Consultation on Future Network Technologies Research and Innovation in HORIZON2020

29 June 2012, Brussels

Workshop Booklet
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Tell us how you see your research fit in HORIZON2020!

Consultation on Future Network Technologies
Research and Innovation in HORIZON2020

Deadline for online contributions: 15 Mai 2012
Open Workshop: 29 June 2012, Brussels

HORIZON2020: A break from the past

HORIZON2020 will be a seven-year programme for Research and Innovation (2014-2020) with an € 80 billion budget, implementing the Innovation Union, a Europe 2020 flagship initiative aimed at securing Europe’s global competitiveness.

HORIZON2020 is part of the drive to create new growth and jobs in Europe and will focus resources on three distinct, yet mutually reinforcing, priorities, where there is clear Union added value:

- generating Excellent Science,
- creating Industrial Leadership,
- and tackling Societal Challenges,

all essential for the sustainability and long term prosperity and wellbeing of Europe.

The objectives of Horizon 2020 will therefore be addressed through a strong emphasis on finding efficient solutions, going well beyond an approach based simply on traditional scientific and technological disciplines and economic sectors.

Future Network Technologies in HORIZON 2020: Opportunity to help reinvent an entire global industry

Future Network Technologies research in HORIZON2020 will primarily be addressed under the Industrial Leadership pillar. The Industrial Leadership pillar will aim at making Europe a more attractive location to invest in research and innovation, by promoting activities where businesses set the agenda. It will provide major investment in key industrial technologies, maximise the growth potential of European companies by providing them with adequate levels of finance and help innovative SMEs to grow into world-leading companies.

The aim of this consultation is to collect clear and convincing evidence to show that:

- EU research and industrial players are ready in HORIZON2020 to take further long-lasting commitments and be able to develop and deploy leading network infrastructure technologies here in Europe for the benefit of its citizens.
- EU industry will translate successful research and scientific breakthroughs into innovative products, services and systems, which will foster EU economic leadership worldwide.
- EU taxpayers will receive value-for-money from research and innovation: in terms of growth, high-quality jobs and a sustainable life and economy.
How do we get there? Can we actually do it?

The Digital Society enables a whole range of industries to use the network and European industry has a strong position in the global network technologies sector. We need to support all industries using ICT and therefore we need a deep focus on communications as an enabler. If EU will not be in the lead someone else will be. We need to explore new constituencies and methodologies to maximise the impact of research and innovation. The increasing number of connected devices requires enhanced network capacity and performance. This will require significant research efforts into the underlying technologies.

Call to Action & Next Steps

We are seeking advice, comments and input on stakeholders’ specific areas of interest to address and help prioritise in a strategic manner the needs and challenges in network communications research in Europe in HORIZON2020.

- We call on researchers from industry and academia, providers, manufacturers, current and future users of networks communications, to act together for a shared, convincing and trusted common EU goal! Take this challenge with us and submit your contributions before 15 May 2012! You can upload it directly via the consultation website.

We are particularly interested to know your views and opinions on the following questions:

- Which sector are you representing? What are the strengths and size of your market in Europe and/or worldwide?
- How would you describe (in less than one page) your ideas and/or plans for future R&D challenges/topics relating to Network Technologies?

N.B. This could encompass any topic from basic research to innovation and experimentation.

- How do you see the potential role of your organisation in HORIZON2020 in connection to the network technologies design, experimentation and/or deployment? What are your research priorities?
- Which network technologies requirements and expectations, do you consider important to inspire innovation and bring most benefits to your (business) development in the future?
- Which cross sector synergies in relation to the network technologies research are of strategic importance to generate growth in your business sector?
- How do you think that the network research community should best engage with the user community?
- Which constituencies and methodologies in relation to network technologies research are most important to maximise the impact of research and innovation in HORIZON2020?
- How should research developments in network technologies in HORIZON2020 be measured against delivering EU industrial leadership worldwide, sustainable economic growth and high-quality jobs creation in Europe?

The results of this consultation will be presented at an Open Workshop organised on 29 June 2012 in Brussels, where key contributions will be invited to make a presentation of their ideas for HORIZON2020 Future Networks Research.

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Future Network Technologies Research and Innovation in HORIZON2020
Consultation Workshop Agenda
29 June 2012, Brussels
Avenue de Beaulieu 25 – Room S1

9h00 - 9h15 Welcome remarks, Luis Rodriguez-Rosello, European Commission, Head of Unit

9h15 – 11h00 Integrated Infrastructure Panel Session
Chair: Philippe Lefebvre, European Commission
Panel Firestarter: Net!Works ETP Contribution, Werner Mohr, Net!Works Chairman, Nokia Siemens Networks
Panel Opening Statements:
- ASTRIUM (Philippe Boutry)
- COSTIC1004 (Narcis Cardona, COST IC1004 Chairman)
- ERICSSON (Henrik Abramowicz)
- ISI ETP (Nicolas Chuberre, ISI Chairman, Thales)
- DEUTSCHE TELEKOM (Hans Einsiedler)

11h00 – 11h15 Coffee break

11h15 – 13h00 Smart networks & architectures Panel Session
Chair: Rüdiger Martin, European Commission
Panel Firestarter: Alcatel-Lucent Contribution, Didier Bourse, Director, European Research Cooperation
Panel Opening Statements:
- CAON Cluster (Dimitra SIMEONIDOU, University of Essex)
- DANTE/GN3 NREN (Michael Enrico - DANTE, Mauro Campanella - GARR)
- Steve UHLIG (Queen Mary, University of London)
- Eduardo JACOB (UPV/EHU, University of the Basque Country)
- Olivier MARTIN (Independent ICT expert, exCERN)
- ETNO/ORANGE FRANCE TELECOM (Yvan Meriau, Orange)

13h00 – 14h00 Lunch break

14h00 – 15h45 Users’ Perspectives Panel Session
Chair: Andrew Houghton, European Commission
Panel Firestarter: NEM ETP Contribution, Jean-Dominique Meunier, ETP Chair, Technicolor
Panel Opening Statements:
- BARCO (Ronny Dewaele)
- EARPA (Ben Rutten, Technical University of Eindhoven)
- Anders Rockström (KTH - Kungliga Tekniska Högskolan)
- IoT Cluster (Ovidiu Vermesan)
- Celtic Plus (Jacques Magen, Celtic Plus Chairman)
- SINTEF (Arne Lie)

15h45 – 16h00 Wrap-up & Conclusions, Luis Rodriguez-Rosello, European Commission, Head of Unit

N.B. The selected contributions are available online:
Overview of Key Trends and Drivers from the received contributions

Global trends bring in an unprecedented pace of changing and increasing demand and requirements on technologies and solutions for Future Networks. In this consultation three major areas namely Integrated Infrastructure, Smart networks & architectures and Users’ Perspectives have been identified as areas where major actions have to be taken towards the Future Internet and where intensive research is required for Horizon2020. An overview of the resulting trends and drivers from the received contributions is presented below:

Integration and Convergence: Development of common/shared infrastructure enabling any-to-any communication independently of the physical access technologies (wireless, wireline), capacity/resource usage, user utility, host/device movement and density, existing infrastructure. 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. wireless and wired infrastructures need to be better integrated to ensure the required bandwidth is always available, everywhere, at the right cost.

Demands on mobile communication and networks calling for 5G Wireless: The demands placed on mobile 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. Trends like growth of world populations, globalisation, mobility in all dimensions (goods, people, information), technology race, generation gaps, digital and educational dividend, social communities and networking, scarcity of resources, climate change still develop more and more momentum. These global trends are calling and demanding innovation in mobile communications.

Demands on Optical Networks: Optical network technologies will need further development as fibre-optic systems now also start approaching a limit. New research is needed to increase fibre capacity 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 optimize end user experience over a fibre-constrained backhaul-infrastructure. Research areas include support of multi-Gbps access rate, Spectrum Management, Optical Network and IT convergence, optical network control plane, cognitive, self-managed and energy efficient optical networks.

Demands on Satellite Networks: Demand driven activities enabling, improving and sustaining EU industry competitiveness on the worldwide SatCom market, can be split into five components: broadcast services, backbone, broadband access, communications with mobiles and Governmental services. Satellite R&D activities include Reconfigurable, resilient and secured broadband connectivity, Enhanced broadcast systems, Integration/hybridising of future
SatComs in the Future Internet, Capacity Distribution Scenarios, In-orbit validation, on-board regenerative processor, new Adaptative Coding and Modulation (ACM), Interference Mitigation techniques and technologies enabling in-flight connectivity for passengers in commercial aircraft.

**Continuous exponential growth of traffic and Technologies approaching their intrinsic limitations:** All network technologies will need further development as we reach the limits of current systems. New research is needed to ensure a thousand-fold increase in network capacity in coming years. Network usage changes, Traffic types, traffic rates and flow size distribution changes resulting in new requirements traffic control, Not human generated traffic (for instance from M2M capillary networks) will increase and coexist for network usage, coming along with Massive node deployment. In Wireless networks this goal could be achieved by including exploring new frequency bands and complete revise of frequency allocations and licensing, spectral efficient techniques such as addressing spectrum management with cognitive radio agile radio. higher spectrum utilization (e.g. bandwidth efficient modulation, out-of-band suppression like FBMC, higher frequency bands, dynamic spectrum access/Cognitive Radio), better spatial utilization (smart antennas, interference control, topology optimization such as heterogeneous networks), and improved overhead ratio (efficient MAC and signalling protocols).

**Standardised and interoperable architectures for distributed systems and Heterogeneous networking:** As more and more devices are connected to the Internet it becomes essential that they can interoperate not only on the network but also on the service and control layer. Open and standardised interfaces will help but an overall architectural framework is recommended. These kinds of architectures for distributed systems will be the key to enable next-generation services and open up the market for new players. Continuous evolution of mobile terminals and tablets, due to progress of OS, mobile processors and embedded sensors will add further requirements and models for mobile networks. The word of mobile internet and IoT shall meet creating new solution and technological challenges.

**New applications and content 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. Data and content delivery need further research in order to ensure that they meet the user needs. 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. Furthermore, the variety of media consumption, in particular the different types of real-time video and video- on-demand type services, has increased rapidly. Therefore, the classical distinction between broadcast-only networks and (Internet-based) communication networks is no longer valid. Integrated solutions are required which fulfil the customers’ media consumption demands on stationary and mobile devices in a cost-, energy-, and spectrum-efficient way.

**IoT:** The use of networks to connect machines to the Internet is still in its infancy. Internet architectures should be resilient and trustworthy and designed to support open access, increasing heterogeneity of end-points (multimode devices, people, things) and networks (self-adaptive, self-healing networks, opportunistic networks, networks of networks), with the need of a seamless and generalised handover. Networks will sustain a large number of devices, many orders of magnitude higher than the current Internet, handle the large irregular information flows, and be compatible with ultra-high capacity end-to-end connectivity.
Security and trust issues in shared and more autonomous infrastructures: 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. Security of the shared infrastructure becomes a key area of concern, the expansion of the infrastructure together with the increasing complexity of technologies (amplification effects resulting from interactions among components that are sometimes hidden or unknown at design time) makes novel types of anonymous attacks possible. Coping with the security challenges without impacting accessibility, scalability, and privacy of the infrastructure is one of the main challenges of the next decade. Security topics such as beyond DRM, trust, and security, will also 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.

Solutions for demographic changes and integration of smart city & smart home networks and applications: In times of demographic change, increasing health care costs and shrinking resources, innovative ICT solutions become more and more vital to ensure high quality of life and future health care. First ambient assisted living (AAL) solutions are available today already, but will be even more beneficial when combining information from smart home and smart city environment (sensor networks, home management systems), thus enabling the home as a location for care and health care.

Green industry / life and Energy saving: Energy efficiency is now a primary target for new communication systems and solutions. This work addresses issues such as new applications and technologies for reducing energy consumption, and to actively manage and control the best use of energy in sectors like health, transport, energy, e-government, urbanisation, knowledge and culture. Energy efficient hardware and software algorithms are key parameters in future networks, not only to ensure market success, but also to fulfil green radio obligations.

Proliferation of the cloud concepts beyond pure applications: (a) Technology breakthrough (e.g. SOCs offering capacity as offered by nodes), enabling unprecedented scalability, flexible distribution, (b) Networked cloud and (c) Cloud services. Economy of scales both for quick upscaling and downscaling of required processing, storage and network resources ‘on demand’, pay as you need by means of virtualization.

Societal needs and User perspectives: A connected society: Everybody and everything will be permanently connected to a Network. Network bandwidth and quality will increase significantly. We can summarise this future network paradigm as: *Anything, anytime, anywhere on any device.* More specifically, needs for networking will increase drastically in coming few years (number of connected objects, higher data rate, pervasive access to information from users, delinearised content, cloud computing etc.). This will make users’ behaviours strongly network-dependent. The future networks will thus have to face future connectivity characteristics and to bind connectivity with smart mediation. New societal challenges are appearing where communication technologies will have to play a large role e.g. in environmental awareness. 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”. New and broader QoS requirements result from new advanced services.

User interfaces and immersive experiences
Proliferation of 3D, immersive and beyond-HD experiences with interfaces are becoming even more intuitive, including speech, tactile and multisensory interactions. Experiencing content is king – rich, connected, immersive, intuitive experiences are the future.
**User and usage data:** 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. Converged service that will give access to all types of information found or to be found on the Internet: health, transportation, pictures, music, movies, power, sensors, social, etc. The Internet of Services is user-centric. The Future Internet infrastructure components must be secured against intrusion, hacks and misuse. The privacy of each actor must be guaranteed and controlled. Content will be transformed into smart content by adding metadata during the content creation process or during exchange. Virtualisation implementation is necessary as they will offer the link to services and data accessible on the Cloud, as well as more adaptive systems and technologies being able to sense their neighbourhood and adapt accordingly and new ways of handling enormous amount of connected devices in a cost-efficient way.

**Customer analytics for quality assessment and service management:** What can we learn about the user, and about how much she/he likes or dislikes a service, by combining different sources of information from network- and device-based monitoring systems that collect information both about network properties as well as user behaviour? This is an increasingly relevant topic addressed by large non-European companies for a long time already. It requires research and development at European level to exploit the substantial possible economic benefits, by considering the diverse technological aspects underlying different approaches to the topic, and especially addressing the most important show-stoppers such as the related privacy concerns.
Net!Works ETP Contribution by Werner Mohr
Future Networks: Consultation on Future Network Technologies
Research and Innovation in HORIZON2020

Questions

1. Which sector are you representing? What are the strengths and size of your market in Europe and/or worldwide?

- The Net!Works European Technology Platform (ETP) represents the communication networking technology sector with a main focus on mobile and wireless communications. In addition, Platform extended its scope to optical communication with respect to the convergence of communication networks. Optical communication systems provide the backbone network for broadband mobile communication networks.
- This ETP represents the:
  - communications technology manufacturing industry,
  - IT industry with their activities towards communication networks,
  - communication service providers,
  - SMEs,
  - R&D centers in this field and
  - universities.
- The communications technology sector is relying on international – and ideally on global – standards in order to ensure interoperability of systems and economy of scale to reduce cost. In particular mobile and wireless communications is requiring global interoperability as much as possible to serve roaming users and devices and to ensure quality of service.
- Major global standards and systems in mobile and wireless communications as well as in optical communications are based on European collaborative research projects. Results were used for consensus building between organisations, which are also cooperating in international standards organisations. This ensures the exploitation of results.
- The following two documents summarise major EU funded projects and their contributions to global standards and systems:
According to Bitkom [1] the worldwide ICT market volume increased in 2010 by nearly 5% to about 2500 Billion €. The biggest ICT market are USA with market share of 28.7 % (Figure 1).

For example Germany with 5.1% global market share is No. four after the USA, Japan and China.

![World market share for ICT in 2010 without consumer electronics](image)

**Figure 1**  World market share for ICT in 2010

The LTE (Long-Term Evolution) system, which is based on a series of European collaborative research projects, is now being globally deployed (Figure 2) [2].

![LTE deployments and commitments](image)

**Figure 2**  LTE deployments and commitments
• European industry has a significant share in this business and is in fierce competition with Asian manufacturers.
• 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 3).

![Figure 3](image)

**Figure 3** Worldwide Internet audience

• It is expected that communication traffic will further grow significantly. The following diagram (Figure 4) shows a study by CISCO, which is expecting in the coming years an exponential growth [4; 5].

![Figure 4](image)

**Figure 4** Consumer Internet traffic growth forecast
• ITU is supporting these expectations, where the number of subscribers is growing globally (Figure 5) [6].

![Figure 5] Global availability of ICT development

- Investment in broadband communication systems is providing positive effects on economic growth and additional deployment [7]. Figure 6 shows the expected impacts for the example of Germany.
- Broadband investments between 2010 and 2020 will add 170.9 billion € to GDP (Gross Domestic Product) and 968,000 jobs.

![Figure 6] Impact of Broadband Investments in Germany

- Worldbank has studied the impact of broadband communications on economic growth in developed and developing economies for different network systems like fixed networks, mobile communications, Internet and broadband communications [8].
• The left hand-side graph in Figure 7 from [8] indicates that increased broadband penetration can create GDP growth up to 1.38 per cent points.
• This productivity improvement will increase GDP without increasing resources used in production.
• For example, the US could increase its GDP by 100 billion $ with an increase of 10 additional broadband lines per 100 individuals (30 million lines).

![Figure 7: Input of Broadband on GDP](image)

**Source:** Qiang 2008.

**Note:** The y axis represents the percentage-point increase in economic growth per 10-percentage-point increase in telecommunications penetration. All results are statistically significant at the 1 percent level except for that of broadband in developing countries, which is at the 10 percent level.

**Figure 7** Input of Broadband on GDP
2. **How would you describe (in less than one page) your ideas and/or plans for future R&D challenges/topics relating to Network Technologies?**

- 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 Machine-to-Machine (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.
- New technologies must be developed to meet the requirements of the new applications and to ensure high service integrity, reliability, availability of more than five 9's, robustness and resistance to potential cyber security threats.
- Wireless network technologies will need further development as we reach the limits of current systems. New research is needed to ensure a thousand-fold increase in wireless network capacity in coming years. This goal could be achieved by (these figures show the size of the problem in the coming decades to cope with the forthcoming growth of traffic):
  - 100x more spectrum: including exploring new frequency bands and complete revise of frequency allocations and licensing.
  - 100x spectral efficient techniques.
  - 100x more access points.
- Concepts as software radio helped to reinforce innovation in the last eight years changing architectures, processing and new principles could applied to
  - addressing spectrum management with cognitive radio agile radio and
  - addressing infrastructure to provide the best QOS with software defined networks.
- 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 optimize 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.
- 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. Therefore, concertation with the Future Internet is important.

N.B. This could encompass any topic from basic research to innovation and experimentation.
3. **How do you see the potential role of your organisation in HORIZON2020 in connection to the network technologies design, experimentation and/or deployment? What are your research priorities?**

- The Net!Works ETP is preparing on regular basis a Strategic Research Agenda for mobile and wireless communications including basic topics for optical communications [9].
- The Strategic Research Agenda is identifying necessary and relevant research topics and is used as a contribution to the preparation of Work Programs of the EU Framework Programs and also for HORIZON2020.
- In addition, the Net!Works ETP is facilitating the preparation of proposals for research projects by bringing stakeholders together in networking events in order to support the development of consortia.

