Net!Works

Net!Works European Technology Platform

Expert Working Group on

ICT - National Critical Infrastructure

White Paper

Chair: Prof. Panagiotis Demestichas, University of Piraeus Research Center

pdemest@unipi.gr

Co-Chair: Pedro Soria Rodriguez, ATOS

pedro.soria@atosresearch.eu

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List of Contributors

Contributors	Company/institute	e.mail address
Panagiotis Demestichas	University of Piraeus	pdemest@unipi.gr
Pedro Soria Rodriguez	ATOS	pedro.soria@atosresearch.eu
Rahim Tafazolli	University of Surrey	R.Tafazolli@surrey.ac.uk
Yiouli Kritikou	University of Piraeus	kritikou@unipi.gr
Armin Dekorsy	Bremen University	dekorsy@ant.uni-bremen.de
Emmanouil Panaousis	Kingston University	e.panaousis@kingston.ac.uk
Tipu Arvind Ramrekha	Synelyxis Technologies	arvind@synelyxis.com
Miguel Egido Cortés	GOWEX	megido@gowex.com
Hamed Al-Raweshidy	Brunel University	Hamed.al-raweshidy@bruenl.ac.uk
Seyed Reza Abdollahi	Brunel University	SeyedReza.Abdollahi@brunel.ac.uk
Luis Muñoz	University of Cantabria	luis@tlmat.unican.es
Bernhard Raaf	Nokia Siemens Networks Management International GmbH	Bernhard.Raaf@nsn.com

List of Acronyms

ICT	Information and Communication Technologies
IoT	Internet of Things
LE3S	**L**atency, **E**nergy efficiency, **S**pectral efficiency, **S**calability and **S**tability
M2M	Machine-to-Machine
PPDR	Public Protection Disaster Relief
Tb/s	Tera Bits per Second. Tera = 1000 Giga

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Table of Contents

Executive Summary

This White Paper presents the Information and Communication Technologies as a national critical infrastructure. ICT infrastructure is the most important and critical asset of a nation for both business and citizen's quality of life. It enables a balanced day-to-day operation of a country. Furthermore, it is expected that other national critical infrastructures will depend on ICT technologies as well as infrastructure for their efficient operation and modernisation. Through enriched connectivity offered by mobile networks and internet, ICT infrastructure is and will be the main enabler in realisation of a fully connected digital economy.

Mobile broadband networks are regarded as the main stimulus for economy recovery in Europe. However, despite the importance and all the advantages offered by ICT infrastructure, one should not be complacent with the fact the connectivity is "Just there". There is an urgent need for huge investment in making such connectivity "ubiquitous" and "smart".

A number of strategically important areas are identified as a research agenda for Europe in provisioning of mobile broadband internet based on market drivers and user expectations.

A new concept or framework is suggested for future network research, called LE3S standing for low **L**atency, **E**nergy efficiency, **S**pectral efficiency, **S**calability and **S**tability.

In addition to mobile broadband in Internet, it is suggested that Europe should initiate process of research, specification and standardisation for an emergency network for time of crisis and disasters.

The white paper ends with a number of recommendations to stake holders, national and European research funding organisations to ensure sufficient fund is set aside for collaborative research on ICT, in general, and mobile broadband internet technologies specifically.

1 Rationale

Critical infrastructure is a term used by governments to describe assets and functions that are fundamental for the society and economy to operate. The assets and functions that compose the critical infrastructures [1,2] as depicted in **Error! Reference source not found.**~~Figure 1~~, are energy and electricity generation and networks; water (drinking water, waste water/sewage, stemming of surface water); food production and distribution; transportation systems (fuel supply, railway network, airports, harbours, inland shipping); health (hospitals, ambulances); telecommunications and Information and Communication Technologies (ICT); government, financial and security services.

