Trends and Techno-economic Analysis for Networked Society 2020

Document presents an initial contribution on Trends and Techno-economic Analysis in future networks and ICT at large, created by the Networked Society (NetSoc) project, to be used as base for corresponding discussion within the NetSoc Expert Group.

Table of Contents

Section 1 of the document is based on the NetSoc Deliverable D1.1 Joint technical position papers and technology roadmap towards and beyond Horizon 2020 - Version 1, which includes position papers created by European ICT stakeholder industry group. Section 2 is derived from the Net!Works White Paper on "Economic impact of the ICT sector" , issued in October 2012 - http://www.networks-etp.eu/fileadmin/user_upload/Publications/Position_White_Papers/Net_Works_White_Paper_on_economic_impact_final.pdf.

1) Vision of the Networked Society towards 2020

We are on the brink of an extraordinary revolution that will change our world forever. In this new world everyone and everything can be connected anywhere and anytime in real time. We envision that by 2020, there will be more than 50 billion connected devices. We call this the Networked Society, and it will fundamentally change the way we innovate, collaborate, produce, govern and achieve sustainability.

The clear vision shared by many is that the communications environment of 2020 will be infinitely more rich and complex than the networks and services of today. We are advancing towards 2020 with an initial driver of dramatically growing demands for data throughput for all services. Our expectation is that in 2020 the Internet infrastructure will be capable of connecting everything: people, things, processes, content, knowledge, information, goods, in a flexible but powerful way.

These demands for bandwidth and high-speed connections are emerging from all users. As soon as universal high speed access is available, the demands on the core networks for performance will explode. In addition the numbers of devices that will be connected is also exploding and dramatically increasing the demands on the networks and infrastructures**. Everything that can benefit from a connection will have one. As people we are already online. The next step is to get things and places online.** And we are moving fast in that direction. We must now anticipate these growth characteristic and start the revolution in terms of infrastructure that will be needed to cater for these explosive growth scenarios. With ubiquitous mobile broadband-enabled internet access, connectivity and networking are becoming completely independent of location. Combined with significant deployment costs, connectivity services and embedded computing, the drivers for new services and functionality – broadband ubiquity, cost of connectivity, and openness and simplicity – will lead to more efficient business models and improved lifestyle for individuals and society. . ICT will play a major role on allowing to share content but also to enable/simplify sharing physical objects (cars, tools, machines, offices, etc).

In parallel, the interaction with all aspects of society and industry, as they understand and adopt the new capabilities of the advanced networks and infrastructure will create even more innovative services and increasingly demanding performance requirements. Within this vision we can see that in the mid-term the demands will change from just pure speed of connection to include requirement on the quality of the connection and even for the infrastructure to be proactive in improving the perceived service through intelligent enhancement and optimisation of the service delivery for the maximum positive service experience.

Mobile and wireless traffic volume is expected to increase thousand-fold over 2010 figures. Moreover, an increase in the number of wirelessly-connected devices that counts in the tens of billions will have a profound impact on society. Massive machine communication will make our everyday life more efficient, comfortable and safer, through a wide range of applications including traffic safety and medical services. On the other hand data security and privacy aspects have to be considered from the beginning to ensure that such solutions will be accepted by users. The variety of

applications and traffic types originating from or reaching mobile, short-range, and sensor networks, will be significantly larger than today, and will result in more diverse requirements on services, devices and networks.

City businesses – including utilities (energy, water, gas), transportation, education, health care, retail, government, finance, culture and entertainment – are all facing a fundamental shift in the way consumers demand and purchase their products and services. New media services and business concepts such as smart grids, intelligent traffic and e-health, are examples of recent responses to this new landscape. Governments and leaders in society recognize that connectivity along with ICT policy, literacy, and sustainable business models are all crucial in order to create a positive climate for innovation and business. Many sectors – including technology, telecommunications, entertainment, media, banking, retail and health care – will continue to be reshaped by the application of ICT into their business. The constantly changing global marketplace, fuelled by high-growth economies and new technology, has accelerated the speed of business activity from product development to customer response.

ICT has become an integral part of our working and living environments and will continue to be an important resource for business, government and society at large. By combining information, knowledge, processes, and technology, ICT is driving efficiencies and fuelling innovation – and will play a crucial role in helping organizations of all sizes to connect, collaborate and compete more effectively.