4. **Which network technologies requirements and expectations, do you consider important to inspire innovation and bring most benefits to your (business) development in the future?**

- In future several different access systems from wide-area to short-range communications will be used to use the available frequency bands in the most efficient way.
- Interworking of these access systems is required to handover running sessions to different systems without compromising user experience and without user intervention (traffic offloading).
- More wideband systems will be needed for data hungry applications.
- Systems using heterogeneous networks offer potential to address challenges (so-called HetNets).
- Sensor based networks will require processing and support at the network edges.
- Several applications require significantly lower latency than today’s systems.
- The overall user experience in terms of coverage, reliability and availability of systems as well as throughput rates and latency should significantly be improved.
- With respect to the reduction of the CO$_2$ footprint and economic needs a significantly improved energy efficiency will be needed to cope with the overall increasing traffic.
- System capacity has to be increased to support growing traffic demand.
- Broadband backhaul technologies based on optical communications as well as on microwave links (e.g. in the 60 to 90 GHz frequency range) are needed for network deployment. Cost of deployment of the backbone network should be reduced by more cost-efficient optical communication components and systems and sufficient frequency spectrum for microwave links.
- A better frequency spectrum usage can be provided by cognitive approaches.
- Self-organised systems will help to handle the increasing system complexity.
- Trust and security of the transaction and of the data flow need to be considered further.
- Collaborative research projects will help to prepare future international standards by consensus building. Research results can then directly be exploited in standardisation bodies.
- Such projects should also contribute to the preparation of ITU-R WRC 2015 for the potential identification of additional frequency spectrum for mobile and wireless communications.
5. Which cross sector synergies in relation to the network technologies research are of strategic importance to generate growth in your business sector?

- Communication technologies will increasingly be applied to other sectors in industry and society to make such other sectors more efficient.
- As a precondition at first requirements and needs from other sectors on the necessary ICT have to be understood.
- In order to enable investment in communication technology for other sectors as much as possible standardised technologies and systems should be applied. This ensures economy of scale and enables interoperability, which is important for European-wide solutions.
- Cross sector synergies can be expected in connectivity solutions, cloud computing, IoT (Internet of Things) solutions.
- This will allow growth for the ICT industry in addition to classical communication applications like for telecommunication.

6. How do you think that the network research community should best engage with the user community?

- Cooperation between different communities to be involved will be key to engage with the user community.
- Both the communications and the user community have to further improve mutual understanding on the needs of the user community and on the potential offer of the networking community to develop new solutions for societal challenges.
- Networking events will be needed and based on that joint projects including both communities.
- Common projects for application domains, which will be part of the Societal Challenge pillar in HORIZON2020, provide the best means to cooperate between different communities.
- It is essential that appropriate networking technology components and systems can be applied and implemented in projects of the Societal Challenges pillar, which may be under the responsibility of other Directorates General of the EU Commission than DG Connect.
- HORIZON2020 has to ensure that even in projects of the Societal Challenge pillar sufficient budget and room for ICT research will be provided that in such application oriented projects necessary ICT activities will be possible based on new technology developments and solutions, which will be carried out in the Industrial Leadership pillar in HORIZON2020. It is essential that research results from Industrial Leadership will be reused in Societal Challenge projects where appropriate.

7. Which constituencies and methodologies in relation to network technologies research are most important to maximise the impact of research and innovation in HORIZON2020? Be maintained

- There are basically two complementary approaches, which should be followed:
  - Technology research projects are needed to progress system capabilities significantly forward. The technology know how position of Europe has to maintained and improved in relation to other regions. Such projects should be organised in the Industrial Leadership pillar of HORIZON2020 under the responsibility of DG Connect. Stakeholders from the communication community should be involved.
  - Application-oriented projects should use and implement newly developed technologies and systems for new solutions, e.g. for societal challenges. Such projects will be suited in the Societal Challenge pillar in HORIZON2020. Ideally, they should be organised under the responsibility of DG Connect. If
other DGs will be responsible, appropriate ICT components and systems have to be used in such projects. Results from Industrial Leadership should be reused as much as possible.

- Best suited methodologies are collaborative projects like IPs and STREPs or for bigger challenges PPPs (Public Private partnerships) with a single source of funding (EU Commission) to keep the complexity of overall implementation of the action in a reasonable order.
- Relevant stakeholder groups have to be involved to ensure economic exploitation in international standardisation and/or products and systems for new solutions for societal challenges.
- Collaborative research projects should be used for consensus building, which can be exploited in international standardisation via established channels of partner organisations.
- A similar approach can be followed for regulatory contributions.

8. *How should research developments in network technologies in HORIZON2020 be measured against delivering EU industrial leadership worldwide, sustainable economic growth and high-quality jobs creation in Europe?*

- The network technology sector is based on an ecosystem of global companies with globally R&D organisations and SMEs, which provide special know how and expertise.
- According to [10] the contribution of ICT to economic growth in the EU is in the order of 50 %. This is also shown by [7; 8].
- Therefore, it is essential to deploy new broadband networking technologies, which are also based on results of collaborative research in Europe, by reasonable conditions for an investment-friendly climate in Europe. The regulatory environment is playing an important role in this context.
- The impact on global standards by anchoring IPRs coming from Europe is an essential condition to ensure an important position of European industry in global competition.
References


The growth of mobile communications, since the launch of the GSM system on the market in 1991, has been phenomenal. Mobile communications has changed people’s lives for the better the world over by enabling people to communicate anytime and anywhere. Mobile communication drives productivity growth and economic performance across all sectors of the economy and is expected to continue to do so for many years to come. The services enabled by mobile networks made a strong contribution to the rapid growth in the ICT sector in Europe and generated several million new jobs. The results of Framework Programme research projects have played a key role in enabling this growth. The projects developed the basic concepts, processes and product innovations, contributing to several generations of mobile communication systems and services (e.g. GSM, UMTS, DVB, LTE and IMT-Advanced), over a twenty-five year period.

The introduction of mobile technology accelerated the global growth in the ICT sector. The Information and Communication Technologies (ICT) sector now generates 5% of European GDP, with an annual value of €660 billion. ICT has become a ubiquitous technology and investments in ICT are responsible for at least 50% of European productivity growth in recent years.

Many of the basic concepts and technologies used in the 3G UMTS standards and the newer LTE standard had their origins in Framework Programme collaborative research projects, co-funded by the European Union.

The investment of Framework Programme funds in mobile communications research has contributed strongly to job creation in Europe and improvements in living standards and economic growth on a global scale. The level of return on investment achieved by the key collaborative research projects has few, if any, parallels in other sectors and contributes to the export power of European industry. Collaborative research provides an environment in which many stakeholders (competitors, customers and research experts) can cooperate to prepare consensus before global standardisation starts. Collaboration provides the opportunity to quickly exploit research results through standardisation, leading to the global deployment of new ICT systems.

We can already see a dramatic increase in data traffic on converged mobile and fixed communications networks generated by smart city, smart energy, environmental monitoring and ehealth applications. By 2020, enormous growth in network traffic is expected. The European success story resulting from the investment in collaborative research projects is certain to continue for many years to come, if Europe continues to invest in collaborative research!
The development of the GSM standard was part of the early formation of the European Union at the level of technology and mobile communications. For the first time, a solution was developed for Europe and the world enabling users to roam internationally using only one phone. Europe pooled its R&D, industrial base and services to provide the user with a mobile world without national borders. This initiative and the further collaborative R&D created a new generation of technologists focused on European and global needs. The GSM group was formed in 1982. GSM networks are now accessible in more than 85% of the world’s land area. First commercially introduced in 1991

1991

GSM, UMTS and LTE are registered trade marks.

1991

European research projects developed the key contributions to the 3G UMTS standard in the ‘90’s. 3G systems provide users with broadband multi-media mobile communications, including voice and video services, mobile Internet access, mobile TV services and machine to machine communications services.

Key Framework Programme co-funded project:
FRAMES (FP 4)

First introduced in 2001

2001

European research projects developed key contributions to the LTE system in the ‘00’s. LTE provides high speed mobile broadband connectivity to laptops, smart phones, tablet PC’s and other mobile devices. On-line gaming services, streamed video and cloud computing services are brought to life by LTE. The LTE service is already commercially available in Stockholm and is being introduced widely in European cities in 2011.

Key Framework Programme co-funded projects:
WINNER (FP 6), WINNER II (FP 6)

First introduced in 2010

2010

The technical basis for ultra high speed broadband and M2M communication using energy efficient techniques are research challenges being addressed in Framework Programme 7 projects at present. European research has to continue in Framework Programme 8 to ensure that European organisations further develop their leadership positions in communications technologies!

2025 and beyond

Future

The development of the GSM standard was part of the early formation of the European Union at the level of technology and mobile communications. For the first time, a solution was developed for Europe and the world enabling users to roam internationally using only one phone. Europe pooled its R&D, industrial base and services to provide the user with a mobile world without national borders. This initiative and the further collaborative R&D created a new generation of technologists focused on European and global needs. The GSM group was formed in 1982. GSM networks are now accessible in more than 85% of the world’s land area. First commercially introduced in 1991
From groundbreaking discoveries, such as optical fibres and EDFAs over products such as WDM systems and OXCs to global standards such as SDH, OTN and ASON, Europe has been at the forefront of optical communications R&D for nearly 50 years. The EU Framework Programme played a pivotal role in developing several generations of optical networks over the last 25 years. 7 of the top 20 network operators are headquartered in Europe. 6 of the 20 largest optical equipment manufacturers have major R&D centres in Europe and represent more than 30% of the global equipment market. Two of the top 3 component manufacturers have operations in Europe. Over a hundred SMEs’ and universities deliver complementary innovation on network, system, or component levels. According to a recent Photonics21 study, optical technologies leverage a telecommunication infrastructure market of 350 Billion EUR and impact more than 700,000 jobs in Europe.

By 2020, at least a 10-fold increase in fibre capacity and Tb/s per wavelength will be required. Fibre communication will move closer to the user and will become a critical infrastructure in datacentre, private, home, vehicle and sensor networks. Based on its strength and expertise, Europe is well positioned to respond to these challenges, if it continues to invest!

Many architectures, concepts and technologies had their origins in collaborative research projects, co-funded by the European Union.

The investment of Framework Programme funds in optical communications has created a network of experts from industry and academia, provided education and has contributed directly and indirectly to the creation of over a hundred thousand jobs in Europe for highly-skilled knowledge workers. The collaborative approach of the projects allowed consensus building on central topics such as the optical network evolution and network control. The results, disseminated in publications and standard contributions, formed a solid foundation for the product roadmaps of participating system/component manufacturers and enabled network operators to develop their technology introduction strategies ahead of time.
## European research projects contributions to optical networking successes!

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<td>1 x 2.5G</td>
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<td>50GHz DWDM ROADM rings</td>
<td>50GHz DWDM Colour-/directionless MD-ROADM mesh</td>
<td>50GHz DWDM Colour-/directionless MD-ROADM mesh</td>
<td>Flexible Grid DWDM Colour-/directionless MD-ROADM mesh</td>
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<td>SDH</td>
<td>WDM TMN</td>
<td>NG-SDH, OTNv1 ASON</td>
<td>OTNv2 GMPLS</td>
<td>OTNv3 PCE</td>
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For more information please visit [www.networks-etp.eu](http://www.networks-etp.eu)
ASTRIUM by Philippe Boutry
1 - Which sector are you representing? What are the strengths and size of your market in Europe and/or worldwide?

Telecommunication satellites is a high technology and high growth sector. The trend of the last 40 years is due to the very high reliability of the space infrastructure and the high quality of the services delivered to the users. In Europe as worldwide, satellite communications lay at the heart of many networks, be it for TV broadcast (80% of European households receive TV thanks to SatCom), services to mobiles, business networks etc.

The turnover of the European space industry (upstream) is of the order of €6 Billion, employing 30 000 highly skilled engineers and technicians. The telecom market represents more than 70% of the European satellite industry turnover and employment, and for 90% of all European commercial launches. Three of the biggest satellite operators are European and key customers of space. Therefore, the European satellite communication industry is a fundamental element for Europe in sustaining it’s whole space industry and its strategic independent access to space.

However the European Satellite Communication Industry is facing huge challenges in commercial markets, since competition is growing, in particular from industries outside of Europe. The US industry benefits from a huge aggregated and highly protected domestic market, a long lasting favorable national currency/€ depreciation and a financial government support accounting more than 80% of their activities, while the Chinese, Indian and Russian space industries benefit from reduced labour costs combined with long lasting $/€ depreciation and large political, financial government support and restricted domestic market.

In this context, Astrium designs, builds, delivers and even operates in-orbit telecommunication satellites. In 2011, Astrium was the first SatCom industry in Europe and the second in the world. This position has been acquired thanks to a long standing successful track record of satellite productions started 40 years ago: Astrium already manufactured 67 Eurostar-based satellites (Eurostar being the Astrium-designed platform hosting the payload specified by the customers), 43 of which are currently in orbit operated by our customers (including 19 over Europe) and 13 of which being under construction.

The SatCom industry delivers high quality products which in turn allow high quality and sustainable services for the satisfaction of the satellites operators. In particular, Astrium never lost a satellite in orbit. Service continuity is also a core aspect of the SatCom solutions: satellites have an average 15 years life-time and are continuously improved and replaced in orbit.

Satellite operators are convinced by the capabilities of the space technologies: they pursue their investment and continuously renew their fleet with always more performing infrastructures; indeed about half of the satellites orders are aiming to replace or enhance existing capacity.

This dynamic, initially triggered by broadcast services, is now emerging for broadband services. The first European satellite fully dedicated to broadband services (KA-SAT from Eutelsat) is operational since spring 2011 and offers internet solutions as performing and equivalent in price to the terrestrial ones.

EC actions are fundamental to maintain competitiveness and accelerate the take-up of those services; in particular, awareness for new services must be raised further.

Nota: Astrium is an active member of ISI, the European Technology Platform Integral SatCom Initiative. As such, Astrium has also contributed to the answer provided by ISI to the present consultation. This specific Astrium answer contains additional elements stemming from Astrium specific experience in the SatCom manufacturing sector.

2- How would you describe (in less than one page) your ideas and/or plans for future R&D challenges/topics relating to Network Technologies?

Astrium priorities go to demand driven activities enabling, improving and sustaining EU industry competitiveness on the worldwide SatCom market which can be split into five components: broadcast services, backbone, broadband access, communications with mobiles and Governmental services.
Astrium considers that today, broadcast services represent the core of the installed market while broadband access is the most probable next growth axis. Therefore, Astrium concentrate its R&D effort on sectors aiming to enhance the performance of the Astrium products in those market sectors.

Astrium has fed its input into the Strategic Research and Innovation Agenda (SRIA) elaborated by the ISI ETP.

In particular, Astrium has identified the following areas as requiring R&D activities in the short term:

- **Broadband**: optimisation of the ground component of High Throughput Satellites (cost versus performance), including moving towards users mobility
- **Broadcast**: integration/hybridising of terrestrial solutions and networks with satellites systems to develop “broadcast over IP”
- **Capacity Distribution Scenarios**: Flexibility in term of coverage, power and bandwidth
- **In-orbit validation** is deemed a necessity to enable market access.

At last, in the mid-term, the following technical areas will require R&D activities to maintain: on-board regenerative processor, new Adaptative Coding and Modulation (ACM), Interference Mitigation techniques and technologies enabling in-flight connectivity for passengers in commercial aircraft.

**Beyond the technical aspects**, another challenge of research activities is their **funding**. Astrium internally finances a large part of its R&D effort, but public support is needed to keep-up with the much higher and still growing support of the US, Russia, China and India to their national industries.

The European Framework Programme provides one source of co-funding through the ICT component. It has to be pointed out that the Space component of the Framework Programme 7 is hardly used for specific SatCom topics while it could serve as an interesting complement. Beside, the ARTES programme of the European Space Agency is a major co-funding source and helped, for example, to develop: a new generation of very high power platforms (AlphaBus).

**Coordination between ESA and the EC is key to achieve best use of the public funds.** This coordination should ensure a larger coverage of R&D domains to be co-funded and will avoid redundancies by taking into account the complementarities of ESA and EU.

**3 - How do you see the potential role of your organisation in HORIZON2020 in connection to the network technologies design, experimentation and/or deployment? What are your research priorities?**

The ICT activities ran in the fame of the framework programme are generally very “user-centric”. Astrium believe that this approach is key to raise awareness of public authorities and citizens, and help removing the roadblocks (technological or not). Astrium has thus already ran or participated in several Framework Programme ICT projects aiming to demonstrate the usefulness of satellite broadband applicative services on the basis of existing broadband offers, and thus enhance the demand. Of particular relevance are Twister, Rural Wings, NetAdded, SFERA:

- **Twister** co funded by the EC (FP6) deployed and operated 105 validation sites in rural areas throughout Europe combining satellite broadband services with wireless local networks in the domains of agriculture, education, community services, health care and e-business. This project has been followed by participation to other EC projects: **Rural Wings** (tele-education) and **NetAdded** (e-health/e-learning in developing countries). **SFERA** aimed to assist Member States in the efficient use of Structural Funds for bridging the digital divide in underserved areas.

Astrium wishes to pursue this type of activities in H2020. Furthermore, Astrium is a company very close to the market and thus able to realistically estimate the commercial needs in term of space technologies. Astrium tight relations with its customers allow the company to understand the positioning of the space component within the complete value chain. More particularly, as already hinted in the answer to question 2, Astrium believes that there are two major areas of work in the short term:

- **Broadband**: actions aiming at increasing throughput this decreasing the €/Mbps
- **Security**: technologies enabling the development of flexible payloads (in term of coverage, bandwidth, frequency etc.).

**4 - Which network technologies requirements and expectations, do you consider important to inspire innovation and bring most benefits to your (business) development in the future?**
Satcom based services have a role to play to address many societal challenges of the EU: the Digital Agenda per se of course, but also specific broadband applications enabling a fair access to all European citizen to public services such as e-health, e-education and e-administration. Beside, SatCom services are an obvious tool to support Crisis management and Security issues and a mean for terrestrial network resilience.

It is thus of utmost importance that ICT include space-based solutions as one eligible solution, unambiguously and without a priori since the latter lack awareness although it provides services competitive while complementary with terrestrial solutions regarding the technical and the economical performance. A clear requirement from the EU to achieve seamless integration of satellite based solution into the global networks would certainly be a strong enabler.

5- Which cross sector synergies in relation to the network technologies research are of strategic importance to generate growth in your business sector?

In line with the arguments already development in Question 3, Astrium is a strong promoter of full scale pilot projects as key tools to trigger the take-up of space-based network technologies. Therefore, Astrium insists on the strategic importance of the synergies below as potential generators of growth:

- Synergies between Terrestrial and Space-based networks
- Synergies between Telecom networks and applicative areas (e-Health, crisis management etc.).