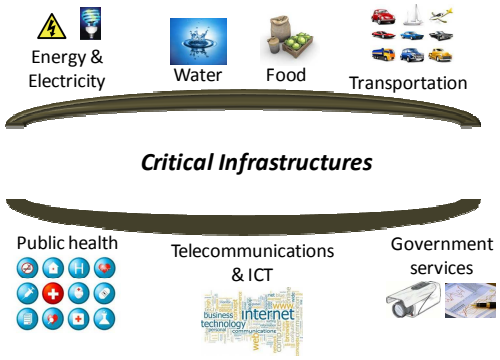

Figure 1: Critical infrastructures as currently identified

The global Internet with more than 2.25 billion users globally (status December 2011)[3]. European industry is supporting this growth by deploying, e.g. the necessary networks (Figure 2).

[1] Europa.eu webpage. (Accessed on May 11th 2012) http://europa.eu/legislation_summaries/justice_freedom_security/fight_against_terrorism/l33260_en.htm

[2] Commission of the European Communities "Communication from the Commission on a European Programme for Critical Infrastructure Protection", Brussels, 2006. (Accessed on May 11th 2012) http://eur-lex.europa.eu/LexUriServ/site/en/com/2006/com2006_0786en01.pdf

[3] Internet statistics: http://www.internetworldstats.com

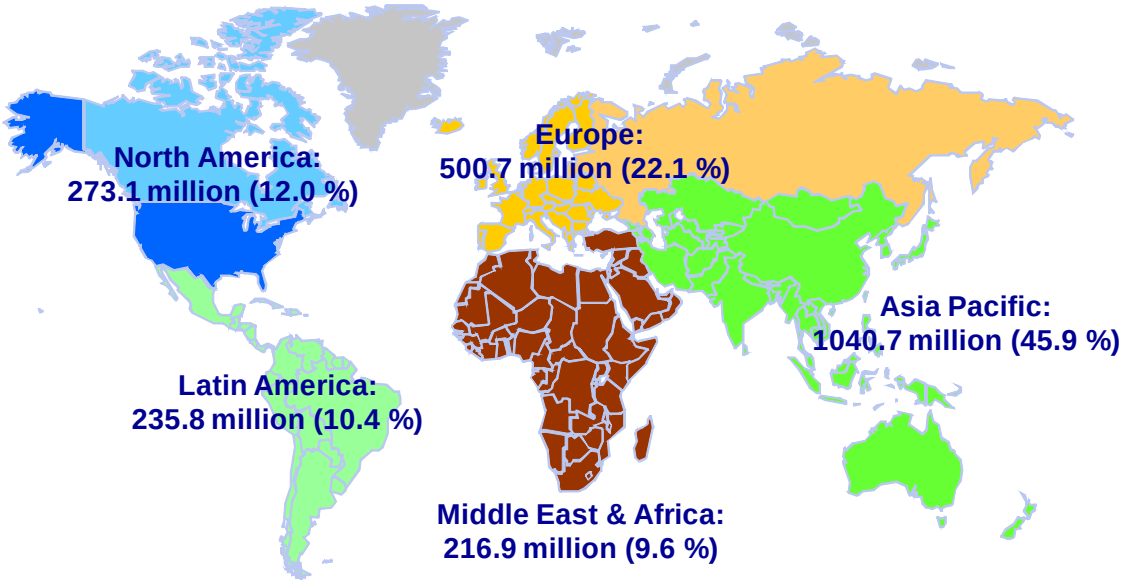

Figure 2: Worldwide Internet audience

Each of the infrastructures mentioned above, play an important role in preserving a balanced operation of a country. ICT is now part of any country's National Critical Infrastructure and its importance is growing even more as it is the transformative technology in modernisation of other national critical infrastructure. ICT is the pillar for other national critical infrastructures in form of acting as control and transport planes for the aging Energy networks, transportation systems, Health services and Greener environments. On the environment, it is widely reported that ICT is responsible for only 3% of CO2 footprint, however ICT can help in minimising the other 97% generated by other industries. These are only a few amongst many other societal challenges that Europe is facing.

All these present many new challenges to the entire business chain in mobile communications and networking industry. Next section present list of priority research topics that are deemed essential in sustainability and growth of current and future networks in Europe.

