on the service depending on the quality of experience values.

3.2.4. BUSINESS AND SOCIETAL ISSUES

This includes all aspects related to business models and their evolution, together with the user point of view, for example:

- Evolution of value networks in the telecommunications business
- Forecasting the changes in value networks and business models e.g. due to VoIP, Internet-TV, regulation and use of license-free frequencies
- Rating charging and pricing.
- Economic studies

4. CELTIC-PLUS MAIN RESEARCH TOPICS AND RELATED R&D PROGRAMMES

This section aims to outline how the priority topics of Celtic-Plus relate to other R&D programmes and initiatives around Europe. It also indicates if and how such topics are mentioned in key EC documents on the Future Internet and the general ICT strategy. We believe that **it is important to know what programmes and initiatives are concerned with the Celtic-Plus priority topics.** This is sometimes difficult, because the various documents are structured in very different ways and often refer to a global architecture or system view rather than to specific topics.

Furthermore, the angle from which a similar topic is addressed in other programmes is quite often different. It is indeed not because topics are tackled in more than one R&D programme that it is necessarily leading to an overlap. As stated in the associated document "*Celtic-Plus: why a follow-up of the Celtic programme is needed*", the various programmes do not address the research challenges in the same way, either in terms of time to market, or in terms of coverage, or in terms of participants. In fact, having a few programmes and documents mentioning a similar topic from various angles would tend to indicate that this is indeed a priority feature to be addressed in the short, medium and long term, at European and worldwide level.

Only the Celtic-Plus topics are mentioned. The R&D programmes and initiatives, as well as the documents, cover also other areas not related to Celtic-Plus, which are not included in the table.

In order to have an easier reading of the table, summary tables are presented in this section. **The full table with all the details can be found in a separate document, annexed to this Purple Book.**

The exact references of the documents may be found at the end of this Purple Book, in the *References* section.

4.1. EUROPEAN TECHNOLOGY PLATFORMS & FUTURE INTERNET CROSS-ETP

CELTIC-PLUS PURPLE BOOK	eMobility SRA	eMobility SAA	NEM SRA	NESSI SRA	ISI SRA	EPoSS SRA	FI Cross-ETP
I GET CONNECTED							
A1 NETWORKS ELEMENTS AND INFRASTRUCTURES				X		X	X
A2 Mobile/ Wireless/ Broadband	X	X			X	X	X
A3 Optics	X						X
A4 Energy efficiency (networks)	X	X					X
B1 NETWORK ARCHITECTURE AND CONNECTIVITY	X				X		X
B2 Networking/ platforms	X	X	X			X	
B3 Autonomic Networks	X						
B4 Other network infrastructure aspects	X			X	X		
II WHILE CONNECTED							
C1 FUTURE END TO END SERVICES	X	X	X	X			X
C2 Digital/ Smart Home		X	X				X
C3 Digital Enterprise		X		X			
C4 Digital/ Smart City		X	X				X
C5 Digital School							
C6 Digital Car		X					
C7 eHealth		X					
III FUTURE SERVICE ENABLERS							
D1 Future Service Platforms	X	X	X	X			
D2 Future interfaces		X	X	X			
D3 Multimedia enablers		X	X		X	X	
D4 Security/ safety, trust and identity	X	X	X	X			X
D5 Data Mining, Reality Mining, User modelling			X				
D6 Business and Societal Issues			X	X			
IV FUTURE INTERNET							
F1 Technology foundation							X
F2 FI Use-case scenarios							X
F3 FI Test environment							X
V ENERGY EFFICIENCY							
F1 Energy Efficiency (services/ software)							X
F2 Smart Grids etc.							X