6 - How do you think that the network research community should best engage with the user community?

To ensure usage of network technologies developed through H2020, the users community should be better involved in all the different stages of the activities:

- At the early stages in research actions to specify the technology performance needs
- At later stages in pilot action to specify the operational need and validate the results.

Outside of that project frame, the relations with users should be pursued, typically through Thematic Networks, to continually iterate on best practices and allow for a sustainable dissemination of the information.

7- Which constituencies and methodologies in relation to network technologies research are most important to maximise the impact of research and innovation in HORIZON2020?

Astrium has identified four principles to follow in order maximize the impact of R&I actions:

1. R&I actions must follow a “demand-driven” approach which is already developed in Question 3
2. R&I actions must involve the users at all stages of the development, as developed in Question 6
3. R&I action should always have in perspective the possibility for follow-up pilot/demo project
4. A pilot/demo project should always be implemented with a sustainable perspective (e.g. always involve a operator or service provider to assess the economical model).

8- How should research developments in network technologies in HORIZON2020 be measured against delivering EU industrial leadership worldwide, sustainable economic growth and high-quality jobs creation in Europe?

As a satellite manufacturer, Astrium measures the success of its activities within the Framework Programme against two criterias:

1. The demand for satellites from satellites operators or governmental customers
2. The success in the commercial competition, once the demand is established.

To generate demand and achieve competitiveness, Astrium uses research activities as follows:

1. Demand for new types of satellites and payloads stems from the next most probable growth axis, namely, in Astrium opinion, broadband access and new broadcast content. This is why Astrium has developed since a few years a so-called Target/Target 2 approach illustrated in the scheme below for what concerns Broadband access.
The Twister project (EC FP6) has been used to prepare the demand for the KA-SAT, a satellite fully dedicated to broadband services. TWISTER included the deployment and operation of 105 validation sites in rural areas in 8 EU countries combining bidirectional satellite broadband services with wireless local networks. At project end (mid 2007) nearly half of the sites remained active and commercially operated. Twister has definitely been a tool to test the market by offering (through sharing of a satellite access point) a lower price for satcom services which can be now offered to individual users through high capacity KaSat satellite.

2. **Demand for renewal of current satellites is triggered by a good market take-up.** For example, in the case of broadband services, the competition between the terrestrial and the space-based solutions, coupled with a poor awareness of satellite solutions performance and prices render this take-up not as easy as planned. Astrium thus expects the EC to launch full-scale pilot project very early within H2020, in order to demonstrate the multiple usages and benefits of such solution for white and under-served areas.

3. **Success in commercial competition relies much on the mastering of key enabling technologies.** It is a major asset to be first on the market. Typically, new broadcast information content is one growth axis of this market which will necessitate technology developments. Therefore, Astrium participates to the FP7 project MUSCADE which, among other things, investigate and implement techniques for the scalable & robust transmission of 3DTV. These techniques may be used in the future generation of TV broadcast satellite.

In conclusion, criteria for measuring the interest of H2020 activities for Astrium will be:
- the amount of technologies developed through H2020 contracts which turned up a key asset in a competition for satellite or payload development contract.
- the installation or generation of users demand for Satcom-based solutions.
COST IC1004 Position Paper on Horizon2020

Research Challenges on Communications Networks and COST Actions role in the future European Research Framework

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Abstract
This document summarises the position of COST IC1004 Action on Cooperative Radio Communications for Green and Smart Environments towards the future Research Framework in Horizon2020. The European research in the area of Communication Networks has many open challenges to become competitive under the current evolution of the wireless communication services and the exponential growth in the spatial density of data traffic demand. The position of COST IC1004 related to research challenges is grouped in six main topics: Energy Efficient Cooperative Networking, Networks beyond the Cellular concept, Smart Adaptive Antennas, Efficiency and Security at the Terminal side, Wireless Communications for Traffic Safety and Efficiency, and Testing the Adaptive Distributed Cognitive Mobile Systems. The document also describes how COST Actions can play a significant role in Horizon2020, becoming a strong instrument for scientific networking between academia and industry in Europe.

1. What is COST IC1004

[IC1004] is a European COST Action [www.cost.esf.org] on Cooperative Radio Communications for Green Smart Environments.

The Action builds substantially on the work of the previous one, [COST 2100] and its predecessors [COST 273] [COST 259] [COST 231] [COST 207], whose remarkably continuous success for nearly three decades is a strong encouragement to pursue this European collaboration in IC1004 for 4 more years. This sequence of COST Actions has provided an important platform for result-sharing, discussions and cooperation in wireless network technologies, particularly in radio channels, radio algorithms and networking issues. Valuable contributions in radio channel models and over-the-air test methodology have been standardised, contributing to GSM, UMTS and HIPERLAN.

The scientific scope of IC1004 is on Radio Communication Systems and Networks, within the framework of Energy Efficiency and Smart Environments. A Smart Environment (SE) is a physical space populated by sensors, actuators, embedded systems, user terminals and any other type of communicating device, which cooperatively pursues given tasks by exchanging information and shares resources of all types such as radio spectrum or energy. Examples of SE can be found in domains such as health (body area networks), transports (smart cars), energy (smart metering) and many others. The radio channel is central to the paradigm of GSEs. The optimal exploitation of this resource through its study and modelling, through the development of cooperative transmission techniques and through the design of self-organising and energy efficient protocols and algorithms, is the major goal of IC1004.

After one year of activities, IC1004 is one of the largest COST Actions in terms of participants, a total of 275 individuals from research institutions and companies. IC1004 meetings are attended by more than 100 experts, only 1/3 of these being MC members. The fact that the majority of participants to COST IC1004 meetings cover the expenses from their own resources, clearly indicates that the activity in IC1004 is generating significant results, not only in terms of the meeting discussions with colleagues, but mainly in the scientific networking of methodologies, standards, references, techniques, models and tools.
2. Research Challenges on Radio Communication Networks Technologies

Two very substantial challenges remain for wireless communications in the next ten years and beyond: to keep up with the exponentially increasing demand for data bandwidth, and to reduce energy consumption. These are of course interlinked, in that data bandwidth needs to increase without increasing energy consumption in proportion, but needs even to reduce it. From the COST IC1004 point of view, future scenarios of wireless communications services will require the following aspects on Communications Networks Technologies to be considered as major challenges for research in Horizon2020:

2.1. Energy Efficient Cooperative Networking

The rapidly developing “Internet of things” (IoT) applications (essential to supporting the “grand societal challenges” which are central to Horizon 2020) will require dramatically reduced energy consumption, to enable long-endurance self-powered nodes, or nodes powered by energy harvesting, while radio spectrum and overall energy resources remain strictly limited. To give some numerical values, in the medium term (~10 years), wireless access systems should provide throughput densities up to 10 Gbit/s/km² outdoors, 100 Gbit/s/km² indoors. Especially for IoT, total energy requirements of 1 pJ/bit/node (including all contributions to node energy consumption) will probably be necessary.

To achieve such goals will require extensive research on implementation technology, especially low power hardware architecture and energy-efficient signal processing. Since these goals are close to theoretical limits, it will also require a paradigm shift in wireless system design to dramatically improve efficiency in terms both of power and spectrum. Notably the existing “layered” protocols, with their requirements for retransmissions, multiple acknowledgements, etc, may be highly inefficient, and in multihop networks result in bottlenecks that prevent them scaling as required both for high capacity density access networks and large scale IoT networks. However in principle such multihop, cooperative networks have the capability to greatly increase capacity density and reduce energy consumption by bringing the access network closer to the end-user.

Wireless Network Coding (WNC – a.k.a Physical Layer Network Coding, PLNC) is a technique that has potential to become a “disruptive” technology for such networks. It has the capability of naturally solving problems related to dense, cloud-like, massively-interacting networks of nodes. It can also be regarded as an example of the more general concept of the “network-aware physical layer”, in which functions (such as routing) conventionally performed at high layers of the protocol are more efficiently carried out at the physical layer, which alone has the capability of processing signals directly, without loss of information.

These networks will nevertheless need to be self-managing to optimise their efficiency, adapting to varying demands and resource availability. This will require new cognitive methods, implemented using distributed artificial intelligence, based on tools such as game theory.
2.2. Networks beyond the Cellular concept

Mobile terminals have ceased to be the edge of the wireless communications networks, and are becoming a local area communications node entity for many of the current scenarios. The first decade of the 21st Century has seen how the computer and the phone have converged into a single concept of user terminal, making mobile telephony and nomadic computing facilities coexist in a single device. In this second decade European Research has to focus on the communications networks evolution. There is already a natural trend in the infrastructures of mobile networks to reduce the range and hence the size and complexity of the base stations, while increasing the number and bandwidth of the physical connections between smaller cell sites. The reason for this is the continuously increasing data traffic demand, which generates new opportunities for the provision of new services, which at the end give rise to a further increase of traffic capacity and throughput requirements. The wide deployment of optical communications networks, with fibre connections closer to the end users, make sense also for those wideband connections between small cells, changing the current basic concept of traffic-scaled cellular deployment to a modern view of opportunistic spectrum-access based cooperative networking.

How is this managed when a network is designed?: The deployment of new radio networks is based on facilitating access to wireless devices by installing small cells or access nodes, which are interconnected in groups by high speed (optical) networks, and cooperate within the group to manage the resources in a joint (local or wide) cooperative area. Given this trend in mobile communications networks, the whole concept of "cellular" will in future be replaced by "cooperative", and the major infrastructure embodied in base stations will be replaced by a connected sub-network of small cells.

Putting together these two concepts – wireless terminals as a local manager of radio communications not only to the user but to the surrounding smart devices, plus the reduction of cells size and the changes to the cellular based deployment concept – leads to a view of a future convergence between a mobile device and a small base station, acting as a local access enabler, either via a fixed connection to the fibre loop or by a wireless connection to another access point or mobile device.

This scenario of wireless access enablers, both fixed and mobile, is also an inclusive approach for the current technologies being investigated and developed in Europe. To mention a few: Mobile Opportunistic Relaying, Cooperative Networking, Distributed Antenna Systems, Dynamic Spectrum Resources Allocation, Cognitive Radio, Distributed MIMO.

The evolution towards “the smaller the better” will bring radio network architectures to consider the roaming user device (on the bus, in the street, inside the car, at home, etc) as a sort of relaying node able to provide coverage extension and to act as access points to the Internet for the “things” equipped with IP(v6) address; similar service will be provided by urban radio backhauls deployed using non-cellular low-energy and low cost radio interfaces; this will make the IoT paradigm become true through a network of mobile and fixed gateways interconnected according to the random mobility behaviours of humans. Delay tolerant M2M applications will emerge where roaming people will be available to act as data mules.
2.3. **Smart Adaptive Antennas**

Antenna systems are crucial for any wireless network. The conventional approach to antenna system research has been to optimise certain antenna parameters in terms of antenna-level properties such as impedance matching and radiation patterns. Such an approach is no longer adequate to deal with the stricter performance requirements imposed by new technologies such as multi-antenna systems, mm-wave communications and cognitive radio.

In this context, future antenna system research will undergo a paradigm shift. Specifically, it will account for various interactions between the antennas and their surroundings to achieve optimal system-level performance, including interactions between the antennas and the user, as well as the antennas and the propagation channel. One important aspect in these interactions is **smart adaptability**, not only to changes in the surroundings, but also to different application requirements (e.g., flexible bandwidth on demand for cognitive radio). Existing work in these topics is in its infancy, partly limited by the slow but steady development of various enabling/supporting technologies such as new materials and circuit components (e.g., MEMS).

2.4. **Efficiency and Security at the Wireless Terminal side**

Wireless terminals remain an open challenge for the radio communications evolution in the coming decade, and avoiding efforts to make them more efficient and secure would impact the competitiveness of future European Telecommunications Industry. In this sense, the major challenges are to develop:

- Terminals able to exploit the full potential of nanoscale hardware and devices in terms of performance and low power, e.g. massive multi-core hardware, which opens the route to novel physical (PHY) and higher layer algorithms.
- Terminals with extra wide band capabilities and mainly digital RF, which will require a major evolution of PHY schemes and design in order to mitigate the more significant imperfections resulting from these very wide capabilities (in terms of spurious, reduced dynamic range, enhanced interferences, harder linearities to cope with...) and exploit the full potential of these terminals
- Massive wireless device deployment of highly variable capabilities, which will require networks able to recognise and integrate these devices and compensate for their limited performance through various means
- Much enhanced security, combining PHY layer security, cryptography and protocols to ensure the highest confidentiality and integrity of data in the case of wireless connectivity
- Extremely simply self-configured but controllable connectivity of devices to the various wirelessly accessible environments (BAN, PAN, WLAN, MAN, etc.), allowing a simple switch to one or another according to user demand
- Seamless (but user controllable) integration of the various localisation techniques and location providing systems (GNSS, network based, UWB, and/or any other) for a fully transparent use with extremely limited need for user intervention
- Extremely fast (Gbit/s) wireless download/upload of data at local connectivity points for multimedia mobile devices
2.5. **Wireless Communications for Traffic Safety and Efficiency**

An emerging area of great significance for the safety and comfort of people as well as for the environment is cooperative traffic safety and traffic efficiency applications. Such applications require vehicles and road infrastructure (road signs, traffic lights, toll booths, etc.) to exchange information to make the transport safer (less accidents, injuries, and fatalities) and more efficient (less traffic jams, fuel consumption, and emissions). Hence, wireless communications is a crucial enabling technology for these applications. Although much is known about traditional cellular wireless channels, this is not the case for the vehicle-to-vehicle or vehicle-to-road side channels due to low antenna heights, high mobility scenarios, complex propagation environments, and particular constraints for antenna systems installed in vehicles.

To make an efficient design of a wireless communication system requires detailed channel knowledge, which currently is lacking. Hence, this lack of knowledge needs to be addressed with channel measurement campaigns and channel modelling work. Once this task is completed, we can conduct research on antenna systems, coding, modulation, medium access control, and other subsystems. The research output will allow us to provide scientifically sound advice on how to evolve the wireless standards being developed by ETSI technical committee on Intelligent Transport Systems.

2.6. **Testing adaptive, distributed, cognitive mobile systems**

Few people will realise that the mobile phones they might be using daily, are normally 100% tested for software, for radio frequent performance and compatibility but not for operation under realistic conditions, even twenty years after the advent of GSM. Part of this is caused by the fact that the standards do not demand such testing and that the mandatory testing is already an appreciable overhead. The notion of how much overhead testing under realistic operational conditions may add, seems to work paralysing. First steps are now taken by ETSI 3GPP to reach a standard on this so-called Over-the-Air testing for MIMO devices at the end of 2012.

As this first step is already difficult enough, it aims at emulating single device performance over a realistic channel, incorporating the influences of antennas at both ends. But, only the downlink is tested, the device is still under central control and the smart, adaptive features of LTE or LTE Advanced are switched off, those features that were designed into the system for increased performance compared to earlier generations.

However, when (link and antenna) adaptivity will be used to the full, when central control gradually shift towards distributive, and when cognitive functions using dynamic spectrum access are exploited – likely evolutions that have already been described in this document - testing has to assess how devices more or less on their own operate in environments and networks that become increasingly chaotic and crowded. Implementing these types of technology with thorough testing is not an option but a revolution of test technology itself is required to cope with such challenges. The conclusion is that the development of operational testing of systems should be concurrent with the evolution of communication systems and is a serious theme for future research programs.
3. Research Priorities in Europe for Horizon 2020

According to the research challenges described in the previous sections, some research priorities to be included in Horizon2020 are:

Networks beyond the Cellular concept:

- Scale of Radio Channel Modelling to small and complex scenarios, by numerical electromagnetic techniques.
- Evolution of Self-Organised Network Protocols for Energy Efficiency
- Development of cooperative spectrum-sharing techniques in non-homogeneous bands
- Heterogeneous radio network architectures where human mobility acts as enabler for capillary coverage and access to the network

Energy Efficient Cooperative Networking:

- Deployment of Wireless Network Coding Systems applied to dense, cloud-like, massively-interacting networks of nodes
- Implementation of new cognitive radio methods, using distributed artificial intelligence and game theory
- Harmonisation and gathering of experimental data, by setting up an international experimental network which provides remote access to users to configurable infrastructure, and a database of wireless measurements in different environments to enable efficient design of novel wireless networks and experimental test beds for the evaluation of emerging wireless network technologies.

Smart Adaptive Antennas:

- An understanding of the fundamental limits of the antenna systems in future wireless communications, which will provide the performance benchmark for smart adaptability.
- A complete strategy to the design of future antenna systems, which are able to take advantage of, rather than suffer from, interactions with the surrounding environment, including interactions with the user and the propagation channel. In addition, the health-related issues in the antenna-user interaction must also be taken into account.
- An integrated approach to the implementation of future antenna systems, where the system-level performance can be effectively optimised by appropriate sensing of the physical environment and adaptation of the relevant antenna system parameters.

Efficiency and Security at the Wireless Terminal side:

- Efficient integration of adaptive techniques at PHY, MAC and NET layers and beyond to allow the generalised use of multi-antenna techniques combining the operation of all possible frequency band and wireless access technologies in a given device with instantaneous aggregation or switch according to spectrum availabilities at a given instant and location.
- Seamless and transparent integration of multi-RAT technologies, ensuring fully resilient >Mb/s wireless connectivity, which requires: dominating the propagation loss curse through a combination of generalised diversity systems and techniques (such as
cooperation) and an excellent assessment of the characteristics of propagation in all relevant physical media

**Wireless Communications for Traffic Safety and Efficiency:**

- Acquire detailed understanding of the vehicle-to-vehicle (V2V) and (V2R) radio channels through measurement campaigns and channel modelling activities
- Analysis and design of efficient PHY and MAC layers for V2V and V2R communications to support traffic safety and efficiency applications

**Testing adaptive, distributed, cognitive mobile systems**

- Understanding how to reduce the amount of features of the mobile channel to the bare minimum without impairing the assessment of devices' performances, as straightforward implementations of nowadays comprehensive models or high-resolution measurements have prohibitive complexity even for a single link.
- Developing a feasible strategy for testing full-duplex communication incorporating realistic channels both on down- and uplink
- A paradigm shift from testing a single device in isolation over a single communication link towards the testing of communication performance in lively networks over multiple, distributed links, not necessarily in the same frequency bands
4. The role of COST Actions in Horizon 2020

(COST as an instrument for research developments in HORIZON2020 to deliver EU industrial leadership and high-quality jobs creation in Europe)

COST Actions have succeeded in providing one of the best networking instruments of FP6 and FP7. In COST the research excellence of universities meets the technological leadership and applied view of the Industry, increasing the synergies between both, and getting mutual benefit from joint discussions. The new framework should use and reinforce this model as the reference for scientific coordination activities between Academia and Industry, and the role of COST Actions in Horizon2020 has to be based on the following strengths:

a) To keep promoting scientific networking in COST without the partnership restrictions of projects,
b) To evaluate and grant COST Actions in terms of their outcomes, real dimension and industrial participation,
c) To keep serving as an open forum for Early Stage Researchers,
d) To keep attracting Industries to meet Academia for research discussions in COST
e) To establish formal procedures to link COST Actions to other FP instruments, and
f) To evolve mature COST Actions towards stable Networks of Knowledge,

a) COST Actions: Networking without partnership

COST Actions base their success in the networking effects produced within its framework, which are not relying on any partnership contract or specific funded competitive objectives, but on the bottom-up approach of sharing results, and the technical discussions among its participants. COST actions are better understood as a networking instrument, where results from projects funded by many different sources are discussed, and a natural coordination between the participating researchers’ interests is reached.