2 Research priorities

ICT, in addition to providing quality of life to citizens, will continue to be a key driver to the future economy growth in Europe. According to Bitkom[4] the worldwide ICT market volume increased in 2010 by nearly 5% to about €2500 Billion. The biggest ICT market is USA with market share of 28.7 % (Figure 3). For example, Germany with 5.1% global market share is No. four after the USA, Japan and China.

[4] Bitkom: Bitkom Branchenbarometer 2012, http://www.bitkom.org/de/markt_statistik/64074_64903.aspx

However, ICT and in particular broadband mobile networks is facing its new challenges and if not addressed sufficiently soon enough can have major implications on both our society's quality of life and business. It is widely believed that the mobile traffic is doubling every year and by year 2020, mobile data traffic alone will be 1000 time that in 2010. If the growth of traffic continues at the same pace, the mobile data traffic in 2030 will be 1,000,000 times of that in 2010. Such unprecedented increase in mobile data traffic is strongly supported by many in industry and in particular the Cisco's study as illustrated in Figure 4. This rate of growth clearly indicates the tremendous increase in mobile communications usage and therefore will be a major stimulus in the socio-economy growth dynamics in the upcoming years. Moreover, the extensions of service variety, diverse service mix, user density and data security are also important drivers that must be considered for future broadband network research in order to meet the continuously evolving needs of the users and requirements other national critical infrastructures. Furthermore, as shown in Figure 5, laptops and net-books will continue to generate a disproportionate amount of traffic and newer device categories such as tablets and Machine-to-Machine (M2M) nodes will begin to account for a more significant portion of the traffic by 2016[5].

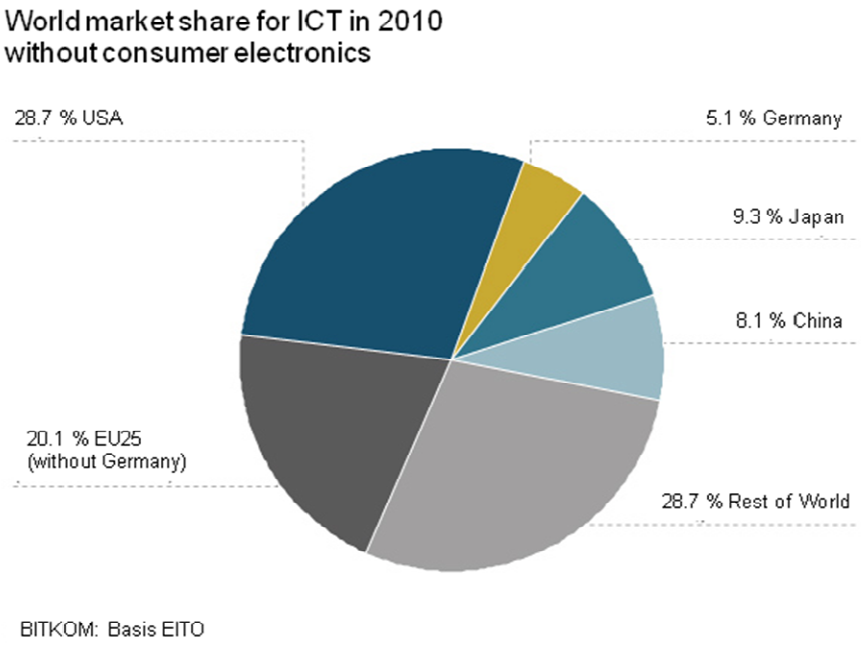

Figure 3: World market share for ICT in 2010

[5] Cisco White Paper, "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2011–2016", February 2012