We will need fundamentally new and improved solutions which fit the needs beyond 2020 conducted on network topologies, radio links, multi-node, and spectrum usage techniques. We need to integrate solutions into a system concept that provides the necessary flexibility, versatility and scalability at a low cost based on a next generation wireless that exploits many different technologies to provide high bandwidth, capacity, scalability, as well as low latency especially for critical real time interactive applications over ubiquitous coverage at optimised deployment cost. This implies full network convergence (satellite, fibre, copper, mobile, wireless, IoT, etc.) including handover and best network connectivity mechanisms.

If we then expand this scenario by considering large scale crowds accessing such services then we are into designing a new architecture for the networks and infrastructures that intelligently understand user needs and trends and dynamically reconfigure connectivity and information availability in real time to satisfy literally millions of customers. These challenges require extensive research work on ICT infrastructure and communication networks, which is driven by user and application demand.

Service shall be provided beyond cities that means in rural areas where the population density may be scarce as well as for the maritime and aeronautical markets.

The increasing presence of ICT will be effective in all the sectors of our daily life and ICT systems and networks will appear more and more as critical infrastructure. Several aspects of our industry, business, daily life relies on ICT technology, and this trend will continue and will be amplified by the need of interconnection between several domains of application. The evolution of devices will provide access to a large range of services. However, the counterpart of this evolution is the need to secure these sensitive infrastructures from any failure for which consequences could be dramatic. The security, availability and reliability and resilience of this future network infrastructure are essential features for the functioning of our societies and economies.

This vision will create big challenges on the necessary ICT infrastructure in terms of ubiquitous coverage, system capacity, latency, flexibility in terms of throughput rates and network security and privacy and will be associated with huge necessary upfront investments for deployment. Therefore, such investment can only be mobilised, if viable business models with reasonable time for return of investment would be available to earn more than capital cost. In addition, barriers in the regulatory domain have to be removed, which may prevent nationwide investments in infrastructure.

Real-time business intelligence and predictive analysis is required not only for faster decision-making but to cope with unexpected market risks and opportunities.

It is therefore anticipated that the demand of safe and secure system will become more and more stringent in the 2020 infrastructure. This demand will encompasses all the aspects of secure networks, including authentication, reliability, resiliency, cryptography, and confidentiality. **The vision of 2020 networks can only be conceived with trustful and reliable network infrastructures and secure content delivery.**

ICT Trends and Challenges

Based on the vision that the new infrastructure is the essential basis for communications and services, we can see that it will be a very complex system that needs stepwise developments in many aspects to be ready for the **2020 challenges**, which include:

- **New Architectures**
  1) The network resources will be virtualised and application interfaces have the ability to work with the virtual interface to demand and agree parameters for the performance of the services in real time. This means we need an integrated service/infrastructure architecture where the infrastructure can translate all the service demands into physical support and actual delivery for the services with low latency especially for critical real time interactive applications.
  2) The capability to reconfigure the network elements, using Software Defined Networks (SDN) approaches, to vary the configuration of the network in response to demands means we must have an architecture where strong robust algorithms will ensure continuous and efficient operation of the infrastructure. This architecture will address the problem of providing processing, storage and network capacity on a demand basis.

3) Separation of applications from the constraints of today's infrastructure and means of communication, through new architectural and technological solutions based on the virtualisation of the network resources.

- **A new generation of mobile infrastructure**: where the term "5G" might imply the cellular model like in the last 30 years we need to stress that this actually involves much more, including different wireless technologies, high frequency short distance communications, coordinated and shared spectrum usage, increase of spectrum, mixed of unicast and multicast services etc., essential for addressing the capacity, speed and scale challenges. A term like "future radio systems" may provide more flexibility and avoids the connotation from the past.
- **The big data challenge** involves new mathematical and statistical tools enabling knowledge engineering to identify, collect, collate, process and present the network and infrastructure data in a consumable form for novel applications and services to use. This also has an impact on networks in terms of necessary throughput values, latency and security as the logic for bringing data and computing together for efficient analysis creates yet another optimisation puzzle.
- **Cloud computing** is not mentioned here. This will require ubiquitous coverage with sufficient user experience to ensure access to data and applications independent of location.
- **New efficiency paradigms** not only in terms of the optimisation of resources in the infrastructure (computing, storage, communication, etc., etc.,) but also ensuring that each and every element is an environmentally and energy efficient as possible. Sustainability must be a key dimension of the infrastructure evolution for "opex: reasons as much as environmental ones. Opex and capex have to be balanced for a positive business case.