COST Actions should continue to be the inclusive scientific networking instrument in Horizon2020, but COST administration should not run it like projects, which they are not. COST should limit administrative duties and rules to the minimal, and rate Actions according to what they demonstrate, favouring a liberal approach where the reward comes from the outputs as compared to the commitments, where such commitments should be guided by properly evaluated benefits to the European community of Science and Technology.

b) Evaluation and funding of COST Actions

COST should substantially revise its evaluation and reviewing mechanisms, in order to ensure the most profitable success of these Actions towards the benefits of the European populations. Funding should be based on activities, dimension, outcomes, impacts out of COST, participation of industries, ESRs, presence in standardisation and regulatory frameworks, etc. Evaluation of COST Actions success should take into account all that
factors, as well as the dissemination activities and impact that the COST joint activities (among participants) has produced in literature, conferences, books, standards or reports.

COST should concentrate its resources on a smaller number of Actions able to demonstrate this capability rather than spreading them among a large number of Actions that are dominated by a minor selection of academic players. The future of COST should be even more ambitious, trying to find ways to evolve, to spread and to promote the success cases, the quality of the Actions and the integration of research synergies between Industry and Academia.

c) The importance of COST for ESRs

Early Stage Researchers (ESRs) are taking advantage of COST Actions like in any other forum in the European Research Area. ESRs find in COST those colleagues who are working in the same topics, both senior researchers from other institutions and young people in their same situation, who in some years will take responsibilities and could propose joint participation to future projects. When a young researcher comes to a COST meeting to show the results of a research work, he or she can expect a long and constructive discussion around it. In addition, the younger researcher can bring back after the meeting some new ideas on how to improve the investigations. The situation is radically different if the young researcher attends a big conference, where a very limited time slot is assigned for the presentation, very few questions are expected and the audience is usually of wider scope.

d) Academia meets Industry in COST

COST should allow the creation of excellent far reaching academic research where deeply novel "clean slate" schemes are investigated by high level and high potential researchers while at the same time encourage industry-driven focused R&D networking. This is because significant benefits are expected from better cross-fertilisation of the two worlds towards short or mid-term societal impact. IC1004 is a good example of COST Actions on this point, with the necessary mix between industry and academia, in the best sense. There is no other benefit for companies to come than grasping what's going on in academia and transferring some of their own needs. It is probably a purer way of interacting than in projects, where funding tends to create some bias.

e) COST Actions related to other instruments

Up to date, COST Actions contracts have been not related to other FP7 instruments. The philosophy of the Actions is to serve as a networking activity, assuming that the individual participants are getting funds from other public or private programs. Inside the COST Action the results of research projects are shown, with COST being a way for dissemination of such results, but also a framework where to discuss the ongoing work, with colleagues who are not partners to those same funded projects. COST Actions have also played a match-making role among their participants, resulting in consortia that obtain large research grants, including those from EU framework programmes.
In Horizon2020, it would be recommendable, and will provide advantages to both sides, if some budget in the new framework projects is eligible, and specifically allocated, to the participation of researchers to COST Actions, since COST has an excellent track record of being a guarantee for successful scientific networking, with its effectiveness orders of magnitude above scientific symposia and conferences. This would reinforce the discussion of relevant results in the COST Actions meetings, and will serve as an effective way of coordinating research projects at the scientific level, as well as creating new relationships between projects researchers for future proposals.

f) Evolution of COST Actions

COST is an excellent platform for the free brainstorming and vivid science & technology exchanges between University and Industry. However, COST should be strengthened by fostering Actions such as COST IC1004 and the previous related Actions of the series, where the continued efforts over the years were able to gather academic and R&D researchers at a highly sustained rate for 20 years.

The creation of the COST Actions followed the basic rule of “inclusiveness at all levels” [2], being nowadays in fact what was intended to: a bottom-up oriented and open networking instrument. In this sense, COST mechanisms have worked very well as for the launch of new Actions. The success of a COST Action in terms of “Networking” is measurable by the number of joint activities, participants, countries, non-funded percentage of participations, industries involvement, published reference documents to standards or policy bodies, joint books, etc. But when a COST Action ends, the group of researchers who have reached good practices, established relationships, attracted industries to participate to the meetings discussions and to other COST Activities like STSMs or training schools, have simply to dismiss the group and close the Network.

What is then the real outcome of a successful COST Action? It’s not only the specification of models, references, common scenarios, joint documents or publications, but the “Network” of researchers that after 4 years of activities is consolidated. Why pulling out this result from the Research Framework?

In the future Horizon2020, there should be a way to continue the activities of successful Actions under the funding of the EU, consolidating what has been reached and which is the most valuable outcome of COST: Inclusive Networks of researchers, both from Academia and Industry. Horizon2020 should then set up an instrument for those successful cases of COST Actions that reach a dimension and the expertise enough, to evolve to a formally established **Network of Knowledge**.
Contribution
The following is input from Ericsson research in response to the public consultation of Future Networks Technologies Research and Innovation in Horizon 2020

Our vision is a future where anyone and anything that can benefit from being connected will be connected and a large part of these connections will be wireless connections.

Within ten years we expect tens of billions ("50 billion"?) wirelessly connected devices, a number that, in a longer term-perspective, may grow to perhaps hundreds of billions devices.

This is a technology problem in terms of amount of traffic, but even more a problem in terms of sheer number of devices. New ways of handle such enormous amount of connected devices in a cost-efficient way will need to be researched and developed.

Although the wireless-communication industry today only contributes a very small part to the overall global CO2 footprint, with the expected increase in traffic and connected devices, this contribution will increase substantially unless the energy efficiency can be substantially improved. Thus, means for further improved energy efficiency of the wireless-communication networks and their components remains as a most important research and development area. The task should be to be able to provide the dramatic increase in traffic and connected devices with not substantial increase in the overall energy consumption. In this way, tele
communication in general and wireless communication in particular will be able to remain as a key tool to reduce the world's overall energy consumption.

In the past 30 years we have seen a steady increase in the service level, in practice the data rates, provided by the wireless-communication systems, going from tens of kbps with early GSM systems, via a few hundred kbps to multi-Mbps data rates in 3G systems to the tens of Mbps typically provided by the first 4G (LTE systems). Although questions have often been raised, in advance, about the need for such data rates, history has told us that the availability of new service levels triggers the invention of new attractive applications and there is no reason to expect that this will change. Thus we see a need to continue on the path towards even higher data rates supported by the future wireless communication systems, be it by means of further wider bandwidth, massive antenna solutions, or others.

In terms of network structure we already today see much more of a heterogeneous structure with co-existence of different technologies, use of different spectrum, and a mix of low-power and high power nodes operating together and we expect this trend to continue. Thus there will be a need for more adaptive systems and technologies being able to sense their neighbourhood and adapt accordingly.

In this context, “trusted networks” become crucial, i.e. the ability to provide guarantees on the security and reliability of such networks to an extent where services and users can trust the network. This is also highly relevant when cloud becomes part of the networking. Identity management, authentication, and privacy are also important aspects here.

Public procurement

In order to bridge the gap between research and actual development and deployment it is suggested of making use of public procurement as a means of expediting market uptake and demonstrate product feasibility. This has been proven earlier as a good tool.

Collaboration with ICT labs on innovation

Since ICT labs now is part of the Horizon 2020 programme it would be beneficial for the innovation process to collaborate with ICT labs on
innovations based on the research results on Future Networks Technologies.
Input to the Horizon2020 consultation

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Networking in general will include heterogeneous network technologies and multiple actors. In this context, “trusted networks” become crucial, i.e. the ability to provide guarantees on the security and reliability of such networks to an extent where services and users can trust the network. This is also highly relevant when cloud becomes part of the networking. Identity management, authentication, and privacy are also important aspects here.

We also see a continued need for device security. Many new devices, such as tablets, smart phones, are used both for private and business purposes, and thus connected to enterprise networks. This also means that devices contain more sensitive information, both private and commercial, which calls for security solutions to easily and safely separate and handle different types of information and communication.

Specific topics for research

• Terabit Networking;
• Cloud transport and SLA assurance
- Control and management
- Wireless backhaul technologies
- Silicon photonics

Public procurement
In order to bridge the gap between research and actual development and deployment it is suggested to look into the possibility of making use of public procurement as a means of expediting market uptake and demonstrate product feasibility. This has earlier been proven as a good tool between competent purchasers and suppliers.

Collaboration with ICT labs on innovation
Since ICT labs now is part of the Horizon 2020 programme it would be beneficial for the innovation process to collaborate with ICT labs on innovations based on the research results on Future Networks Technologies.
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1 Which sector are you representing? What are the strengths and size of your market in Europe and/or worldwide?

The Integral SatCom Initiative (http://www.isi-initiative.org/) is an ICT European Technology Platform led by European SatCom industry and supported by the European Commission to address Satellite Communications (SatCom) strategic research challenges. It gathers more than 200 members organizations representing all the European SatCom industry stakeholders from 29 different countries. It includes members from manufacturing industry, network operations and service provision, SMEs, research centres and academia, European and National Institutions.

In the last 30 years, the European space industry has grown progressively to become recognized as only second to the USA on the World stage and fourth in owned assets, with some specific areas attaining World leadership. This applies to both the upstream, with major satellite infrastructure companies as well as in the downstream with a myriad of content and service provider companies spread across Europe. As such it is a major employer and contributor to the European Gross Domestic Product.

The turnover of the European space industry (upstream) is of the order of €6 Billion, employing 30 000 highly skilled engineers and technicians. In the downstream it is many times greater. In Europe it also has links with Centres of Excellence in Universities and Public and Private research centers which are World class.

Telecoms markets account for more than 70% of the European satellite industry turnover and employment, and for 90% of all European commercial launches. Three of the biggest satellite operators are European and key customers of space. Therefore, the European satellite communication industry is a fundamental element for Europe in sustaining it's whole space industry and its strategic independent access to space.

Satellite communications infrastructures and associated services are called to play an important role to support the successful achievement of the European policy based on the European Digital Agenda.

However the European Satellite Communication Industry is facing huge challenges in commercial markets, since competition is growing, in particular from industries outside of Europe. The US industry benefits from a huge aggregated and highly protected domestic market, a long lasting favorable $/€ depreciation and a financial government support accounting more than 80% of their activities, while the Chinese, Indian and Russian space industries benefit from reduced labour costs combined with long lasting $/€ depreciation and large political, financial government support and restricted domestic market. To fight these threats, research and innovation in the SatCom related technologies is crucial for the European industries to maintain its worldwide prospective.
2 How would you describe your ideas and/or plans for future R&D challenges/topics relating to Network Technologies?

ISI vision is to foster the development of innovative SatCom solutions addressing in priority:

- The 2020 goal of all Europeans having access to Internet speeds of above 30 Mbps as set by the European Commission in its European Digital Agenda policy for an Inclusive Growth.
- The improvement of Europe's capacity to prevent and respond to crisis and/or to ensure the security of persons and goods as set by the Europe Commission in its Security and Defence Policy. "There is no development without security and no security without Sustainable Growth», Kofi Annan.
- The Integration of future SatComs providing a flexible and resilient network overlay and/or with cost effective broadcast capabilities to the future internet for a Smart Growth economy.

This will enable the development of innovative technologies, products and services up to large scale pre operational experimentations in the areas of:

- Very high speed broadband access via satellite complementing fibre and wireless networks.
- Reconfigurable, resilient and secured broadband connectivity SatComs to support professional and institutional telecommunication demands (e.g., Private communication networks, Backhaul, Backbone connectivity, public safety)
- Integration/hybridising of future SatComs in the Future Internet to build up smart infrastructures.
- Enhanced broadcast systems, efficiently supporting scalable video quality (3D/HDTV/SDTV), mobility and interactivity.

Responding to the identified R&D challenges will enable the European SatCom Industry to:

- Strengthen its positioning on the international competitive commercial and institutional markets.
- Propose added valued and harmonised solutions complementing future terrestrial networks in tackling societal challenges of Europe as well as other continents.
3 How do you see the potential role of your organisation in HORIZON2020 in connection to the network technologies design, experimentation and/or deployment? What are your research priorities?

3.1 Planned research, development and innovation activities on SatCom systems in the institutional frameworks

Satellite Communications (SatCom) belong to both space and ICT enabling and industrial technologies identified in the H2020’s industrial leadership part. On one hand, it represents the most important application domain for satellites and on the other hand it is an essential element of any network infrastructure:

- To provide cost effective broadcast and/or data collect capability over wide area.
- To provide connectivity to remote places, vessels or aircrafts.
- To ensure resilience by doubling terrestrial based communications.

Therefore research and innovation activities on SatComs shall be planned under the H2020 part “Leadership in enabling and industrial technologies”.

SatCom also supports a wide range of applications which contributes to major European societal challenges:

- “Inclusive, innovative and secure societies”: SatCom is an essential enabler to fulfill the broadband for all objectives as defined in the Digital Challenges thanks to current (2013 objectives) and future space assets (2020 objectives). It is also an essential element for security missions among which crisis management, transport security, critical infrastructure protection. SatCom integration with other space technologies namely earth observation and navigation, will enable added value services to contribute to a secure society.
- “Health, demographic change and wellbeing”: SatCom will help to assist patients under medical treatment in their homes and interconnect hospitals and medical teams in low density populated areas. Moreover, as the need for
improving healthcare in rural and low density populated areas intensifies and the importance of bringing the international medical community together in the years ahead grows. SatCom are ideally positioned to facilitate the flow and sharing of medical expertise and information between medical centres.

- “Smart, green and integrated transport”: SatCom can be used to alert about events (e.g. accidents, traffic jams, local bad weather conditions) impacting the traffic at regional level and provide guidance to the public and private transport resources, the travellers and decision making tools via fixed or mobile broadcast systems. SatCom can also support asset monitoring anywhere beyond terrestrial reach (low density populated areas, over seas) and hence ensure a permanent status report.

- “Secure, clean and efficient energy”: SatCom can be used to monitor the power grid and to implement a global and secure energy grid that ensures the energy supply. In particular, it is well suited to optimise the efficiency of the global monitoring and black-out management. Furthermore, telecom satellites can back-up high availability links of the communication and control network in critical parts of the smart energy grids.

Within Europe, SatCom research and innovation activities are also supported by European and National Space agencies, however these frameworks differs significantly by the approach:

- The H2020 will help the SatCom industry to establish the eco system for space technologies by undertaking end to end system definition and developments exploiting the technology bricks/segments developed with space agencies support, Trials/Pilots for validation and/or market probing. It is the optimum framework for cooperation with stakeholders from terrestrial ICT networks and for the cross fertilization of ICT technologies from non space industry.

- European and national space agencies enables the SatCom industry to progress the space technology by carrying out Technical feasibility study on
future space segments and providing support to development of space technology and on specific aspects of the related ground segment.

In summary:

<table>
<thead>
<tr>
<th>Institutional framework</th>
<th>SatCom related research and innovation activities</th>
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<tbody>
<tr>
<td>H2020: ICT industrial pillar</td>
<td>Innovative satellite network infrastructure system analysis, trials, interoperability with terrestrial networks, Standardisation and regulatory activities</td>
</tr>
<tr>
<td>H2020: Space industrial pillar</td>
<td>Integration of satellite networks with other space technology e.g. in the area of navigation and earth observation</td>
</tr>
<tr>
<td>H2020: “Inclusive, innovative and secure societies” Societal challenge</td>
<td>Trial and Pilot networks also including support to in orbit validation</td>
</tr>
<tr>
<td>H2020’s other societal challenges</td>
<td>Development and test of innovative service and applications</td>
</tr>
<tr>
<td>ESA and national space agencies</td>
<td>Technical feasibility study on future space segments, Development of space technology and of specific features of ground segment such as e.g. antennas and RF components</td>
</tr>
</tbody>
</table>

Tableau 1 : Planned SatCom R&D&I activities in H2020 and Space agencies

As illustrated above, research, development and innovation activities on SatCom are planned in the Horizon 2020 complementary to activities planned in european and national space agencies frameworks.

=> Therefore ISI asks the DG Infso to explicitly add “SatCom” in the relevant section of the H2020 framework program.
3.2 Potential role of ISI in HORIZON2020

As a Technology platform, ISI interacts with numerous actors

- User groups such as service providers (institutional, commercial) in order to identify their future user requirements
- Other application domains which may drive the emergence of new applications and hence new markets for SatCom. SatCom is increasingly used for example in transport and logistic for asset management.
- ICT industry sector in order to analyse the general trends and identify the potential future role of SatCom. For example the large deployment of cellular infrastructure reduced the mobile satellite market but contributed to create the satellite backhaul market
- European and National space agencies to position complementary activities in the EC research and innovation framework
- Relevant DGs in the EC to promote the harmonised research and innovation plans

ISI mission is to define and promote the R&D &I roadmaps for the European satCom industry towards the European Commission and other relevant European and national relevant bodies/Agencies. ISI doesn’t provide industrial roadmaps, nor promote satellite-based architecture solutions. It undertakes the following activities:

- Analysis of market and regulatory trends
- Definition of SatCom mid/long term vision on the different market segments
- Definition of the needed Research, Development and Innovation roadmaps to support the vision
- Promotion of the R&I topics to institutions
- Monitoring of the R&I activity implementation
Promotion of the R&D&I roadmap by highlighting how the resulting solutions will find a market and/or contribute to support European policies (e.g. Digital Agenda, Security and Defence)

Last but not least, the participation of numerous SMEs in the development process of SatCom technologies and their deployment is a crucial European asset, which ISI can contribute as an organization promoting the participation of SMEs in the upcoming Horizon2020 calls.

