Networked Society

(NetSoc)

Deliverable D1.4

Joint technical position papers and technology roadmap towards and beyond Horizon 2020 – Version 2

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Abstract

Analysis of technology and market trends relevant for the future network infrastructure has been discussed within the NetSoc Expert Group, where the NetSoc consortium created a corresponding document "Trends and Techno-economic analysis", which is summarised in this document and its full version is provided as attachment to this deliverable. The NetSoc project also facilitated discussions and creation of needed document, defining technical scope of the "Advanced 5G Network Infrastructure for the Future Internet - An Industry Proposal for a Public Private Partnership in Horizon 2020 - Creating a Smart Ubiquitous Network for the Future Internet", including corresponding public consultation process. The outcome of this work is presented through the proposal and outcome documents, which were used to create technical annex to the 5G PPP contract. The documents are summarised in the deliverable and also provided as attachments.

Disclaimer

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1   INTRODUCTION

This deliverable provides results of the NetSoc project activities mainly carried out during year 2013 in the scope of the NetSoc Work Package 1 "Identifying Requirements and Challenges" and it's following two tasks:

- Task 1.2 Trends and Techno-economic analysis
- Task 1.4 Joint technology position papers and dissemination

In respect to the Task 1.2, a detailed analysis of technology and market trends relevant for the future network infrastructure has been launched at the NetSoc Expert Group meeting on 13 November 2012, followed by further off-line discussion of the Expert Group and at its meeting on 19 March 2013. Afterwards, based on the outcome of the mentioned discussions, the NetSoc consortium created a corresponding document "Trends and Techno-economic analysis", which was submitted to EC in autumn 2013. The complete Trend document is provided as attachment to this deliverable and is summarised in Chapter 2.

The task 1.4 was carried out to identify actual needs of the ICT research community, in particular community devoted to research in the networks infrastructure domain, discussing the future of collaboration among ETP's in the ICT area and future organisation of their work by considering the upcoming Horizon 2020 EC R&D programme. In order to do so, the NetSoc project together with the Net!Works, ISI, and NEM platforms representatives initiated and facilitated work within an industry working group, which prepared a Call for a focused ICT Initiative on "Network and Information Systems in Horizon 2020", as documented in the NetSoc deliverable D1.1 "Joint technical position papers and technology roadmap towards and beyond Horizon 2020 – Version 1".

After extensive discussion on the provided documents within the research community, the industry group moved towards a more focused initiative, proposing a Public Private Partnership Programme that will deliver solutions, architectures, technologies and standards for the ubiquitous 5G communication infrastructures of the next decade to be included in the Horizon 2020 programme. The NetSoc project facilitated related discussions and creation of a needed document to define technical scope of the "Advanced 5G Network Infrastructure for the Future Internet - An Industry Proposal for a Public Private Partnership in Horizon 2020 - Creating a Smart Ubiquitous Network for the Future Internet". The outcome of this work is presented through the following documents, which creation was facilitated by the NetSoc project:

- Horizon 2020 Advanced 5G Network Infrastructure for Future Internet PPP - Industry Proposal for public consultations
- Annex to the Contractual Arrangement of the 5G PPP, which was created in accordance with feedback received during the public consultations. Note, that chapter 4 of this document – Governance – has been facilitated by the NetSoc WP2 "Building ICT network positions", Task 2.2 "Generating holistic ICT network positions" – corresponding deliverable; D2.3 "Report on the building of ICT network positions during Project Year 2".

The mentioned documents are provided as attachment to this deliverable and are summarised in chapter 3.

2 TRENDS AND TECHNO-ECONOMIC ANALYSIS

The Networked Society of 2020 is 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. It can be envisioned that by 2020, there will be more than 50 billion connected devices.

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.

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.

Based on the vision provided above 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 network architectures** – Network virtualisation and Software Defined Networks (SDN)
- **A new generation of mobile infrastructure (5G)** – different wireless technologies, coordinated and shared spectrum usage, mixed unicast and multicast services, etc.,
- **The big data challenge** – 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, as well as
- **Enhanced cloud computing and network management efficiency** (computing, storage, communication, energy consumption, etc.) ensuring sustainable infrastructures.

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.

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.

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.

3   5G NETWORK INFRASTRUCTURE

3.1   Public Consultations

The technical part of the proposal for the PPP on 5G, given for public consultations by wide European research community, was mainly based on the Strategic Research Agenda of the Net!Works European Technology Platform, including relevant elements from documents of the NESSI ETP and information from the ETNO (European Telecommunications Network Operators) association.