Management of all network elements and devices will be a big challenge which needs to be handled in real time and with ease. This management of increasingly complex systems requires extensive research.

Drivers of Change

This list of challenges is obviously not complete and many of these need to be subdivided into more specific items that are addressable in modular form, representing the **Drivers of change**, such as:

- **Access Speeds:** The current drivers of change in the communications infrastructure are Speed/Bandwidth and access issues where the European focus is on having more and more people and industries connected at higher and higher speeds. This driver still presents significant challenges and creates increasingly challenging issues for the underlying infrastructure to evolve to cater for all these high speed connections. If we project this forward to 2020 where mobile speeds of 5gb/s and fixed speeds of 100gb/s will be under discussion we can see that this, combined with the dramatic increase in numbers of devices communicating, will be a significant driver for the foreseeable future.
- **Advanced Applications:** Like the previously quoted augmented reality, we foresee future applications needing to understand the user context in terms of the infrastructure available so

that the user experience can be ensured despite the limitations of the physical infrastructure in the user location. Future services agreements will include performance/delivery parameters and the infrastructure must be intelligent enough to understand and commit to these.

- **Big data:** The big data scenario includes many new roles for data aggregation but also anticipates the impact on the infrastructure if millions of sensors stream data continuously into the infrastructure and expect it to be processed continuously. Much of this data will be generated for a primary business model but then may be used in novel ways to generate further value. In many cases the data owning companies may not realise what assets they have in their data and entrepreneurs may help them to identify and commoditise the additional value.
- **New usage models:** The increased use of cloud computing and cloud services shows market willingness to use the infrastructure to store and process their data – both personal and commercial. As security and privacy techniques improve we can expect this trend to continue. This also has direct impacts on the infrastructure not only in the dimensioning and distribution of cloud facilities, but also in the availability and reliability of ubiquitous access to the Internet with sufficiently high throughput rates, low latency. The provision of high availability and reliability of communication networks, as well as high security, is vital for mission critical applications. We can see the trend already now that more and more critical infrastructures in our societies and economies are dependent on the Internet and communication networks.
- **New market parameters:** Europe has reasonable prices for Internet access and an almost universal price versus speed type of competition in the market. Ba 2020 period of time, we foresee a new maturity in the internet services market where the competition will move to new factors such as quality, reliability/resiliency, availability, openness, eco-responsibility and security/trust level and many other factors will become much more critical rather than the current focus on price only. In the storage context, users may require clear information on where their information is stored and assurances that it does not fall under different legal domains.

2) Economic Landscape and Perspectives

ICT Market Overview

Communication networks are a key enabling technology for all sectors of society and economy to provide connectivity. Increasingly, many infrastructures like electrical energy systems, gas and water networks, traffic, health and other societal challenges depend on reliable and highly available communication networks. The worldwide ICT market volume increased in 2010 by nearly 5 % to about 2500 Billion €. The biggest ICT market is USA with a market share of 28.7 %, so that Europe with a market share of 25.2 % is in a similar order of magnitude. Furthermore, the mobile communications market in Europe reached a total revenue of 174 billion € in 2010, which is comparable to the aerospace industry and larger than pharmaceuticals. These figures are related to the entire ICT market.

Industry from Europe is serving the global ICT market. The global ICT market was also affected in 2009 by the financial crisis. The worldwide ICT market volume increased in 2010 by nearly 5 % to about 2500 Billion€ According to Bitkom the biggest ICT market is USA with a market share of 28.7 %. In Europe for example Germany with 5.1 % global market share is No. 4 after the USA, Japan and China. Europe with a market share of 25.2 % is in a similar order of magnitude like the US.