4.2. NATIONAL R&D PROGRAMMES AND INITIATIVES

CELTIC-PLUS PURPLE BOOK	Spanish National Plan	Tekes GIGA, Strategy, ICT SHOK (FI)	ICT 2020 (DE)	Technos Clé 2010 (FR)	NICT Networking the Future (JP)
I GET CONNECTED					
A1 NETWORKS ELEMENTS AND INFRASTRUCTURES		X			
A2 Mobile/ Wireless/ Broadband	X	X	X	X	X
A3 Optics			X		
A4 Energy Efficiency		X	X		X
B1 NETWORK ARCHITECTURE AND CONNECTIVITY		X	X		
B2 Networking	X	X	X		X
B3 Autonomic Networks		X	X		X
B4 Other network infrastructure aspects		X		X	X
II WHILE CONNECTED					
C1 FUTURE END TO END SERVICES	X	X			
C2 Digital/ Smart Home		X	X		
C3 Digital Enterprise	X	X			X
C4 Digital/ Smart City	X	X			X
C5 Digital School					
C6 Digital Car					
C7 eHealth	X	X			X
III FUTURE SERVICE ENABLERS					
D1 Future Service Platforms	X				X
D2 Future interfaces	X		X	X	X
D3 Multimedia enablers	X		X	X	X
D4 Security, trust and identity	X	X	X	X	X
D5 Data Mining, Reality Mining, User modelling		X			
D6 Business and Societal Issues		X			
IV FUTURE INTERNET					
E1 Technology foundation E2 FI Use-case scenarios E3 FI Test environment					
V ENERGY EFFICIENCY					
F1 Energy Efficiency (services/ software)					
F2 Smart Grids etc.					

4.3. VARIOUS EC DOCUMENTS

CELTIC-PLUS PURPLE BOOK	ISTAG ICT Strategy	Interdisciplinary Research Activities for Future Internet	FI 2020
I GET CONNECTED			
A1 NETWORKS ELEMENTS AND INFRASTRUCTURES		X	
A2 Wireless			X
A3 Optics			X
A4 Energy Efficiency			X
B1 NETWORK ARCHITECTURE AND CONNECTIVITY	X	X	X
B2 Networking		X	
B3 Autonomic Networks		X	
B4 Other network infrastructure aspects		X	
II WHILE CONNECTED			
C1 FUTURE END TO END SERVICES	X		
C2 Digital/ Smart Home			X
C3 Digital Enterprise			
C4 Digital/ Samrt City			
C5 Digital School			
C6 Digital Car			
C7 eHealth			
III FUTURE SERVICE ENABLERS			
D1 Future Service Platforms		X	X
D2 Future interfaces			X
D3 Multimedia enablers		X	X
D4 Security, trust and identity	X	X	X
D5 Data Mining, Reality Mining, User modelling			
D6 Business and Societal Issues	X		

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ABBREVIATIONS AND ACRONYMS

3G	Third Generation
3GPP	Third Generation Partnership Project
4G	Fourth Generation
ADSL	Asynchronous Digital Subscriber Line
CATRENE	Cluster for Application and Technology Research in Europe on Nanoelectronics
Celtic	Cooperation for a sustained European Leadership in Telecommunications
DSL	Digital Subscriber Line
DVB-H	Digital Video Broadcasting - Handheld
EDA	Even Driven Architecture
EITO	European Information Technology Observatory
eMobility	Mobile and Wireless Communications European Technology Platform
EPoSS	European Technology Platform on Smart Systems Integration
ETP	European Technology Platform
FI	Future Internet
FIA	Future Internet Assembly
ICT	Information and Communications Technology
ICT	Information and Communication Technologies
IETF	Internet Engineering Task Force
IMS	IP Multimedia System
IP	Internet Protocol
ISI	European Technology Platform on Integral Satcom Initiative
ISTAG	Information Society Technologies Advisory Group
ITEA	Information Technology for European Advancement
JCP	Java Community Process
JTI	Joint Technological Initiatives
LTE	Long Term Evolution
MTV	Music Television
NEM	Networked and Electronic Media (European Technology Platform)
NESSI	Networked European Software & Services Initiative
NFC	Near Field Communication
NGN	Next Generation Networks
NICT	National Institute of Information and Communications Technology
OMA	Open Mobile Alliance
PCRF	Policy Control Resource Functions
PPP	Public-Private Partnership
R&D	Research & Development
RFID	Radio Frequency IDentification

SaaS	Software-as-a-Service
SAE	System Architecture Evolution
SDF	Service Delivery Framework
SDP	Service Delivery Platform
SET	Simplicity, Efficiency, Trust
SIM	Subscriber Identity Module
SME	Small and Medium size Enterprise
SOA	Service Oriented Architecture
SRA	Strategic Research Agenda
U/SIM	Universal/Subscriber Identity Module
W3C	World Wide Web Consortium
WLAN	Wireless Local Area Network