The community were consulted in two different phases. First phase started with Net!Works experts with the following plan:

- April 12th –Send ideas (ALL)
- April 19th – Compile all into a homogeneous document and send out for your final comments (Rahim Tafazolli and Laurent Herault)
- April 23rd – Receive all comments/feedbacks (ALL)
- April 28th –Final version of White Paper (Rahim Tafazolli and Laurent Herault)
- May 11th final version produced taking into account feedbacks (Rahim Tafazolli)

This resulted in a white paper titled: Europe 5G Public Private Partnetship Programme-Strategic Research and Innovation Agenda "Internet on The Move".

In the second phase, the consultation process started on 9th of May 2013 on industry prepared 5GPPP document. The whole community including that of Net!Works and ISI were invited for feedbacks through a purposely setup email account: consultations@networks-etp.eu

The feedbacks were received intensively until end of May 2013 and then sporadically until end of Sep'2013.

This provided document describes the problem definition, the background of the proposal, the stakeholders behind the proposal, the added value of action at EC level and via a contractual PPP, the overall long term vision and finally the strategic and specific objectives of the PPP in the context of EC Horizon 2020 (H2020) programme and related policy areas. Furthermore, a first the scope of R&D and innovation challenges to be addressed and the roadmap of identified research and innovation priorities and activities, including expected key outputs, secondly the key stakeholders along the value chain and finally the indicative timeline and estimated budget for implementation of the roadmap have been provided for the following identified challenges:

1. **Faster, More Powerful and More Energy Efficient Solutions for High Capacity Access and Core Networks for a Wider Range of Services**
   - Wireless Networks
   - Optical Networks
   - Automated Network Organisation - Network Management and Automation
   - Implementing Convergence Beyond the Access Last Mile

2. **Re-Designing the Network**
   - Information Centric Networks
   - Network Function Virtualisation
   - Software Defined Networking
   - Networks of Clouds

3. **Ensuring Availability, Robustness and Security**
   - Security Level Agreement
   - Network security and integrity
   - Network Data Analytics

4. **Ensuring Capable End-user Devices and High Amount of Other Connected Devices**
   - Building an Information-aware Future Internet - A Laboratory for new Network Infrastructure Experimentation

Furthermore, the consultation document describes first the industry commitments to implement the multiannual roadmap, then the expected impacts of the PPP and strategic objectives and the ability to leverage additional investments in research and innovation. Follows the strategy and methodology/mechanism for coordinating the implementation and measuring progress in R&I activities to ensure objectives are met, the identified indicators and the proposed methodology for monitoring industrial commitments.

A large number of feedbacks were received and were reflected in the 5GPPP documents. Some feedbacks were in form of emails with suggestions on the actual documents and some were in form of separate documents/emails as well as some were verbal feedbacks through telephone calls. A number of versions of the document were produced and circulated to the community for further feedbacks. This process was intense on weekly basis and slowed down in Sept 2013.

3.2   Final Annex of Agreement on the 5G-PPP Definition

The communication network and service environment of 2020 will be infinitely richer and more complex than that of today. Our expectation is that in 2020 the network infrastructure will be capable of connecting everything according to a multiplicity of application specific requirements: People, things, processes, computing centres, content, knowledge, information, goods, in a flexible, truly mobile, and powerful way. The future will encompass connected sensors, connected vehicles, smart meters and smart home gadgets way beyond our current experience of tablet and smartphone connectivity.

There is urgency to properly address the novel infrastructure that will be needed to cater for these challenging and unprecedented growth and performance characteristics. Manufacturers, service providers and also internet players, that are operating data centres, are involved in this evolution. This will lead to redefining the value chains, reinventing the roles and relationships between the players, whilst opening new innovation opportunities. In parallel, a turning point is coming in communications networks with the progressive introduction of virtualisation and of software based network functionalities to offer the required flexibility and reactivity.

These novel network requirements, technologies and architectures will introduce a wide range of industrial opportunities for both established and new actors and also for SME's. Europe must take this golden opportunity to drive the changes and position European vendors, service providers and innovative SME's in new markets and with new offers.

3.2.1 The Vision

Communication Networks have evolved dramatically over the past decades. In the nineties digital mobile communications were introduced, ADSL technologies have matured and more recently, at the beginning of this millennium, massive deployment of broadband fixed access, followed by mobile and full IP architectures, have nurtured the development of the Internet ecosystem. Europe has been a key player on the related technologies, and particularly in the mobile domain. This evolution will continue and even strongly accelerate over the next decade considering the ever growing needs of users and varieties of applications and environments to serve.