### 3.3 ISI’s your research priorities

The research priorities of ISI are organised among three different lines, namely:

1. **Space segment: High-Throughput, Flexibility and Reconfigurability**
   
   Research efforts aiming at increasing throughput per spacecraft, flexibility in terms of power, bandwidth and frequency allocated to each beam will have to be improved in order to better use the satellite capacity. Dynamic reconfigurability of the coverage area in terms of number and sizes of beams will be another important asset to cover, enabling e.g. to quickly set-up hot-spots over specific regions where high capacity may be needed. This entails the need to pursue the development of reconfigurable antenna systems (passive solutions, as well as active and semi-active with the objective of getting cost competitive offers for the commercial market), allowing small antenna beams and high accuracy pointing, as well as flexible satellite payload RF front-end to efficiently cope with different level of traffic aggregation. Regenerative payloads are an additional step to consider for providing high flexible and reconfigurable satellites systems, suitable for adapting the network for the service scenario needs. The key challenge will be to propose fully in-orbit reconfigurable processors (Software Defined Payloads - SDPs), which would ultimately combine the advantages of fully regenerative payloads with the waveform agnostic flexibility of transparent payloads.
2. Ground infrastructure and Radio Interface: Advanced Interference Management

Next generation satellite systems will be based on several hundreds of beams/feeds in order to increase the system efficiency with denser frequency reuse. A key issue in this perspective is the efficient management of interference. Intra and Inter-beam as well as inter-system interference shall be smartly managed in order to achieve unforeseen increase in the spectral efficiency. The research shall be addressed towards applications to multi-beam/multi-feed/multi-gateway satellite systems of advanced concepts like precoding techniques, multiuser detection, interference cancellation, and interference alignment and coordination. Generally speaking, new paradigms relying on the idea of exploiting the knowledge of the interference rather than trying to reduce it by bandwidth segregation and/or antenna discrimination shall be investigated. That is, in contrast with traditional interference avoidance schemes (passive treatment of interference), satellite networks shall strive for a proactive treatment of interference. In this course, the latest techniques developed within the terrestrial cellular community on interference management should be investigated in order to maximize synergies between the two realms.

3. Networking: Integration and Convergence

The convergence between fixed and mobile network is the new paradigm in the world wide telecommunications network. Satellites are striving to become an important actor in the Future Network Infrastructure due to they cover vast regions and sparsely populates areas, or in areas where terrestrial systems have been destroyed by a recent disaster. A tighter synergy between terrestrial and satellite networks and also among satellite operators would be leveraged through the foundation of network abstraction and virtualisation architectures, which would offer new business opportunities by enabling the real time brokerage and collaborative use of terrestrial and satellite resources and also their integrated management as unified overlays. In this context, novel inter-domain network management paradigms would enable enterprise users and also
Virtual Network Providers (network resource brokers) to establish, manage and exploit hybrid terrestrial-satellite virtual network overlays spanning across several satellite and terrestrial operators/physical infrastructures in order to fully meet their customers’ needs in terms of geographical coverage and capacity, in cases when the coverage and/or capacity provided directly by a single network operator is either insufficient or uneconomic.

Satellites comprise the following (non exhaustive list of) primary features which may have a major role in Future Internet: (i) all the time: satellite networks are key to provide service continuity and robustness under disaster cases; (ii) everywhere: especially in rural, low density populated areas, satellites are the most economical access technology and provide the means to access non-traditional networks as SCADA sensor networks. This induces also the potential of satellites to allow for/or accelerate the high-speed Internet access in developing countries; (iii) native support for wide area broadcast / multicast; (iv) support for inter-planetary communication and deep space networks; and (v) Satellites support security and content reliability on an operational level, since the infrastructure is easy to protect, network management is centralized and under operator control and the access to the network is strictly under control of the network control manager. It is therefore necessary to study the applications and services that are typically susceptible of being used in a satellite network, so that its evolution goes online with the Future Internet guidelines. The development of future satellite systems will not consider only the network aspects as the connection bandwidth required or the necessary traffic engineering, but also higher level factors (such as scalability, security, mobility,...) that impose requirements to the lower levels. A promising Future Internet (FI) technological solution which seems pertinent to integration with SatCom networks refers to Information/Content-Centric Networking. It constitutes an alternative to the conventional, IP-based internetworking, with information being identified rather than the host where it resides (which is the case for IP networking). That is, rather than interconnecting pair of end hosts, FI information-centric networks will evolve as a substrate for information
dissemination and will be based on named data identifiers instead of end hosts addresses. These identifiers relate to content and/or services. This approach appears to be very promising in the Future Internet. Especially, the Publish-Subscribe Internetworking (PSI) approach, seems well suited to SatCom because of the related Broadcast/Multicast nature.

4 Which network technologies requirements and expectations, do you consider important to inspire innovation and bring most benefits to your (business) development in the future?

Satellite Communication Networks inherently offer three undisputable characteristics:

- All the time: As a dependable solution, SatComs are key elements to ensure a service continuity under natural or man made disasters.
- Everywhere: Thanks to their ubiquitous coverage, SatCom are the most economical technology to address fixed, portable, nomadic or terminals onboard vessels, trains, cars or aircrafts in low density populated areas for connectivity or broadcast applications.

Based on these key elements, Satellite Communication Networks are expected to provide significant contributions in areas where coverage, resiliency are essential especially for:

- Broadcasting/multicasting of media content in real time or non realtime with caching techniques
- Broadband access: fixed and mobile
- Security missions such as crisis management
- Machine to machine

The SatCom contribution will pertain provided that the industry continue to innovate along the following drivers:
Firstly, Satellite networks are expected to improve significantly their performances to keep up with the service and economical trends associated set by terrestrial networks.

Secondly, the need for increased resiliency, service continuity drives the SatCom industry to undertake research activities to integrate Satellite component in the global terrestrial networks in a seamless manner so that the end-users benefits from the natural and undisputable SatCom characteristics.

Thirdly, the evolving regulatory context (towards more flexible spectrum usage) puts additional constraints on the design of future satellite networks.

The innovations will enable the industry to find new satellite applications and other growth axis.

5 Which cross sector synergies in relation to the network technologies research are of strategic importance to generate growth in your business sector?

As indicated in the previous response, the following domains are expected to generate growth for the SatCom sector:

- Future Internet and especially for Networked media applications
- Security missions and especially crisis management, infrastructure protection, etc.

The growth will come from a renewed contribution of SatCom based on its integration with

- terrestrial network technologies
- other satellite applications: Earth Observation (GMES) and navigation (Galileo)
6 How do you think that the network research community should best engage with the user community?

User groups need to be involved throughout the research and innovation process to consolidate the user requirements taking into account future SatCom capabilities, contribute to the selection of the most relevant use cases, define the market acceptance criteria and possibly define aggregation of demand. Their involvement shall be encouraged during project execution but also via workshops or even the establishment of appropriate platforms.

7 Which constituencies and methodologies in relation to network technologies research are most important to maximise the impact of research and innovation in HORIZON2020?

ISI believes that there are two keystones that should sustain satellite network technologies research in order to maximize its impact:

1. The research shall be done along a strategy agreed by the community concerned. In the case of ISI, the Strategic Research and Innovation Agenda serves as the driving strategy

2. For what concerns Space related Networks technologies, the research activities shall be coordinated across the European stake-holders to maximize its span while avoiding duplications (namely between the EU, ESA, and MS space agencies).

Beside, ISI considers that the following elements also constitute impact-methodologies:

- EC to support Communication actions on general public medias (Radio and TV), in order to promote the European technologies capabilities, as done to support the agrifood industry. In particular, communication towards the regional authorities is much needed (awareness is currently found a roadblock)

- EC to balance activities of Academics and industry (today FP7 is rather used by Academics) by fostering the involvement of European industry
stakeholders with attractive funding rate to ensure the exploitation of the research, development and innovation outcomes in service, product and/or technology roadmaps

- EC to foster the development of European standards but also favouring access to market for technologies developed in compliance with European standards
- EC to implement projects including, when relevant, In-Orbit technology Validation.

Although the above orchestrated actions could have an impact, it is also relevant that specific actions should be made in order to reach European Institutions, particularly, Regional authorities.

8 How should research developments in network technologies in HORIZON2020 be measured against delivering EU industrial leadership worldwide, sustainable economic growth and high-quality jobs creation in Europe?

Indicators of success of the H2020 action regarding the above targets can be measured against:

- The number of trained persons (technicians, engineers, PhD diplomas) from European Member states to SatCom networks technologies
- Number of space and ground segments contract awards to European manufacturers (LSIs and SMEs) based on a technical solution developed through an H2020 project
- The amount of SatCom technologies developed by European industry stakeholders, through H2020. In particular technologies that contribute to the achievement of EU 2020 objectives (e.g. Digital Agenda for Europe/DAE, Common Security and Defence Policy/CSDP)
- The amount of SatCom-based services take-up in Europe and worldwide triggered by H2020 demo/pilot projects.

END
DEUTSCHE TELEKOM by Hans Einsiedler
Horizon 2020 – Ideas of the Telekom Innovation Laboratories


Telekom Innovation Laboratories (T-Labs) are the central research and development unit of the company. Their mandate is to work closely with operative units at Deutsche Telekom, offering new ideas and support in the development and implementation of innovative products, services and infrastructures for Telekom’s growth areas. With locations in Berlin, Darmstadt and Bonn (Germany), Beer Sheva and Tel Aviv (Israel) and Los Altos (U.S.), T-Labs concentrates on medium-term themes and on technologies for setting Telekom apart from its competition and founding new businesses. Some 360 experts and scientists from a wide variety of disciplines, as well as young entrepreneurs, from more than 25 nations all work together at T-Labs.

T-Labs combine the best of three worlds to a long-term success factor for the company:

1. In the Innovation Development area experts work impact-oriented and with the current and future business areas of Deutsche Telekom in view.

2. In the cooperation with TU Berlin and the University of the Arts Berlin, Telekom has established six chairs:
   - Internet Network Architectures, Prof. Anja Feldmann, Ph.D.
   - Quality and Usability Lab, Prof. Dr.-Ing. Sebastian Möller
   - Security in Telecommunications, Prof. Dr. Jean-Pierre Seifert
   - Service-centric Networking, Prof. Dr. Axel Küpper
   - Design Research, Prof. Dr. Gesche Joost
   - Assessment of IP-based Applications, Prof. Dr.-Ing. Alexander Raake

3. In addition to these activities, T-Labs maintain a network of Start-ups in Germany, the Silicon Valley and in Israel and have successfully spun-off a number of venture capital-funded companies such as Zimory, wahwah.fm or QiSec.

T-Labs' results are the foundation for numerous current and planned products and services of Deutsche Telekom.

The following topics and collection of ideas are a joint contribution of several teams and chairs. They are split into four topic clusters: Community and legal issues, Business issues, Technical issues, and any other ideas. Since several topics have considerable overlap, we have done only a rough clustering. The document, we present, is a result of an internal workshop.

Please note: The selection of topics is not ordered nor does claims completeness, the selection is meant to stimulate discussions.

Community and Legal Issues:

- **Mobile multimodal interaction**
  We are interested in identifying quality factors when interaction with multimodal mobile apps, i.e. how apps should be designed, when they are used, under which circumstances, etc. The underlying app-in-app concepts allows testing many aspects of user behaviour with different applications, such as eLearning with mobile devices, language learning, perceived security and
privacy threats, apps for increasing public security, apps for doing flash polls, blended prototyping principles for mobile apps, etc.

- **Solutions for demographic changes and integration of smart city & smart home networks and applications**
  In times of demographic change, increasing health care costs and shrinking resources, innovative ICT solutions become more and more vital to ensure high quality of life and future health care. First ambient assisted living (AAL) solutions are available today already, but will be even more beneficial when combining information from smart home and smart city environment (sensor networks, home management systems), thus enabling the home as a location for care and health care.

- **Undivided attention as a resource**
  Connectivity may be a prerequisite, but the main point I am looking for when contacting someone is his/her full and focused attention to dwell on my ideas or concerns. It is an old idea, e.g. "to be received in audience by the pope", but it gets increasingly difficult as people are more and more multitasking even in bilateral meetings and get used to listen to everything “en passant” only.
  I did say twenty minutes of full attention of one single person is much more valuable than superficial of many, and this fact may be relevant for many areas including advertising. So why not try to establish undivided attention as a (billable) resource. Advancements in neurotechnology allow deriving brain-based measures that are indicative of attention.

- **Fair regulation and consistent international legal frameworks**
  The EC should continue their efforts in adjusting the different existing legal frameworks which are relevant for all players in the ICT domain. On a global and rapidly changing market this means more than just adapting the national conditions in Europe. Traditional models which do not take into account the possibilities of the digital society and of the Internet need to be updated. But also fair regulation is required across existing national boundaries.

- **Digital Labour Union**
  It is a reaction to a study of IBM on the future ICT worker that was described in the German magazine “Der Spiegel” several weeks ago. Basically, all ICT workers will be day labourers, whose CVs and evaluations by previous employers are online for everyone. Based on that, they can try to underbid each other for participation in larger IT projects, but all options remain with the employer. This future scenario calls for some kind of "digital labour union" that helps these guys to assume their rights.

**Business issues:**

- **Smart pipes for smart business network**
  Smart business networks provide increased flexibility in implementing, executing, and governing business process spanning over multiple partners involved in joint business, thus best reflect the dynamics of business models base on value networks. Examples can be found in the logistics domain, or in smart city scenarios. For telco operators, smart business networks provide an opportunity to contribute a plethora of services referred to as smart pipe. A smart pipe refers to
an operator’s network which leverages existing or unique service abilities, and the operator’s customer relationships, to provide value beyond that of data connectivity only.

The following services are commonly viewed as part of a smart pipe:

- Location-based services
- Presence information
- Single Sign-On (SSO) service (network based authentication)
- User profile & role management
- Rich Communication Services (RCS) video, file share, chat
- Over The Air (OTA) services
- Customer analytics
- Personalisation and privacy
- Payment and billing
- Directory assistance and services
- Computing platforms, mobile devices or applications
- User interfaces
- Application programming interfaces (APIs), for devices or networks
- Quality of service
- Mobility

**Transformation of today’s social media**

By upcoming service landscapes referring to the Internet of Things paradigm, today’s social networks are supposed to transform from purely human-centric social media to platforms accommodating machine-driven communication as well. First concepts and demos in “Facebook of Things” or “Twitter of Things” style already exist and may substantially change handling of data, information, intelligence, and interaction related to the subjects engaging in utilisation and shaping of these platforms.

**Customer analytics for quality assessment and service management**

What can we learn about the user, and about how much she/he likes or dislikes a service, by combining different sources of information from network- and device-based monitoring systems that collect information both about network properties as well as user behaviour? This is an increasingly relevant topic addressed by large non-European companies such as Google and Skype for a long time already. It requires research and development at European level to exploit the substantial possible economic benefits, by considering the diverse technological aspects underlying different approaches to the topic, and especially addressing the most important show-stoppers such as the related privacy concerns.

**Technical issues:**

**Big data – ownership, privacy, security**

Not only social networks but all kind of ICT systems generates more and more (electronic) data. The challenge of capturing, storing and processing these big data pools needs to be addressed. Properly handled they will enable a new generation of services for the benefit of all. Nevertheless they will only be successful and accepted by the users if all issues of data ownership, including security and privacy aspects, are properly covered on an international basis.
- **Standardised and interoperable architectures for distributed systems**
  As more and more devices are connected to the Internet it becomes essential that they can interoperate not only on the network but also on the service and control layer. Open and standardised interfaces will help but an overall architectural framework is recommended. This should not be fixed but extendable to be ready for any changes required in the future. The concept of Software-Defined Networks (SDN) is a good example: It has different functional elements with well-defined interfaces between them, is flexible and gives enough space for any extensions needed. These kinds of architectures for distributed systems will be the key to enable next-generation services and open up the market for new players.

- **Networked cognition versus cognitive networks**
  The network is actively supporting all kinds of processes that help augment human cognition at multiple levels. From synchronised visualisations (Augmented Reality – AR) for multiple people in a location, to data packing, representation for user specific needs data agglomeration and analysis. Then network will need to provide Secure, Confidential, Real-time, access to data and computing depends of the user.

- **Virtualisation of devices**
  Today we use multiple devices for multiple tasks. Tomorrow, what if we can take any device and commandeer it (convert it) to be used for anything else. Thus a phone could become your laptop, or vice versa. We need to make humanised interfaces/natural interfaces that enable the seamless virtualisation possible.

- **ICT using brain power**
  This is very relevant in the future. Maybe we can unobtrusively mine human intelligence and the brainpower, for computing needs. Brain-Computer Interface (BCI) does not to control other devices, but BCI where the brain can subconsciously solve problems – a new form of Artificial Intelligence (AI) supported by ICT.
  Based on several fundamental research results (e.g. Bernstein Centre) interdisciplinary research and development has to be started in order to combine neuroscience, bio- & nanotechnologies with ICT topics leading to new interaction paradigms addressing numerous application domains beyond healthcare.

- **Green industry / life**
  Research on solutions for “Green Industry/ICT” (e.g. Grids) combing the energy and the ICT domain both form a provider as well as service perspective to solve the biggest challenges for the society (scarcity of resources & save the environment).

- **Cost efficient of multi-standard / multi frequency radio technologies and energy- and frequency efficient operation of multi-standard / multi-frequency radio networks**
  The variety of wireless technologies and networks, operating at of different frequency bands and in different environments is rapidly increasing. In order to manage complexity, and to optimise energy consumption and spectrum requirements, an overarching evolution and optimisation approach is required.

- **Flexible media delivery networks and platforms integrating smoothly all kind of media (including linear 3D TV) in most cost-, energy-, and spectrum-efficient way**
  The variety of media consumption, in particular the different types of real-time video and video-on-demand type services, has increased rapidly. Therefore, the classical distinction between
broadcast-only networks and (Internet-based) communication networks is no longer valid. Integrated solutions are required which fulfil the customers’ media consumption demands on stationary and mobile devices in a cost-, energy-, and spectrum-efficient way.

- **Quality of experience of gaming**
  Online gaming is increasingly influenced by the characteristics of the network. We are interested in finding out what Quality of Experience aspects affect user satisfaction, and how these are influenced by network characteristics such as delay, packet loss, and coding.

- **Networking resource optimisation through intelligent resource and infrastructure sharing, federation, and new business models**
  Current regulatory rules and business models will not offer the possibility to combine resources. Therefore R&D in this area is pretty restricted because there is – for all involved business stakeholders – less benefits. With such optimisation the CAPEX, OPEX, and costs for energy can be reduced and new business models can be installed.

- **Overcome of the client-server paradigm and the layered protocol approach for network and service-delivery optimisation**
  The Internet paradigms were driving a lot of R&D works in the past. However, the client-server paradigm and the layered protocol approach were developed in a time where the Internet was a collection over wired interconnections. New applications and services – mostly mobile and wireless driven – produces and produced a lot of challenges which cannot be solved by the current Internet paradigms. In principle we have currently application and service ecosystems as well as infrastructure ecosystems which communicate not with each other. The Internet Protocol is not the end of the evolution for communication, therefore new ideas and concepts have to be developed and discussed to bring the application and service ecosystem in direct interconnection with the infrastructure – control and technology – eco-system. Which means application and service business aspects is a driver for new infrastructure research and development.

- **Reliable Infrastructure for the Future Internet**
  The transition of services from the offline to the online sphere is still on-going. These include services like health care (e.g. sensors of medical devices like heart rate monitor or information exchange between healthcare players), energy (e.g. smart metering), or agriculture (e.g. weather or chemical sensors) beside the complete transfer of office environments into the cloud. Based on the demand of being permanently online, it is not possible for the services to accept network downtimes of a few minutes only. Actual, the network design principles are contradictory. On the one hand side, the demand by the services require improved network reliability and on the other hand the networks are required to reduce costs due to increased cost pressure and competition. Therefore research and development in this area is required to find the real network requirements and demands for the infrastructure of the next decade and solutions how to further decrease cost while still enabling and guaranteeing the reliability of services.