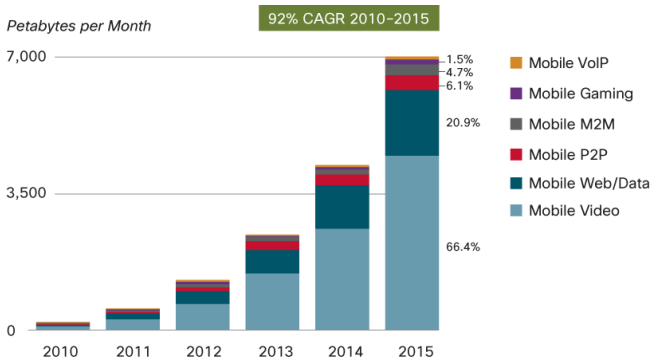

Figure 4: Increase of mobile data traffic for different applications

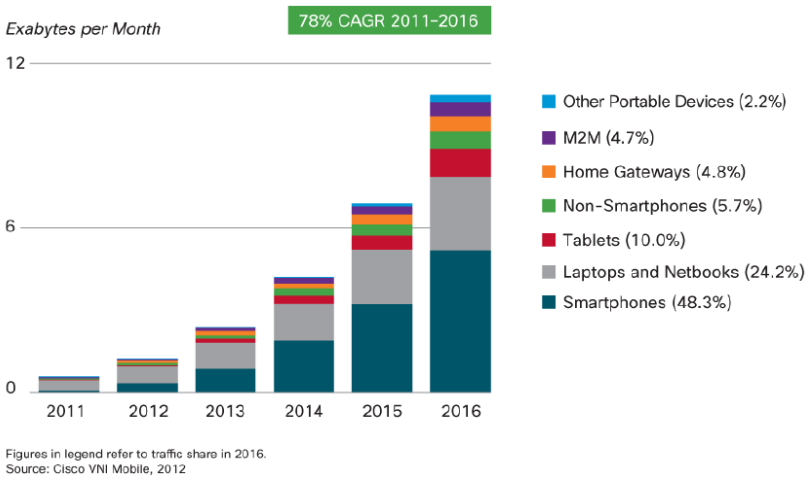

Figure 5: Updated data traffic for different devices

LE3S Concept for Future Networks

It is clear that the demands placed on communications networks are constantly increasing. The growth in the number of new applications running on the networks shows no sign of slowing and, on the contrary, it is accelerating as ever more mobile devices become the preferred device for Internet access for both people and machines. The use of networks to connect machines to the Internet is still in its infancy. Projections suggest that expected rapid growth in the generation of network traffic will be driven by the increasing use of video for communications and the use of networks for M2M communications. New applications are placing new technical demands on the network. Whereas in the past, increasing the transmission capacity of the networks was the focus of research, new applications mean that reducing the latency of networks, increasing their energy efficiency, improving utilisation of spectrum and the scalability and stability of networks are the requirements that future research and innovation must address. ICT networks will be the control and transport plane of other National Critical Infrastructures such as; health and telecare systems, eGovernment, transport systems, energy systems and environmental monitoring systems.

With all these respects, the following research topics are considered as essential for sustainability and growth of ICT and Mobile Broadband Internet. All the research priorities can be captured in **LE3S concept**

that promotes low **L**atency, **E**nergy efficiency, **S**pectral efficiency, **S**calability and **S**tability in future network research.