The anticipated variety of new professional usages brings in new requirements on availability, latency, reliability, trustworthiness and security. This demands new approaches to networking, with networking features and functionalities much more closely embedded with the applications (incl. critical physical and industrial processes) than today.

In parallel, users will be more and more demanding in terms of contents and service requirements, whilst getting increasingly sensitive to privacy and sustainability issues. These requirements will impose very strong constraints on networks and service platforms.

As a consequence, new network approaches are required by 2020 to serve the growing demand and face the associated challenges:

- How to handle the explosion of the traffic and provide the necessary capacity, spectrum;
- How to flexibly accommodate novel classes of services (IoT, M2M, or content based, and others which are not known today) whilst keeping low CAPEX and OPEX?
- How to make the Internet a ubiquitous and dependable infrastructure in mobile, wireless and fixed communications?
- How to guarantee the Quality of Service, including security / privacy needed for professional usages over the Internet?
- How to make the communication critical infrastructure as resilient as required by consumers of interconnected critical infrastructures such as smart grid?
- How to get energy consumption reduced by 90%?

It can be anticipated that the today's artificial separation of the fixed and mobile networks will disappear, with capabilities and performances of mobile networks becoming similar to those of fixed networks in terms of capacity and services diversity. This will in turn require innovative architectural approaches for mobile networks and a proactive approach to solve the anticipated capacity and spectrum crunch.

Future 5G networks will be significantly different from today's networks. It takes on average 10 years to develop a new generation of network infrastructure. Maintaining and enhancing the competitiveness of the European communications industry at large in the long term require starting ambitious research and innovation actions now. This is also critical to ensure the competitiveness of all the industrial sectors that use advanced ICT networked services to keep a competitive advantage.

In ten years from now, telecom and IT will be integrated towards a common very high capacity ubiquitous infrastructure, with converging capabilities for both fixed and mobile accesses. It will be massively based on general purpose, programmable and specific high performance hardware that will offer resources for transport, routing, storage and execution. Network elements will become "computing equivalent" equipment that gathers programmable resources, interfaces and functions based on virtualisation technologies.

3.2.2   Strategic and Specific Objectives of the PPP

Societal objectives

- Contribute to EU 2020 objectives to provide ubiquitous broadband access of interoperable and globally standardised communication networks in order to overcome the digital divide in Europe between densely populated areas as well as rural areas to develop economy across all regions in the European Union. It will be essential to offer broadband access also to such sparsely populated areas in order to develop new business and to create new jobs in such areas. This will help to support economic growth and the development of underdeveloped areas.
- Accelerate the adoption and use of advanced ICT services in Europe. The new 5G systems will open new opportunities for efficient services in the business, administrative and private domain, which will make the societies and economies in Europe more competitive. Therefore, the development and provision and a new 5G communication infrastructure based on secure networks will be an essential prerequisite for positive economic effects in all sectors.
- Establish European leadership in uptake and use of ICT technologies. Europe is rather strong in the development and provision of complex communication networks. However, industry in Europe is now challenged by ambitious competitors from other regions. Extensive research and innovation activities are the precondition to maintain and extend the EU leadership position, which will have positive effects with respect to the creation of know-how, the anchorage of a skilled work force, availability of highly secure networks, the creation of a web-based industry and related jobs in secondary domains.
- Advance the critical communications infrastructure in Europe, its implementation and its protection. The communication infrastructure in Europe is well developed. However, Europe has to keep pace with technological developments and the opportunities, which are provided by more efficient ICT systems. This will help to develop business and jobs in today underdeveloped regions and thereby the overall economic growth and job creation.
- Support the massive amount of new applications that networks will have to support, from IoT to Ultra High Definition-TV (UHDTV).Many sectors of our societies and economies will use advanced communication infrastructure to make processes and activities more efficient, competitive and secure. Such systems will be based to a significant extend on M2M and sensor communication. A second driver is the extensive use of video applications. Communication networks in Europe have to be empowered to cope with the associated system capacity and scalability requirements. The economic opportunities can only be exploited, if the necessary communication infrastructure is deployed and available for all European citizens.
- Improve the energy efficiency. Communication systems are consuming a significant share of the overall energy consumption. With the increasing data traffic there is a strong need to increase energy efficiency of communication networks significantly in order to reduce the CO_2-footprint. This will have positive impact of

climate change and energy cost. In addition, energy efficiency in other sectors will also be improved by means of ICT.