- **Context Data Cloud**
  Context-aware Services are usually coupled to Context Management Frameworks, which determine the contextual situation the user is in in order to execute automatic actions based on the application scenario they are used in. Those frameworks are often built based on a
broker/middleware architecture with context providers/consumers and only work smoothly for the scenario for which they are applied for.

The Linking Open Data Cloud provides a huge pool of context information that is present in hundreds of datasets of various domains semantically modelled and linked to each other by using well-known Web of Data standards. This cloud is increasing rapidly and can be exploited by context-aware services of the future in order to build a new paradigm of Ubiquitous Computing. Therefore, we propose the Context Data Cloud – a Context Management Architecture based on Linked Data principles that support users in future Digital Cities. We suggest a Smart Space where data of all sensors and other context sources is semantically modelled, linked to each other and available at run-time. This data will be combined in real-time in a mashup-manner, so that end devices can make use of this huge Context Data Cloud in order to get services that fit to every contextual situation the user is in.

- **Enabling techniques for distributed online social networks**
  As of today, Facebook, Google+ and other Online Social Networks (OSN) are operated as closed, proprietary platforms that don’t allow their users to change their provider at will or at least interconnect their profiles across different platforms. We expect future OSN platforms not only to be open and interoperable such as e.g. Email or HTTP, but also mobile hosted, i.e. bound to the mobile devices owned by the users. Such changes in the paradigm of OSNs would pose several questions regarding routing, searching and else, while telecommunication providers such possess the infrastructure to provide such services (e.g. via IMS). We propose to identify, describe and implement services and protocols that will allow for mobile hosted OSNs and therefore function as enabling techniques for future OSN platforms.

- **Automatic context discovery for multimedia content**
  Multimedia content (being video, audio, or images) contains countless information which is not utilised by todays platforms and services. Though methods to enrich content with contextual (or meta-) information exist (e.g. Geotagging, adding of date and time), further - less explicit - information that would enrich the contents' description has to be added manually in most cases. We propose algorithms and methods that automatically enrich multimedia content with additional information, such as which people are depicted in an image or video, what kind of situation is shown in the content, what events took place at the place and time when the content was captured, and many more. The proposed algorithms would facilitate users of search engines to find and access the desired content much easier and would further facilitate new search paradigms.

**Other issues:**

- **“Power Topic”**
  I would like that all my electric/electronic devices can supply each other with electricity if necessary. If I am in a room with a lamp or a TV, my mobile phone and the lamp will negotiate everything on their own, and the phone will be recharged by the lamp without me having to get a cable or initiate this whole process otherwise. The only thing would be that I could deliberately set the direction, for example: "Remote control, please charge my hearing device, it is running low on battery."
The catchphrase might be: "Dining devices" referring to the dining philosopher’s problem in computer science.

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Alcatel-Lucent Contribution by Didier Bourse
ALU Inputs to EC D1 Consultation on Future Network Technologies Research and Innovation in HORIZON2020

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This document summarizes the key inputs from Alcatel-Lucent to the EC D1 Consultation on Future Network Technologies Research and Innovation in HORIZON2020, with a specific focus on (a) Ideas and/or plans for future R&D challenges/topics relating to Network Technologies, (b) Role in HORIZON2020 in connection to the network technologies design, experimentation and/or deployment and research priorities, (c) Network technologies requirements and expectations, important to inspire innovation and bring most benefits to (business) development in the future. This document is based on the Alcatel-Lucent inputs provided to the EC D1 29-30.06.11 meeting organized on Future Networks research challenges and strategy.

Main trends affecting research and innovation in the communication networks area

The key trends and mega-trends affecting R&I in the communication networks area are the following:

- **Address new demands on (mobile) communication and networks calling for 5G Wireless until 2020:** Trends like growth of world populations, globalisation, mobility in all dimensions (goods, people, information), technology race, generation gaps, digital and educational dividend, social communities and networking, scarcity of resources, climate change still developing more and more momentum. These global trends are calling and demanding innovation in the ICT sector and especially in (mobile) communications.

- **Continuous exponential growth of traffic and increasing heterogeneity in traffic spatio-temporal distribution and sources:** (a) Network usage changes (e.g. enabler for Smart X), (b) Traffic types, traffic rates and flow size distribution changes resulting in new requirements traffic control, (c) Not human generated traffic (for instance from M2M capillary networks) will increase and coexist for network usage, coming along with (d) Massive node deployment and (e) Limitation on spectrum availability as bottleneck including energy efficiency versus spectral efficiency trade offs and novel spectrum usage (spectrum sharing, coexistence solutions).

- **Global trends demand to go for 5G wireless networks beyond 4G (IMT advanced):** Requirements for which 4G (LTE-A) is not optimally designed: (a) Energy efficiency (intrinsic bounds limiting potential savings as e.g. targeted by the FP7 project EARTH), (b) Support of heterogeneous cell types and (c) Large-scale machine-to-machine communications and device to device communication.

- **Integration and Convergence:** Development of common/shared infrastructure enabling any-to-any communication independently of the physical access technologies (wireless, wireline), capacity/resource usage, user utility, host/device movement and density (sequential vs simultaneous access), existing infrastructure... In the area of mobile communications the ever increasing heterogeneity in sense of (a) Technology, (b) Mobility profiles, (c) Multi-RATs and (d) Integration with fixed has to be coped with.

- **Technologies approaching their intrinsic limitations:** Growing complexity of Internet technologies with decreasing performance/cost gain ratio, in particular the TCP/IP protocols (resulting from reactive add-ons since more than 30 years) leads to a situation where either more resources (being operational or physical) are being continuously injected into the system or new design approaches to the protocol stacks are being initiated.

- **Security and trust issues in shared and more autonomous infrastructures:** Security of the shared infrastructure becomes a key area of concern, the expansion of the infrastructure together with the increasing complexity of technologies (amplification effects resulting from interactions among
components that are sometimes hidden or unknown at design time) makes novel types of anonymous attacks possible. Coping with the security challenges without impacting accessibility, scalability, and privacy of the infrastructure is one of the main challenges of the next decade.

- **Proliferation of the cloud concepts beyond pure applications:** (a) Technology breakthrough (e.g. SOCs offering capacity as offered by nodes), enabling unprecedented scalability, flexible distribution, (b) Networked cloud and (c) Cloud services. Economy of scales both for quick upscaling and downscaling of required processing, storage and network resources ‘on demand’, pay as you need by means of virtualization.

- **Faced with the challenges of increasing network capacity multi-fold despite flat ARPU,** mobile operators continue to seek drastic improvements in operational efficiency and reduction in CAPEX and OPEX. The introduction and adoption of technologies such as Self-Organizing Networks (SON) and cognitive multi-network access would represent a major breakthrough towards future networks. The next big Cognitive Radio Networks (CRN) technology will be the intelligent/dynamic management of spectrum in emerging heterogeneous networks (with macro, small and femto cells).

- **Evolution of mobile terminal and tablets beyond advanced IMT:** Continuous evolution of mobile terminals and tablets, due to progress of OS, mobile processors and embedded sensors will add further requirements and models for mobile networks. The word of mobile internet and IoT shall meet creating new solution and technological challenges.

Main scientific and technical evolutions envisioned between now and 2020, as well as beyond

The main envisioned scientific and technical evolutions are the following:

- **Internet evolution to address the multiple challenges resulting from the increasing heterogeneity** (from application to physical medium/interfaces) and be oriented toward efficient use of energy. The progressive deployment of so-called machine-to-machine communication, and more generally ad-hoc/sensor (mobile or not) networks able to operate in e.g. delay tolerant/lossy environment or with low power will induce several protocol stacks changes (in particular at the transport and IP/routing layer).

- **Networks designed for energy efficiency,** e.g. radio technologies coping with unprecedented demands for capacity, energy efficient coverage and efficiency and support of heterogeneity leading to new air interfaces applying: Novel cooperative transmission schemes and concepts (waveforms, Turbo HARQ...) and short range solutions for very high data rates.

- **Emerging paradigm of Cognitive Radio Networks (CRN)** is an approach to wireless engineering wherein the radio, radio network, or wireless system is endowed with awareness, reason, and agency to intelligently adapt its operational aspects (e.g. radio resources). Cognition enables interference and dynamic spectrum usage and management in very dense heterogeneous networks.

- **Scaling:** Assuming expansion of the Internet in number of Tiers/AS's/nodes/... either scale-free and oblivious processes (independently of number of nodes, objects, robustness to environmental/running condition changes...) are designed and progressively integrated or the Internet will be populated by application specific gateways of all sort (impacting in turn scaling, accessibility...). On the other hand, find means to cope with increasing complexity of technologies is also going to play a major role in preventing scaling degradation (together with degradation of the survivability/robustness of the shared infrastructure).
• **Security**: The Internet architecture is by design not secure, security of the Internet relies on its protocols (exclusively), as functionality, self-defense (cooperative intrusion detection, distributed traffic anomaly detection, intrusion/anomaly detection in asocial/uncooperative context...) is probably going to become a main research direction on its own.

• **Design towards more adaptability and changeability**: (a) Modularization by "layered stack" with static binding at design time is coming at its limits and new approaches to modularity will have to investigated, e.g., dynamic binding at running time, (b) In terms of control processes two main trends can be isolated i) Cognition: Systems autonomously learning what to learn (assuming the "learning" problem is solved), ii) Self-organization: Distributed systems "self-designing" at running time. The underlying goals are better response to uncertainty (unexpected/unattended events), to complexity and energy consumption (if we assume such system could run on different substrate than silicon). The network is even more complex and distributed yielding the needs to have more intelligence and automations for its operation (e.g. performance monitoring, resources allocation). This will influence the network models with new heuristic algorithms and self learning / cognitive networks. The technology behind this model should prepare the basis for new generation of service aware platforms and Software Defined Networking.

• **Content-Centric Networks effort is a very promising step**: Content storage and caching, optimized content delivery, deeply integrated security (i.e. communication security, authentication devices (e.g., in the phone), standardized and secure payment services), return of low-latency communication for interactive voice and video.

• **Evolution of mobile terminal and tablets beyond advance IMT**: Mobile to mobile communication to be considered for future generation of mobile networks. IoT and M2M communication models to be taken into account for new generation of mobile terminals acting as context / environment aware objects creating new possibility and extensions of communication sessions where the status of the environment is captured by communities of mobile devices as well. Mobile devices should be considered as movable sensors, multimedia actuators and communication device as well.

Specific barriers or challenges to be overcome or taken up

The specific barriers or challenges to be overcome or taken up are the following:

**Future Wireless Access**

• **Energy efficiency research** is an area still in its infancy only recently getting first foundations to reason in a scientific way on energy efficiency. The tools (e.g. evaluation frameworks), the modeling (e.g. power models) and the research objects (single technology homogeneous networks) are not general enough for the systems required to cope with the requirements for 5G systems.

• **4G air interfaces are not optimal for energy savings, for support of heterogeneity, massive machine to machine and device to device communication.** A lot of building blocks to allow for more flexibility, manageability and autonomies have been provided by past and current research. However an effort is required bringing the research areas on cognitive radio, autonomic network and internet management approaches together.

• **Main barriers and challenges from Cognitive Radio Systems (CRS) perspectives can be categorized in three domains**: (a) **Availability and maturity of required technology**. A lot of research has being going on in the field of CRS so far primarily focusing on opportunistic use of white
spaces based on spectrum sensing techniques. In order to deploy CRS features on a wider scale, robust and cost effective technology needs to be developed e.g. supporting dynamic use and aggregation of spectrum over spanning large frequency bands, (b) **Trust and Confidence from Operators, Regulators and Incumbent Spectrum Users.** There is still a lot of uncertainty around regarding performance, stability of CRS techniques, and their potential impact on legacy radio systems. Use cases and related Business Models are under investigation but still not very well understood by concerned organisations, and (c) **Adoption of CRS techniques in cellular mobile standardisation (e.g. for LTE advanced, 5G) and regulation.** While standardisation of CRS in IEEE is in a quite advanced stage, for LTE/LTE advanced only some SON features have been considered by 3GPP so far. Exploitation of the full flavour of CRS techniques for next generations of cellular radio systems opens tremendous opportunities to increase the efficiency of future systems.

Content distribution
- **Support of multiple distribution mode** (from on-line/streaming to off-line/asynchronous) supported by a single and unified design - the main barrier being the adoption of various actors and players in the multimedia content space.
- **Addressing** (the Internet addresses machines — computers) and content/information/data. The main barrier for adoption would be a mandatory change of object naming without direct benefit to the end-user (remember IPv6).

Communication systems/Networking
- **Allow hosts/devices to diagnose potential problems,** to perform root cause discovery and analysis by making network capable of providing feedback to hosts/devices (today such cooperation is actually extremely limited).
- The operation of ad-hoc/sensor networks implies development of new traffic and device control model but also control processes compared to those currently employed in core networks.
- To maintain/sustain or even increase their functionality and performance delivery over time, communication networks/systems shall provide greater flexibility in their functional organization, adaptation, and distribution, and shall be able to respond and even predict variation of their internal state, their activity/behavior as well as the environment/external conditions.
- **Non-intrusive and non-discriminatory means to detect misbehavior/security threads and mitigate their effects** while keeping open and broad accessibility to the Internet is a limitation that is crucial to overcome.
- The **current inter-domain routing system is reaching fundamental limits** in terms of routing table scalability but also adaptation to topology and policy dynamics (perform efficiently under dynamic network conditions) that in turn impact its convergence, and robustness/stability properties.
- **Support of end-to-end mobility** (mobile IPv6 is still not widely deployed). On the other hand, design of network would benefit from decoupling of mobile communication from access technology specifics.
- **Prevent overload of certain network segments would prevent capacity shortage** (and thus congestion) over certain segments of the network.

Optical networks
- **The massive expansion of Internet** and the convergence and integration of the networks into IT infrastructure (data centers) can only continue if the physical layer, notably in optical networks, is able to follow the demand of capacity. The slowing down of what the best technologies have delivered in terms of capacity per fiber in the past decade, has indicated that this should not be taken for granted. Alcatel-Lucent has identified **four major questions that must be**
addressed, in order to overcome the bottlenecks that current technologies cannot solve in optical networks: (1) \textbf{How to make optical networks more dynamic?}: From today’s static photonic layer, to remote reconfiguration, to optical restoration, to fully autonomous modes of operation while following the variations of data traffic, (2) \textbf{How to make optical networks more transparent?}: Direct management of photons instead of electrons in many more areas of the network, wherever it brings benefits, (3) \textbf{How to make optical networks faster?}: Propose innovative solutions to respond to the ever-growing demand of traffic from the users and (4) \textbf{How to make optical networks greener?}: Reduce the energy per bit such that future network developments are sustainable. These questions correspond to five underlying market drivers that push simultaneously but that cannot all be satisfied at the same time.

Research topics to be addressed in the coming years (2013-2020)
Research topics relevant at the EU level

The research topics to be addressed are the following:

\textbf{Future Wireless Access}
- \textbf{Energy efficiency modeling, analysis and design} for energy efficiency for multi-heterogenous networks: Build on current research projects working on such topics in context of homogeneous LTE like systems. Evolution towards the new requirements originating from the every increasing heterogeneity.
- \textbf{Establishment of paradigms for architecture, protocols, interfaces constituting the foundation for future energy efficient 5G systems}: Approaches allowing to separate signaling from data communication and to embrace heterogeneity of different technologies, traffic demands and conflicting requirements.
- \textbf{New air interface solutions for 5G systems} (beyond IMT advanced!): Highly dynamic adaptability to traffic demands; interference management in very dense and heterogeneous scenarios, novel transmission schemes and concepts; inclusion of short range solutions for very high data rates.
- \textbf{Cognitive autonomous management solutions for (potentially highly heterogeneous) massive node deployments}. Merging all the different approaches for cognitive radio, self organizing networks, context awareness and (multi-)network management solutions.
- \textbf{Network nodes and components for the heterogeneous 5G world}: (a) Concepts, components allowing for distributed solutions following the cloud concept with a grade of scalability, reconfigurability and energy efficiency as required by the trends and (b) Cloud infrastructure solutions for network clouds.
- \textbf{Architecture for Cognitive, Multi-RATs, Multi-Spectrum heterogenous networks going beyond pico, macro, femto division} to include different additional layers such as Device-to-device communication.
- \textbf{Concepts and algorithms for dynamic, advanced spectrum usage and spectrum sharing}. Models and algorithms for cognitive dynamic spectrum assignment in hierarchical radio networks.
- \textbf{Architecture and algorithms for implementation of Cognitive Network features in the cloud}.
- \textbf{Family of flexible, reconfigurable, power efficient RF frontends} that can be tuned over full or sub-bands in 400 to 3 GHz supporting aggregation of scattered spectrum.
- \textbf{New baseband architectures for flexible, reconfigurable multi-standard baseband implementations} supporting spectrum aggregation and Cloud based concepts.
• **Technologies such as** (a) **Localized spectrum sensing** in APs/BS, (b) **Collaborative Spectrum Sensing database and server** and (c) **Coordination protocols for reliable opportunistic spectrum access** managed by the infrastructure.

• **Technologies to monitor and trend network demands across radio networks to estimate capacity and QoS requirements** in space and time to control resources and multi-band, multi-license spectrum to optimize spectrum efficiency and energy usage.

• **Cognitive functions for dynamic spectrum management and spectrum trading** that could be implemented and deployed in the cloud.

**Content distribution**

• **Support of multiple distribution modes** (from on-line/streaming to off-line/asynchronous) supported by a single and unified design.

• **Determine if a unified (with the communication system) or an overlay approach would better fulfill requirement of content distribution networks.** Scaling and distribution are more than certainly the main requirements of the underlying network-wide and system design.

• **Addressing (the Internet addresses machines — computers) and content/information/data.**

• **Identify potential use and benefit of co-development with (distributed) cloud technologies** (from operating system to distributed multimedia applications).

**Communication systems/Networking**

• **Online detection - identification - analysis techniques from measurement data.**

• **Large-scale distributed control paradigms (self-adaptive, self-organizing...) enabling self-* functionality** (including self-configuration, self-maintenance, self-diagnostic, self-healing, self-protection, self-repair, self-optimization, self-stabilization, etc.) together with dedicated research activity on associated / role of various learning models and techniques.

• **To enable flexibility of communication systems at run time** dedicated research on new communication modularity and design of associated modules (dynamic composition) is required.

• **Design non-intrusive and non-discriminatory means to detect misbehavior/security threats** and mitigate their effects while keeping open and broad accessibility to the Internet.

• **Design of new routing schemes** capable to cope with the (memory/storage and processing) cost of topology, policy, and traffic dynamics while keeping routing path stretch and quality under reasonable bounds.

• **Rethink mobile IP** (in particular MIPv6 and IPv6) and associated relationship to the TCP and data link layer.

• **Effective means to predict the spatial distribution of the traffic** within a timescale that would allow providers to install needed capacity when required or at least expected to prevent overload of certain network segments would prevent capacity shortage (and thus congestion) over certain segments of the network.