- Most important requirement from other National Critical Infrastructures is high availability and robustness much higher than that normally required in communication network designs of usually 99.9% (three 9's). New networking technologies must be developed to ensure high information integrity, network and service **reliability and availability** of more than five 9's, and resilience to potential cyber security threats.
- Optical network technologies will need further development as fibre-optic systems now also start approaching the Shannon limit. New research is needed to increase fibre capacity to >100 Tb/s in the core, >10 Tb/s in the metro and 1 Tb/s in the **access/backhaul** network and to provide a dynamic software and control environment around this. A flexible optical spectrum approach, programmable transceivers and switching nodes, and the use of multiple wavelength bands will be prerequisites for these targets whilst still leaving them challenging to achieve. With increasing wireless capacities and smaller cell sites, a close **wireless-optical** integration and operation will be crucial to adaptively optimise end-user experience over a fibre-constrained backhaul-infrastructure.
- **Data and content delivery** need further research in order to ensure that they meet the needs of users. Research on the issues of intelligent data handling and delivery based on user preferences, and user, device, radio and network contexts offers potential solutions to the challenges.
- There has been many research work worldwide reported on definition and classification of context. However, there is no or little evidence on mechanisms to capture, classify and utilise such information and how it can be implemented and utilise in improving a network performance or in efficient delivery of personalised services. With increasing deployment of machine-to-machine and generally Internet of Things (IoT) it is high time to start a research on technologies and mechanisms for capturing various **context** information, whether it is user's, device's, environment's, network's or so on, and demonstrate their utilisation effectiveness in intelligent service provisioning and overall performance improvements in network assets management. Research is required on scalable and efficient networking between IoT nodes and how such infrastructure-less networks can work with a communication network, Internet and a user device, in a secure, reliable and seamless manner. Another important area of network research is use of context information and their integration technologies for dynamic network resources virtualisation and fast/autonomous network management of resources, service quality and management of self-recovery and healing.
- ICT networks, telecoms and content delivery have still to consider important challenges as **trust and privacy**. As more and more means like electronic signature and digital identity will or are already a basic service to be offered to citizens, reinforcing business dynamicity and growth, trust and related technologies are essential to support such growth of services and traffic.
- Convergence between different National Critical Infrastructure

Emergency Network

Current communication architectures are highly vulnerable to major man-made and natural disasters. For instance, public protection disaster relief (PPDR) or emergency communications are considered part of the ICT critical national infrastructures. Discussions about emergency communications usually diverge into discussions about most prominent catastrophes and terrorist attacks and emergency services personnel (i.e. police, hospital, fire brigade etc.). So far, private citizens are not addressed in such situations which is often a major issue when commercial networks are no longer available due to collapse of the infrastructure (for example, electricity cuts or broken mobile network). For this, it is important to define an appropriate crisis

handling management system for both public and private users. In such situations, private handheld devices can be effectively used to form rapidly an ad-hoc network infrastructure during such incidents to create connectivity between people, as well as help in improving the coverage of public authorities' network. Although the target is to provide a system concept for crisis management as well as critical infrastructure control, the same concepts and solution may lend itself to other usages and applications. For example, in providing normal communication needs cost effectively to the areas where the basic network infrastructure is non-existent such as remote locations and areas with low-dense population and/or in emerging markets where telecom infrastructures do not exists.

This future rapid-deployable network needs to have capability to support basic communication services (for example; telephony and narrow band data services), mechanisms to prevent or reduce the impact of disasters (early warning system), aid in rescue operations and finally ease the recovery from disasters.

3 Summary

This White Paper aimed at providing some justification for consideration of the Information and Communication Technologies and Networks as the most important critical infrastructure and asset of a nation. Dependency of other national critical infrastructures on ICT infrastructure and technologies will increase over time. ICT is considered as the main enabling technology in helping to modernise, achieve higher efficiencies and provide connectivity in other critical infrastructure in addressing the societal challenges. It is also regarded as the main stimulus of ailing economy in Europe through creating a fully connected digital economy and society. Following this logic, a number of research areas were identified in tackling the challenges that ICT and more specifically broadband mobile communication networks are facing. Addressing these important research areas will ensure sustainability and growth of mobile broadband networks beyond 2020. Furthermore, some research areas were identified based on common and dominant requirements of other critical infrastructures.

Additionally, it is proposed for Europe to start activity on specification and research into a highly robust, resilient and rapidly deployable emergency network.

4 Recommendations

R1) Initiate activity on definition, specification and development of emergency network.

R2) Develop technologies in capturing of context information in general sense and demonstrate the effectiveness of context information in autonomous management of network resources, self-healing/optimisation and intelligent delivery of personalised services.

R3) Prioritise network research based on L3S concept

R4) Should not be complacent that "connectivity is just there". Ensure appropriate fund is set aside for collaborative research on huge challenges mobile broadband internet is facing.