- Improve significantly network security and privacy. Recent news on surveillance of communication networks and the Internet demonstrated the need for improved network security to ensure data security and integrity and privacy. In particular, critical infrastructures like energy, water, gas, transport health etc. are increasingly dependent on communication networks. Therefore, secure networks are essential to ensure high availability and reliability of such infrastructures.
- Ensure the continuous education of skilled people with regards to new systems and new application domains. New communication networks and the associated applications brings unique opportunities for creating new jobs in the direct communications networks domain and even to a bigger extent in secondary domains related to the application of new technologies. Studies show a significant potential for job creation and economic growth.

Economic objectives

- Maintain and enhance the European strong position in research, development and standardisation of future communication networks in cooperation with other regions in order to provide globally accepted standards, which ensure interoperability and economy of scale.
- Reinforce the European industrial leadership in network and information systems.
- Strengthen industry competitiveness and promote innovation through openness whilst respecting legitimate interests of partners on securing IPRs and know-how with respect to global competition.
- Leverage the economic advantage of the forthcoming convergence between telecom and IT sectors.
- Drive the integration of the services and the intelligent infrastructures for highly optimised service provision across heterogeneous networks.
- Build extensive know-how and IPR base in Europe for future systems in the research community and industry.

Operational objectives

- Create an appropriate environment for successful R&D&I activities.
- Provide a governance model, which on one hand supports the goals of openness, transparency and representativeness and on the other hand ensures an efficient management with minimised overhead
- Support an efficient information flow between projects by respecting the interests or partners with respect to confidentiality and access rights.

The "Advanced 5G Network Infrastructure for Future Internet" PPP will deliver solutions, architectures, technologies and standards for the ubiquitous 5G communication infrastructures of the next decade. The following high level Key Performance Indicators (KPI's) are proposed to frame the research activities:

- Providing 1000 times higher wireless area capacity and more varied service capabilities compared to 2010.

- Saving up to 90% of energy per service provided. The main focus will be in mobile communication networks where the dominating energy consumption comes from the radio access network.
- Reducing the average service creation time cycle from 90 hours to 90 minutes.
- Creating a secure, reliable and dependable Internet with a "zero perceived" downtime for services provision.
- Facilitating very dense deployments of wireless communication links to connect over 7 trillion wireless devices serving over 7 billion people.
- Enabling advanced user controlled privacy.

3.2.3   Research and Innovation Strategy

The following main strategic topics for the development of the 5G Infrastructure PPP are identified:

1. Faster, more powerful and more energy efficient solutions for integrated high capacity access, core and data centre networks for a wider range of services

- Wireless networks
- Optical networks
- Automated network organisation - network management and automation
- Implementing convergence beyond the last mile access

2. Re-designing the network

- Information centric networks
- Network Function Virtualisation
- Software Defined Networking
- Networks of clouds

3. Ensuring availability, robustness and security

4. Ensuring efficient hardware implementations

Of course, as all the listed topics rather represent complex research and innovation areas, the main document on the 5G PPP defines a number of related sub-topics and discusses in details PPP approach for all of them. This includes the following:

- Problem description
- Definition of specific objectives solving the identified problems and issues
- Needed research and innovation activities
- Related KPIs to help follow-up on achievement of the specific objectives

3.2.4   Road-mapping

The future networks must evolve in pure capacity and connectivity speed terms in the first instance but in the 2020 scenario this will not be enough. The functional capability of the network must be matched with highly sophisticated network control functionality that is capable of overseeing the networking, ensuring all delivery promises are kept while optimising the use of resources and energy for both cost and environmental reasons. We

need to consider the developments necessary and then organise these in terms of when they are needed:

- 2014 – 2016 Design phase, proof of concepts, standardisation
- 2016 – 2018 Prototypes, technology demos, pilots
- 2018 – 2020 Large scale demonstrations and trials, scalability testing, etc.

Timeline

2014: Expected start of first projects under the PPP umbrella.

- Exploratory phase to understand detailed requirements on 5G future systems and to identify most promising functional architectures and technology options which will meet the requirements. These activities will build on previous research work in industry and research framework programmes as well as global activities in other regions and standards bodies.

2015: Detailed system research and development for all access means, backbone and core networks (including SDN, virtualised network resources, cloud systems, undedicated programmable hardware, …) by taking into account economic conditions for future deployment. This work will set the basis for a Pan European experimental infrastructure serving all network domains. The proof of concepts in particular for core network elements is expected in this phase.

2016/2017: Detailed system optimisation by taking into account all identified requirements and constraints.