• **Which new networking paradigm and/or technology trend will emerge from the "energy/power consumption constraint" remains an open question** (most advances so far are limited to technology or system engineering increments and thus part of classical R&D cycles).

**Optical networks**

• **Making optical networks more dynamic:** To Introduce true flexibility in photonic networks through fast-established circuits or optical packets, coping with varying traffic demands, benefiting from elasticity in format, channel spacing or bit-rate, while reducing latency, and managing quality of
service at the photonic layer, to achieve autonomous operation of photonic network elements, including self diagnosis and restoration with efficient use of monitoring.

- **Making optical networks more transparent**: To let photons go deep into the network instead of electrons, by removing unnecessary opto-electronics conversions in optical nodes, routers and switches, while managing the resulting increase in heterogeneity in fiber types and network architectures, allowing several bit-rates, modulation formats, and radio standards to travel across the same generic infrastructure, enabling cost-effective convergence of radio and fixed, metro and access networks.

- **Making optical networks faster**: To elaborate disruptive mix of technologies to keep up with capacity growth to 10Gb/s in wired and wireless access, to 100Gb/s and beyond in the core, involving coherent detection, with clever digital signal processing, exploiting all modulation spaces, original multiplexing schemes such as polarization and mode multiplexing, so as to increase spectral efficiency, while expanding optical amplifier bandwidths.

- **Making optical networks greener**: To expand the role of photonics from core down to home access, promoting optical bypass whenever possible, turning all photonic equipment to idle mode when needed, performing power-efficient all-optical processing, simplifying or removing unnecessary protocols, performing energy-aware optical routing.

All topics are considered to be relevant at EU level as they need to be addressed in a global manner involving collaboration between industry, operators, regulators and academic research.

**Conclusions and Recommendations**

Global trends and mega-trends bring in an unprecedented pace of changing and increasing demand and requirements on technologies and solutions for Future Networks. In this document four major areas namely Future Wireless Access, Content Distribution, Communications Systems/Network and Optical Networks have been identified as areas where major barriers have to be taken towards the Future Internet and where intensive research is required.
CAON Cluster by Dimitra Simeonidou
Title
Contributions from the CaON Cluster: Key Research Challenges for Optical Networking

Contribution
Support of multi-Gbps access rates:

Acceleration of access deployment through reduced total cost of ownership, broader introduction of open access models and converged solutions supporting transport of mobile and fixed traffic in both front- and backhaul scenarios. Seamless integration of access and metro/aggregation with unified control and management planes also through software-defined networking paradigms for traffic engineering, virtualization and context-aware networking. New solutions for simultaneous support of more users per feeder (>1000) with higher speeds (up to 10 Gb/s peak) and longer reach (100 km). Green and fast (1 Gb/s and beyond) home networking.

Spectrum management: capacity management and bandwidth granularity provisioning

Flexible spectrum allocation taking advantage of elastic space, frequency and time multiplexing, ability to dynamically and efficiently partition the fibre bandwidth into variable-size spectrum slots. Future research should focus on: transmission, switching and grooming technologies enabling transport services ranging from 100s Mbps to beyond Tb/s with associated new control plane solutions to support adaptivity, flexibility and elasticity in optical networks.

Optical Network and IT convergence: for high performance, global reach clouds empowered by optical network infrastructures
Research should address service provisioning over hybrid infrastructures composed of both IT resources (i.e. compute, storage, data centres) and optical networks. It will require the capability to virtualise the physical optical network infrastructure (analogue or digital) and federate heterogeneous resources from different providers. It also needs unified management and provisioning procedures including considerations for dynamic control plane functionalities and Software Defined Network procedures for the whole integration with the IT network infrastructures.

Optical network control plane:

Main research challenges include: (i) true multi-vendor and carrier control plane solutions, including extensions for elastic technologies (ii) split architectures that decouple the control plane from the optical transport – several architectural options might support this: OpenFlow as an open/vendor-independent interface to network data plane; multi-technology and multi-domain path computation services coupled with traffic optimization, Software Defined Networking at large, (iii) control plane interfaces to external end-user “systems” (e.g. clouds) for any type of bandwidth-on-demand service and seamless integration with the service layer workflows.

Cognitive, self managed optical networks:

Technology platforms to dynamically re-purpose, evolve, self-adapt and self-optimize functions/devices/systems of the optical network. Research should focus on optical/opto-electronic technologies that would allow for environment-aware, self-x systems that can change any parameter based on interaction with the environment with or without user assistance. Research on cognitive control and management plane should enable network-wide infrastructure dynamic self-adaptation, self-handling across heterogeneous systems.

Energy efficient optical networking:

Improve the design, planning and operations for energy aware management, introduction of new simpler protocols, definition of energy friendly resilience and support of planning and routing algorithms capable of 100 times energy consumption reduction. Work should particularly focus on energy efficient network services for applications such as P2P, grid or cloud services relying on optical-based network infrastructure.
The CaON reference architecture model

The CaON cluster has developed network reference model (Figure 1) which presents a layered architecture for the convergence of optical networks and Future Internet technologies and services. The model promotes the convergence of the optical infrastructure layers with upper layers (applications and services) and aims to strategically place optical networks as key enabler of Future Internet and cloud networking service deployment.

![Diagram showing the CaON reference architecture model](image)

* = (s) to reflect network & IT and multiplicity of infrastructures

Figure 1: The CaON reference model

This is a bottom-up reference model, where the infrastructure and provisioning layers, together with cross-layer SLA and the management, are identified the key focus for future research trends within the CaON cluster community.

The physical infrastructure layer covers from the core to the access optical network technologies. Within the infrastructure layer we can also identify the need for infrastructure virtualisation capability. Virtualisation will provide a more flexible way to deal with infrastructure resource utilization by overcoming the multilayer, multitechnology and network segmentation problems, and facilitate a whole new set of functionalities (flexibility and new dynamic provisioning of services) that will enable the convergence of optical infrastructures to support cloud services delivery.

The provisioning layer is focused on a control plane architecture that may provide a new set of functionalities at the infrastructure level, enabling:

- Scalable for multi-domain and multi-technology scenarios with Open control planes and enhanced UNI’s interfaces.
- Automated end to end service provisioning and monitoring between different network segments and operators with coordination with the management plane.
- Network resources optimization by an integrated control of different network technologies (e.g IP and optical).
- Network/IT resources optimization by means of cross-stratum interworking mechanisms.
- Operation over Virtual instances of the network infrastructure.
- Convergence of analogue & digital communications unifying heterogeneous technologies.
- Unified OAM mechanisms able to operate in a complex (multi-technology, multi-domain and multi-carrier behaviour).

On top of the provisioning layer there is the service layer. It establishes the link between the network infrastructure and cloud service requirements. This is the layer where the network exposes its services and capabilities, enabling:

- Application to network interface: this interface may enable the request of new and advanced services form the cloud to the network control plane.
- On demand provisioning services with advance re-planning functionalities.
- Co-advertisement, co-planning, composition and co-provisioning of any type of network resource and IT services (i.e. connectivity + IT resources at the end-points coordinated in a single, optimal procedure)
- Enhanced Traffic Engineering framework for resource optimization, advance allocation and energy consumption, in support of energy-efficiency.
- Implementation of network prototypes comprising the innovative data and control plane solutions designed along the projects, in particular, pre-commercial software (control plane, network-service interworking…) and HW prototypes (subwavelength switching, multigranular nodes, etc).
- Industrial exploitation: Accelerated uptake of the future networks and service infrastructures enabling increased access capacity and flexibility, as well as cost and power consumption minimization for intensive bandwidth consuming applications and cloud services.

At the cross-layer level, the CaON reference model considers two vertical layers. These are the SLA and the management layers. The former takes into consideration the mapping of the SLA requirement from the application layer down to the infrastructure (real or virtual) resources. The later is in charge of extending management functionality across the different set of resources and layers in coordination with provisioning layer.

**Key Research Challenges for Realizing the CaON Reference Architecture Model**

**Support of multi-Gbps access rates:**
Acceleration of access deployment through reduced total cost of ownership, broader introduction of open access models and converged solutions supporting transport of mobile and fixed traffic in both front- and backhaul scenarios. Seamless integration of access and metro/aggregation with unified control and management planes also through software-defined networking paradigms for traffic engineering, virtualization and context-aware networking. New solutions for simultaneous support of more users per feeder (>1000) with higher speeds (up to 10 Gb/s peak) and longer reach (100 km). Green and fast (1 Gb/s and beyond) home networking.

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Research should address service provisioning over hybrid infrastructures composed of both IT resources (i.e. compute, storage, data centres) and optical networks. It will require the capability
to virtualise the physical optical network infrastructure (analogue or digital) and federate heterogeneous resources from different providers. It also needs unified management and provisioning procedures including considerations for dynamic control plane functionalities and Software Defined Network procedures for the whole integration with the IT network infrastructures.

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DANTE/GN3 NREN by Michael Enrico and Mauro Campanella
European NREN Community Response to EC Consultation on Future Network Technologies Research and Innovation in HORIZON2020

Edited by DANTE in consultation with GN3 NREN Consortium members

30 May 2012
Together, the NRENs and GÉANT represent the network infrastructures that serve the European research and education community, connecting 40 million researchers, students and professors in over 8,000 institutions across 40 European countries.

The networks and services provided by GÉANT and the NRENs are at the leading edge of technology and continuously innovate to ensure that European researchers are at the forefront of international and global collaboration, and to facilitate European industry through collaboration and the public availability of the results of its research and experimentation.

European research networking impacts positively on society both directly through its provision of advanced networking facilities across Europe, and indirectly through the essential tools it provides to support research in a wide variety of academic disciplines. The world today faces major challenges in areas such as climate change, resource efficiency, health, energy and food security. Challenges on this scale require global collaboration that brings together the world’s best minds, irrespective of location. Research networking plays a significant role by providing the critical infrastructure and services to enable researchers around the world to collaborate to tackle such societal challenges.

European research networking is well-placed to continue its positive contribution to European and global industry and society thanks to its proven organisational model, accumulated knowledge and experience, tradition of innovation and extensive network connections to other world regions. The European research networking community is fundamental to the future development of the internet in Europe and globally.
The European NREN community welcomes the initiative of the European Commission to conduct a public consultation about Future Network Technologies Research and Innovation in HORIZON2020, and is pleased to have the opportunity to provide input relating to the needs and challenges in network communications research in Europe in HORIZON2020.

This paper contains the community’s views in response to the consultation questions.

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<th>Q1</th>
<th>Which sector are you representing? What are the strengths and size of your market in Europe and/or worldwide?</th>
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<td></td>
<td>Europe’s NRENs represent the European research and education networking community. Together, they connect 40 million researchers, students and professors in over 8,000 institutions across 40 European countries. The NRENs are interconnected by the GEANT pan-European research network backbone, which connects researchers in Europe and the rest of the world together through its extensive connectivity to other world regions. The annual expenditure on research networking and related services and technologies in Europe is approximately EUR 40 million on GÉANT, EUR 400 million within the NRENS, and EUR 4 billion within the connected institutions, and it is expected to continue to increase.¹</td>
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### Q2

How would you describe (in less than one page) your ideas and/or plans for future R&D challenges/topics relating to Network Technologies?

*N.B. This could encompass any topic from basic research to innovation and experimentation.*

- improve multi-domain collaboration based on network infrastructures in all sectors (e.g. eHealth, education, energy). Support smart cities so they are considered a fundamental element of the European landscape, with a strong collaboration, also involving universities, based on information exchange on energy, waste, water, transportation;
- provide support to physical and economic disaster recovery through information access and exchange;
- develop ultra-dense networks made of sensors/things;
- improve capacity and the means of its utilisation:
  - improve on the cost-effective and timely provisioning of end-to-end flexible lightpaths at bandwidths up to and beyond 100Gbps and global, multi-domain bandwidth-on-demand (BoD) services (e.g. at bandwidths up to 100G);
  - ultra high speed networking (many petabits per single node);
  - steer network development towards elasticity so that the network better supports Cloud Services;
  - empower end-users (industries and citizen) to have greater control of the networking fabric for their purposes through high-level software-defined networking capabilities;
  - support new emerging “real-time” applications that require “all-photonic” transmission over optical fibres alongside conventional digital bandwidth services (e.g. dissemination of ultra-accurate/stable time and frequency metrology signals);
  - trial and utilise new technologies that address Internet scalability issues e.g. OpenFlow and LISP (Location/Identification Separation Protocol);
  - develop Software Defined Networking in the broader sense (beyond just a single technology like OpenFlow).
- seamless eInfrastructures provision: ensure storage, computing and networking are a seamless service for users;
- better integrate wireless and wired infrastructures to ensure the required bandwidth is always available, everywhere, at the right cost;
- adopt federated authentication and authorisation infrastructures such as eduGAIN;
- develop a Europe-wide and global open testbed infrastructure to serve researchers and industry;
• information provision: ensure all types of “knowledge” of interest to industry and commerce is made available on-line;
• adopt state-of-the-art energy efficiency as a key pillar of future network and service architectures and equipment procurements and deployments;

Q3 How do you see the potential role of your organisation in HORIZON2020 in connection to the network technologies design, experimentation and/or deployment? What are your research priorities?

The GEANT network and NREN community have a central role to play in Horizon 2020 in offering facilities that can support leading edge research and pre-production validation in a secure, safe and technology-agnostic network environment. Such facilities are also well suited to connect communities on an agnostic substrate Europe-wide, to facilitate multi-national endeavours. An open, virtualised multi-domain testbed facility will be deployed and expanded globally to also support cloud developments.

The NREN community and GÉANT will be engaging in R&D activities that are open to academia, industry and user communities through open calls, PPPs or pre-commercial procurements, exploring innovative business models for clouds, federated AAI and mobility, exchanging staff and training, and contributing to international standardisation through participation in standards bodies.

The lengthy experience and well-established facilities of the research networking community can serve to engineer and prototype solutions for smart cities, and large smart-energy infrastructures, as well as novel security, safety and disaster recovery trials.

Our research priorities will include large data (millions of Gigabytes per second) transport and management, cloud integration, end user application services, the infrastructure as an agile network and testbed factory, energy-efficient networks and support of novel applications such as distributed time metrology.
**Q4** Which network technologies requirements and expectations, do you consider important to inspire innovation and bring most benefits to your (business) development in the future?

Develop affordable, resilient networks to facilitate anywhere, anytime access to information and computing resource:
- allow enterprises, research and education to distribute and share information more quickly, supporting real-time collaboration;
- support home office and work in a distributed environment, reducing commuting and travel whilst supporting quality of work and collaboration through video, data access and security;
- pioneer, deploy and offer to the user new pre-commercial network services.

**Q5** Which cross sector synergies in relation to the network technologies research are of strategic importance to generate growth in your business sector?

It is important to collaborate with the following players/activities:
- supercomputing and computing grids
- clouds and large data storage
- smart cities, sensor networks
- privacy, identity and trust management
- security and intrusion detection
- optical equipment
- wireless technologies
- Internet policies

**Q6** How do you think that the network research community should best engage with the user community?

It is vital that there is a constant validation of research directions and results in connectivity and networking services with research and societal needs. This is best achieved by working with the e-Infrastructures and communities to understand their needs and involve them in research and development as a collaborator, not just providing “plug on the wall” services as a supplier. By understanding the work of the individual user communities and at the same time informing them of the available and emerging services, it is possible to build bridges between the consumers and providers of e-Infrastructures and services, developing opportunities and stimulating research. Such engagement could be extended to other user communities such as Chambers of
The Living Labs community is a good example of a concrete test case which resulted in a sustainable implementation, involving rapid prototyping and validation.

At the same time a fundamental process of internal validation and research in communities such as those in the Future Internet which often include partners from industry, must take place to ensure that there is consistency, collaboration and cross-validation between research areas and their innovation.

<table>
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<tr>
<th>Q7</th>
<th>Which constituencies and methodologies in relation to network technologies research are most important to maximise the impact of research and innovation in HORIZON2020?</th>
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<td></td>
<td>User consultation and involvement in the development of networking technology is essential to ensure user requirements are understood and met. Innovation may also stem from direct results of high-end users (e.g. astronomy, physics, biology) who have a history of creating new working methods on the basis of network developments, sharing resources across disciplines and technology domains to create virtual eScience research communities. Research objectives and methodologies need to be sufficiently “open” to allow for this, whilst still responding to future needs. The requirements of lower-capacity users also require innovation, for example in the area of ubiquitous mobility.</td>
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<td>The involvement of constituencies such as eHealth, education and not-for-profit entities such as humanitarian organisations can ensure economies of scale to the benefit of societies.</td>
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<td>Methodologies to maximise the impact of research and innovation should include:</td>
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<td>• R&amp;D activities being open to the academic community, industry and user communities through collaborations, open calls, PPPs or pre-commercial procurement, thus also leveraging more investment from the private sector;</td>
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<td>• explore innovative business models, for example for clouds, federated AAI and mobility;</td>
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<td>• offer to all stakeholders a rich open multi-domain testbed facility with privacy and security assurances, and expand it globally and to cloud testing with clear policies and cost minimisation;</td>
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<td>• exchange staff between NRENs, academia and industry, and training;</td>
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<td></td>
<td>• strengthen co-operation between academia and industry by offering e-Infrastructure services for research to industrial</td>
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partners, thus improving innovation and contributing to economic competitiveness and social welfare in Europe;
- seek synergies with public services at European and national levels when appropriate;
- enable virtual presence and mobility of collaborating parties, substituting physical mobility and supporting remote collaboration;
- develop policies for a fair open access to public research data repositories;
- provide a network-based framework for integrating education and research (aiding research-led education and student-populated research);
- attract young people to science by disseminating about exciting technology advances and new research techniques and developments;
- contribute to international standardisation such as in IETF;
- rapid prototyping of ideas coupled with extensive user consultation;
- effort should also be devoted to ensuring synergistic (interoperable) developments between different players, to avoid generating incompatible results.

**Q8** How should research developments in network technologies in HORIZON2020 be measured against delivering EU industrial leadership worldwide, sustainable economic growth and high-quality jobs creation in Europe?

The NRENs and GEANT already collaborate with industry in support of their research; technological results from research networking are publicly available to industry or else via research entities’ achievements. This collaboration – targeted particularly at small and medium enterprises in all European countries - will be further strengthened by fostering more multi-stakeholder participation facilitated by the internet, and by prototyping technology developments, for example in pilot projects such as smart city-to-smart city collaboration.

The success of research developments in network technologies can be measured by:
- research results produced;
- the use of research results worldwide;
- the reduction in the costs of access to high-speed internet and related services;
- the actual usage and usage trend of a network, and its ‘value’ for business, which can be measured by the impact of having no network connection or a too-low capacity connection;
Europe’s ability to attract and retain networking researchers; the number of patents filed, technical standards adopted and peer-reviewed papers and articles published; the adoption of results not only by industry but also by the public sector and in society; the adoption of research results in smart cities, in particular for gains in transportation and energy efficiency through the use of networks; the effect of networking advances on the education sector, in public administration, culture and health.