However, the European ICT market is basically stagnating. Its market value is still below the figure of 2008. The Asia-Pacific region and the USA with a similar market size like Europe and in particular the BRIC (Brazil, Russia, India and China) countries show bigger growth rates, which offer promising economic prospects for industry from Europe. European industry has a significant share in this business. Industry from Europe has to be present in these markets to benefit from that growth with respect to increasing productivity in order to maintain employment and business. The ICT generates between 5 and 6% of the EU GDP. The EU Commission reported that 50% of economic growth in the European Union is driven by ICT.

However, there is fierce global competition in particular from Asian manufacturers. Research and development is essential to maintain the position of industry in Europe to be on the forefront of the technology development. In particular markets like complex devices for optical communications the European market share in the global market corresponds to 45 %. However, production of components is increasingly also shifted towards Asia.

Economic Challenges

Traffic growth creates challenges for mobilising the necessary investments for broadband communication networks. For example broadband applications are driving the need for better mobile network quality in terms of throughput rates, latency and efficiency with high user experience. In order to provide high system capacity, more dense networks need to be deployed compared to voice centric networks. The limited availability of low frequency bands (below 1 GHz) results in the need to deploy smaller cells even in rural areas than needed from capacity reasons in order to meet the coverage requirements. This requires huge investments with long times for return

of investment and high capital cost. Infrastructure sharing in such areas is a means to improve the business case for active communication service providers. However, regulatory conditions have to allow that and legal provisions have to be in place that each communication service provider keeps control about its network.

Increasing demands on communications networks and decreasing revenues for the network operators have been again identified as important issues for the coming period. Communications technology needs to become better and better at same or rather lower costs. Of course, the question how needs to be elaborated. Sensors and actuators have to be simple low-cost devices. Finally, cost reduction and efficiency improvement could be achieved through shared infrastructures followed by smart calculation of rates (not necessary flat rates) for using the networks to be found by considering corresponding regulation constrains.

Today's rate plans based on flat rates result in a low revenue growth of operators even where the traffic is growing much faster. This reduced revenue per bit is requesting significantly lower cost per bit and results in a gap of the business model. Therefore, research on new networking paradigms, a more flexible use of frequency spectrum, radio access technology and backbone networks is needed to provide affordable network deployments for communication service providers and end customers. The ARPU (Average Revenue per User) in Europe is declining per year in the last years significantly due to increased competition and end-customer friendly regulation. This is one of the major reasons for the economic challenges for communication service providers. Further challenges for communication service providers are OTT – Over The Top use of networks, where the communication service providers are challenged by social network providers, messaging service providers, etc.

There are estimates on the necessary investment in the order of 200 to 300 billion € to provide very high speed broadband coverage (technology independent consideration) in Europe with throughput rates > 100 Mbps. With respect to the economic challenges an investment-friendly environment is needed by appropriate regulatory conditions, suitable financing conditions and potential infrastructure sharing scenarios.

Value Generation in Europe

European industry is strong in research, development and the integration of complex systems like communication networks. A wide spread and well established research community in R&D centres and universities is cooperating with industry for knowledge and IPR generation. In addition, communication networks are increasingly be based on software technology and software development. However, know how is also required in hardware and RF design as well as in manufacturing technology for equipment, network planning and operation.

With respect to the fact that communication networks are increasingly regarded as critical infrastructure it is essential for Europe that system research, development, knowledge creation and

IPR generation is performed in Europe. All critical parts of system design and manufacturing needs to be done in Europe in order to have full access to the technology.

Many hardware systems are today based on standardised hardware. That allows that parts of manufacturing is being done close to target markets in order to have direct contact to customers, to reduce transportation cost and to mitigate trade barriers and risks of currency exchange rates. However, it is essential that critical parts of communication networks such as system software and special hardware components with the potential to distinguish products from the competition are designed in Europe and provided to the global manufacturing process.

The technology shift from hardware-oriented systems in the past towards software- and signal processing-dominated systems today requires different skills. However, this allows Europe to create higher skilled jobs in this industry as well in the system design as the development of applications. Therefore, the political discussion should not be focused mainly on industrial manufacturing of hardware systems but more on system and solution design. In this domain Europe is in the position to compete on global basis. This requires continuous innovation and significant investment in research, innovation and development to achieve and maintain technology leadership.