- Finalise consensus on globally identified frequency bands for mobile and wireless communications (also taken into account the result of WRC15) and final system definition and optimisation by means of simulations, validation of concepts and early trials. The PPP will develop contributions to initial global standardisation activities and will build the Pan European experimental infrastructure in collaboration with GEANT and FIRE initiative.
- Preparation of WRC17/18.
- Support of initial international standardisation activities, which will continue in the following years.
- Support of regulatory bodies for the allocation of newly identified frequency bands for the deployment of new systems. New frequency bands should be available around 2019/2020.
- Implementation of large trials of new systems for validation under close to real world conditions, complementary research work as the need will arise as technologies are assessed.

2016 – 2019: Investigation, prototypes, technology demos and pilots of network management and operation, cloud-based distributed computing and big data for network operation.

- 2017/2018: Extension of trials to non ICT stakeholders to evaluate the programme results and its impact in the real economy.
- 2017/2018: Detailed standardisation process based on validated system concepts by means of simulations and close to real world trials.

2018 – 2020: Large scale demonstrations and trials, scalability testing, etc.

- 2019/2020: New frequency bands available for trial network deployment and initial commercial deployment of new systems.
- 2019/2020: Close to commercial systems deployment under real world conditions with selected customers to prepare economic exploitation on global basis.

The foreseen phased projects of the PPP will work jointly towards common goals, with target metrics. The PPP will be organised in a programmatic way, building on few key streams of activities, essential to the 5G Network Infrastructure, such as wireless access, network management, optic, etc. The related research will be organised around Key Research Challenges and enable a balanced approach combining top-down focused research (industry roadmap) and bottom-up innovation-driven research. Both are essential pillars of a successful long-term research effort on infrastructures and future networks. The research roadmap will reconcile longer term research with industry driven research innovation. The organisational structure of the PPP will integrate cross-disciplinary teams (e.g. wireless systems, networks, optical networks, etc.).

Baseline model will track the current state of the art technology in use, and a collection of potential future solutions. Associated with each Key Research Challenge will be a set of research targets broken down by technologies that identify the research required to achieve the overall target metric. When the targets across the many disciplines will be taken together, the result will truly be a combined effort that achieves the larger overall goal of the PPP. Gaps in research effort should be easily identified within this framework as some research results will fall short of targets or new targets will be introduced. This re-planned road-mapping process should evolve throughout the execution of the PPP research programme, continuously focusing, and re-focusing, the research on the 2020 goal horizon. This research roadmap will be of a pre-competitive nature and address pre-standards, serving as a technical beacon for research. Once research accomplishments will be achieved, the roadmap will then provide the framework that the industry can use to build actual standards and define commercial product roadmaps, so that the resulting technologies will have a real and significant impact.

3.2.5 SME Involvement

Communication networks which will be developed in the scope of the 5G PPP programme will provide new business opportunities for SMEs and other sectors to develop new products and services to generate new growth in Europe, where the SMEs are expected to provide particular know how and innovative solutions for specific concepts.

In particular, the SME domain is expected to provide a significant contribution to the emergence of innovative technology solutions. Therefore, it is important to ensure a reinforced SME participation to meet the ambitious goals. Thus, among all stakeholders involved in creation of the 5G PPP programme, 36% were SMEs.

There are different means which are considered to involve SMEs in the PPP in an efficient manner, depending on the various types of SMEs:

- SMEs that naturally come with the ecosystem of large players: The ecosystem will depend on each company and its structure. Each player has to define, which part of its ecosystem should be introduced into the PPP activities.
- SMEs that intervene independently of established links, but are attracted by the upstream research topic: Dedicated information days for SMEs will be organised ahead of upcoming calls for proposals and open calls in ongoing projects in order to present areas and possibilities for involvement in project proposals and ongoing

projects. Representatives from SME organisations from the Net/Works ETP, EIT ICT Labs and other SME organisations in the Association will be asked to support such activities.

- SMEs that emerge as developers, or using opportunities offered by the new technology at testing validation level: A similar approach like in FI-PPP Phase III will be applied. Trial systems will be made available for software and application developers. This will happen either by the direct involvement in projects as partner or according to Special Clause 42 in FP 7 by means of small contracts for dedicated tasks. The experience from FI-PPP will be taken into account.

- It is expected that SME participation will increase during the lifetime of the programme in particular in later phases, where software and applications will be developed based on the provided platform and/or for trials. The overall average SME participation under this initiative will be in the order of 20 % of the resources.