A further indication of the value delivered by networking research and innovation is the extent of adoption of the European NRENs’ collaborative organisational model for the delivery of high-speed networks and services from the local to the global level. The reach of research networks outside urban areas will continue to stimulate new activities and generate jobs. The collaborative model is one which lends itself to public-private funding partnerships to stimulate further new ways of working.
SURFnet response to the Consultation on Future Network Technologies Research and Innovation in HORIZON2020

Introduction
SURFnet is the Dutch National Research and Education Network (NREN), connecting institutions for research and higher education in the Netherlands to each other and to the world.

SURFnet welcomes this opportunity to provide input for the Future Network Technologies part of HORIZON2020. We have demonstrated, through 25 years of history, that NRENs have the ability to develop and deploy leading network infrastructure technologies for the benefit of research and higher education, but also for the benefit of society as a whole.

Question 1: Which sector are you representing? What are the strengths and size of your market in Europe and/or worldwide?
SURFnet ensures that researchers, instructors, and students can work together simply and effectively with the aid of ICT. It therefore promotes, develops, and operates a trusted, connecting ICT infrastructure that facilitates optimum use of the possibilities offered by ICT. SURFnet is thus the driving force behind ICT-based innovation in higher education and research in the Netherlands.

SURFnet serves the needs of approximately one million end-users in research and education, both directly (for ICT collaboration services) and through its 160 connected institutions (for networking services). Through SURFnet and its international partners, end-users in research and education can collaborate with their colleagues elsewhere in Europe and beyond.

SURFnet has been at the forefront of innovation since the early days of networking. Established in 1988, the NREN has not only provided state of the art services to its constituent institutions, but has also performed, together with its research partners, cutting edge innovation and development. The results of these activities are actively disseminated in order to encourage network innovation throughout society.

SURFnet is an integral part of the GÉANT ecosystem, as defined by the GÉANT Expert Group (GEG), in its recent report¹. In this report, the GEG noted that European networks are founded on collaboration, and that the GÉANT ecosystem is a combination of very diverse national NRENs, regional and European collaborations, a European high-speed backbone, as well as the European user communities. Only through collaboration between these domains can the ecosystem as a whole provide end users with the services they require.

Question 2: How would you describe (in less than one page) your ideas and/or plans for future R&D challenges/topics relating to Network Technologies?
Modern research is increasingly built on both global cooperation and global competition. The virtualization of experiments enables researchers from all around the globe to cooperate and share data and research results, using advanced research networks and grid infrastructures. For example, research on climate change requires complex computer simulations that access data stored in online repositories all over the globe. Remaining competitive in the face of these emerging scientific challenges requires collaboration between research teams and resources across Europe and around the world.

the world in Global Virtual Research Communities. These Communities cannot exist without wellfunctioning and seamless global e-Infrastructures, connected through advanced networks.

Research and development in Network Technology will have to provide new tools to support the emerging e-Infrastructure, through seamless connectivity across multiple domains (campus, national, regional, global) and across access methods (fixed and wireless). These tools must provide for on-demand connectivity, and integrate with the on-demand tools emerging in computing, storage, and other elements of the e-Infrastructure. SURFnet intends to work with academic and industrial partners, as well as with the research and education networking community, to define and create these tools.

SURFnet believes that the scope of network innovation needs to cover all domains, from local (campus) networking to global interconnection. This is in line with the GEG report, which stated that NRENs will have to work much more closely with campus and other local networks to ensure that users benefit from high quality infrastructures.

Question 3: How do you see the potential role of your organisation in HORIZON2020 in connection to the network technologies design, experimentation and/or deployment? What are your research priorities?

SURFnet, and NRENs in general, can contribute to the HORIZON2020 in several ways:

- By providing the networking and collaboration tools which are essential to research activities within the Netherlands and to the collaboration of Dutch researchers with their international counterparts, thus directly enabling the Excellent Science objective of HORIZON2020;
- By facilitating collaboration between academic and industrial researchers through networking services provided to the research and development activities of industrial companies, thus directly supporting the Industrial Excellence objective of HORIZON2020;
- By accelerating the development of future internet architectures and services, in collaboration with industrial partners, through large-scale pilots involving advanced users in research and education;
- By encouraging innovation in networking throughout society, enabling ICT-based improvements in all sectors and indirectly supporting the Societal Changes objective of HORIZON2020;
- By further developing the network technology, network architectures and related middleware solutions used within the e-Infrastructure, thus achieving Excellent Science in the field of networking technology and ICT, and enabling Excellent Science in fields such as Computational Science.

Some specific research priorities within SURFnet’s innovation projects are:

- Fixed/mobile integration, enabling seamless connectivity (including authentication and authorisation) for users connected to any combination of public mobile networks, local wireless networks and fixed networks;
- On-demand and virtualised networks, allowing users and applications to gain complete control over relevant (virtual) network resources;
- Advances in optical technology, allowing for flexible multi-Terabit networks;
- Seamless e-Infrastructure provision: ensure networking, storage, computing and other services of the e-Infrastructure are seen as a seamless, on-demand service for users;
- Improving on the cost-effective and timely provisioning of end-to-end flexible, multi-domain lightpaths at bandwidths up to and beyond 100Gbps, both national and international;
- Trialling and utilising new technologies that address the disadvantages of current Internet technology.
Question 4: Which network technologies requirements and expectations, do you consider important to inspire innovation and bring most benefits to your (business) development in the future?

At this time, SURFnet believes that these requirements from users are important for both innovation and development:

- The requirement for on-demand, multi-domain, e-Infrastructure services, including networking, computing, and storage;
- The requirement for ubiquitous connectivity, including high-speed broadband deployment and fixed/mobile integration.

The research priorities mentioned in the previous answer will enable networking and other providers to satisfy these user requirements.

Question 5: Which cross sector synergies in relation to the network technologies research are of strategic importance to generate growth in your business sector?

For SURFnet, the most important synergies are the collaboration between the different networking domains (campus, national, European and global) and between the different parts of the e-Infrastructure.

Collaboration between networking domains already takes place at multiple levels: SURFnet (and other NRENs) work with universities and research institutes to innovate in the campus networks and their end-to-end connectivity, with other European NRENs work in bilateral combinations and in projects such as GN3, and with NRENs around the world in global collaborations such as GLIF2.

SURFnet also collaborates with organisations responsible for other parts of the e-Infrastructure, including supercomputing, grid computing, and storage.

SURFnet believes that much of the innovation potential in networking lies in exploiting these synergies. However, this requires a different way to organise innovation projects at the European level, in order to improve the speed and flexibility. Rather than a single pan-European project, which both upgrades the service delivery network and innovates in networking (as was attempted in GN3 and its predecessors), the innovation should happen in multiple smaller projects. These innovation projects should be executed by various consortia including NRENs, industry, users and academia, in an environment which provides room for experimentation and for multiple, competing approaches. This is in line with the recommendations of the GEG.

Question 6: How do you think that the network research community should best engage with the user community?

It is essential to involve the user community in both the innovation process and in the delivery of advanced network services. Large, advanced users such as CERN and the NEXPReS project should help determine the direction of both network innovation and service delivery, but input from “regular” users should also be taken into account.

As stated in the GEG report, users should have a stronger voice in the running of the networks, including in overall planning and strategy. This implies that they should have an actual say in the governance, rather than just an advisory role.

User involvement in project proposal preparation (including Horizon2020 projects) should help ensure that user requirements drive the objectives of both innovation and service delivery projects.

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2 GLIF, the Global Lambda Integrated Facility (www.glif.is), is an international virtual organization dedicated to lambda networking. GLIF pursues a federated and open approach to global networking.
However, innovation projects should not be limited to stated user requirements: many of the successful services currently provided by SURFnet were developed without a clearly stated user requirement, but always with a clear idea of the value to the user.

**Question 7:** Which constituencies and methodologies in relation to network technologies research are most important to maximise the impact of research and innovation in HORIZON2020?

The constituencies most important to research and innovation in networking are the ones mentioned in the earlier answers: the user communities, and in particular the high-end research users (including the ESFRI facilities), the networking community at the global, European, national and campus levels, and the providers of other resources within the e-Infrastructure. This includes national and European supercomputing, grid computing and storage initiatives.

In terms of methodology, research and innovation in networking needs a format which allows different initiatives to both compete and collaborate. Rather than a single program, this implies supporting multiple initiatives from different consortia, as recommended by the GEG. While some form of control is needed to ensure that funding is used effectively, the governance structure must provide sufficient space for different initiatives to pursue very different approaches.

The GEG report contains several recommendations towards a more transparent and responsive governance structure for networking in Europe. Implementing these recommendations will be a major step forward towards maximising the impact of research and innovation in HORIZON2020.

**Question 8:** How should research developments in network technologies in HORIZON2020 be measured against delivering EU industrial leadership worldwide, sustainable economic growth and high-quality jobs creation in Europe?

Developments in networking should be measured primarily in terms of their indirect impact: advanced networking in research and education networks is essential for top level research and improved higher education, which in turn are two essential elements for industrial leadership, economic growth and high-quality jobs creation.

However, developments in networking also have other positive effects: through collaboration with industrial partners (manufacturers, network operators, system integrators etc.), the innovation achieved in research and education networking leads to innovation in the broader networking community. This innovation helps the commercial operators to achieve industrial leadership and to create jobs, but more importantly it enables further innovation in every industry and in every sector of public service.
Queen Mary, University of London by Steve Uhlig
Proposal by Steve UHLIG (Queen Mary, University of London, United Kingdom)

**Title**
Innovation for the Internet: the need to engage all stakeholders

**Contribution**
The Internet is evolving at a significant pace due to new usage trends and platforms such as mobile devices, social media, streaming networks and content delivery platforms. Within the next EU framework, the researchers need to focus on the future trends, devices and usage habits and strategically align their research to support those needs. In this document, we propose a number of challenges, related to the new interactions between different stakeholders. We also discuss how today’s Internet ecosystem requires to revisit not only the functionalities of the network, but also to rethink the different business models that will shape the future Internet. We also suggest that the Societal relevance of the Internet should be more supported by the Horizon 2020 agenda, as well as encourage that future projects have wider and more specific public engagement and community reach plans, engaging all stakeholders such as user communities, industrial bodies, the research community, policy makers and the Internet governing bodies.

**Links and Documents**
http://netsocionomics.blogspot.co.uk/2012/05/innovation-for-internet-need-to-engage.html
Innovation for the Internet: the need to engage all stakeholders

Prof. Steve Uhlig & Dr. Hamed Haddadi, Queen Mary, University of London, UK.
ABSTRACT

The Internet is evolving at a significant pace due to new usage trends and platforms such as mobile devices, social media, streaming networks and content delivery platforms. Within the next EU framework, the researchers need to focus on the future trends, devices and usage habits and strategically align their research to support those needs. In this document, we propose a number of challenges, related to the new interactions between different stakeholders. We also discuss how today’s Internet ecosystem requires to revisit not only the functionalities of the network, but also to rethink the different business models that will shape the future Internet. We also suggest that the Societal relevance of the Internet should be more supported by the Horizon 2020 agenda, as well as encourage that future projects have wider and more specific public engagement and community reach plans, engaging all stakeholders such as user communities, industrial bodies, the research community, policy makers and the Internet governing bodies.

Motivation: Today’s changing Internet ecosystem

Today’s Internet [1] differs significantly from the one that is described in popular textbooks [2], [3], [4]. The early commercial Internet had a strongly hierarchical structure, with large transit Internet Service Providers (ISPs) providing global connectivity to a multitude of national and regional ISPs [5]. Most of the applications/content was delivered by client-server applications that were largely centralized. With the recent advent of large-scale content distribution networks (CDNs), e.g., Akamai, Youtube, Yahoo, Limelight, and One Click Hosters (OCHs), e.g., Rapidshare, MegaUpload, the way the Internet is structured and traffic is delivered has fundamentally changed [1].

Today, the key players in the application and content delivery ecosystem, e.g., Cloud providers, CDNs, OCHs, data-centers and content sharing websites such as Google and Facebook which often
have direct peerings with Internet Service Providers or are co-located within ISPs. Application and content delivery providers rely on massively distributed architectures based on data centers to deliver their content to the users. Therefore, the Internet structure is not as strongly hierarchical as it used to be [1].

These fundamental changes in application and content delivery and Internet structure have deep implications on how the Internet will look like in the future. Hereafter, we describe how we believe that three different aspects of the Internet may lead to significant changes in the way we need to think about the forces that shape the flow of traffic in the Internet. Specifically, we first describe how central DNS has become as a **focal point between application/content providers and ISPs**. Next, we discuss how **software-defined networking** may change the ability of many stakeholders to influence the path that the traffic belonging to specific flows will follow across the network infrastructure. Finally, we discuss how the distributed nature of existing application and content delivery networks will, together with changes within the forwarding/routing, enable much **more advanced handling of the traffic**, on a much finer granularity compared to the current Internet.

**Challenge 1: DNS and Server Redirection**

The Domain Name System (DNS) was originally intended to provide a naming service, i.e., one-to-one mappings between a domain name and an IP address. Since then, DNS has evolved into a highly scalable system that fulfils the very stringent needs of applications in terms of its responsiveness [6,7,8]. Today, the DNS system is a commodity infrastructure that allows applications and content providers to map individual users to servers. This behaviour diverges from the original purpose of deploying DNS [10]. As application and content delivery infrastructures control how DNS is used to map end-users to their servers, the transport network, namely ISPs, has very limited control as to how traffic flows across the Internet [31]. Note that the case of DNS is a specific instance of a more general class of **mapping systems** for networked applications, such as trackers used in P2P or Locator/ID split
approaches, e.g., LISP. Whatever the actual mapping system being used, the use of DNS by application/content providers is a sign that network-aware application optimization approaches are needed. P4P as well as Application-layer Traffic Optimization (ALTO) are possible solutions for this. Direct CDN-ISP collaboration is another way of ensuring that the application side and the network collaborate to provide the best possible service to the end-users in a cost-efficient manner [32].

**Challenge 2: Software-defined networking**

Applications and content are not the only place where an Internet (r)evolution is taking place. Thanks to a maturing market that is now close to “carrier grade” [13,14,15,16,17], the deployment of open source based routers has significantly increased during the last few years. While these devices are not competing with commercial high-end switches and routers available with respect to reliability, availability and density, they are fit to address specialized tasks within enterprise and ISP networks. Even PC-based routers with open source routing software are evolving fast enough to foresee their use outside research and academic environments [18,19,20].

The success of open-source routing software is being paralleled with increasing virtualization, not only on the server side, but also inside network devices. Server virtualization is now followed by network virtualization, which is made possible thanks to software-defined networking, e.g., OpenFlow [21] that expose the data path logic to the outside world. The model of network devices controlled by proprietary software tied to specific hardware will slowly but surely be made obsolete. Innovation within the network infrastructure will then be possible. A decade ago, IP packets were strictly following the paths decided by routing protocols. Tomorrow, together with the paths chosen by traditional routing protocols, a wide range of possibilities will arise to customize not only the path followed by specific traffic, but also the processing that this traffic undergoes. Indeed, specific actions that are statically performed today by specialized middleboxes placed inside the network, e.g., NAT, encryption, DPI, will be implemented on-path if processing
capabilities happen to exist, otherwise the traffic will be dynamically redirected to close-by computational resources. This opens a wide range of applications that could be implemented almost anywhere inside the network infrastructure.

**Fusing the transport network and applications/content**

As content is moving closer to the end-user for improved quality of experience and the infrastructure opens up to unprecedented control and flexibility, the old business model of hierarchical providers and customer-provider relationships is hardly viable. Nowadays, delivering applications and content to end-users is becoming a less and less profitable business, except for the few able to capitalize on the revenues from advertising, e.g., Google, Facebook. On the other side, network infrastructure providers struggle to provide the necessary network bandwidth and low latency for these applications, at reasonable costs. The consequence of more and more limited ISP profit margins is a struggle between content providers and the network infrastructure to gain control of the traffic.

This struggle stems from fundamental differences in the business model of applications/content providers and ISPs. Today, application/content providers, for example through DNS tweaking, decide about the flow of the traffic by properly selecting the server from which a given user fetches some content [8,22,23]. This makes application/content delivery extremely dynamic and adaptive. On the ISP side, most of the traffic engineering relies on changing the routing configuration [24,25,26]. Tweaking existing routing protocols is not only dangerous, due to the danger of mis-configurations [27], routing instabilities [28] and convergence problems [29,30], but is simply not adequate to choose paths at the granularity of applications and content.

Industry and academia must join forces to address the challenges posed by the evolving Internet. We believe that the three research areas above need critical input from the community in order to enable a truly **content-centric Internet**. First, even after more than
two decades of deployment and evolution, the DNS is still poorly understood. The DNS is much more than a naming system, it is a critical mapping system and a critical point in the application/content distribution arena. Second, **software-defined networking** opens a wide range of possibilities that would transform the current dumb pipes of the Internet core into a flexible and versatile infrastructure. Further, software-defined networking researchers has the ability to allow injecting intelligence inside the network without having to think about how it will affect a whole range of legacy protocols.

One way to go is to enable the different stakeholders to work together, e.g., enable ISPs to collaborate with application/content providers [31,32]. This can be achieved for example by exploiting the diversity in content location to ensure that ISP’s network engineering is not made obsolete by content provider decisions [31,32] or the other way around. Another option in which we believe is to leverage the flexibility in network virtualization and making their infrastructure much more adaptive than today’s static provisioning [33].

**New Internet business models and privacy**

The networks research community has been witnessing an explosive growth in the adoption of wireless devices such as smartphones and tablets. This new fertile market has been fueled by applications and games brought through multiple markets of third party developers. These markets today rely on “App Stores” provided and controlled by device or operating system manufacturers such as Apple or Google, now recently joined by Facebook. At the heart of this trade lies a particular revenue model: provide attractive content and applications, and in return benefit from a trusted ecosystem built from a large number of users. Majority of these ecosystems revolve around targetted advertising and use of personal information. Several recent proposals have been made by the networks and social computing research community, on enabling market places for personal information [34,35].
It has been suggested that personal data is the new currency on the Internet. This highlights the urgent need for understanding privacy issues, which requires engagement with policy makers and investing in new methods to create federated marketplaces for resources and data.

**Engaging all stakeholders**

The deep changes we discussed create unprecedented opportunities for industry and researchers to develop new solutions that will address not only relevant operational challenges, but also potentially business-critical ones. The ossification of the Internet protocols does not mean that the Internet is not evolving. The Internet has changed enormously over the last decade, and will continue to do so, no matter what. What we observe today is a convergence of applications/content and network infrastructure that questions a model of the Internet that used to separate two stakeholders: application/content infrastructures on the one side and a dumb transport network on the other.

The fundamental changes in the Internet lead to fundamental questions about the possible directions in which the Internet might be going, not only at a technical level, but also from a business perspective. These are Societal questions, that ask for answers for the sake of Internet governance and to ensure that the infrastructure is serving the purposes of the Society as a whole, not of a few business players. Emphasis must also be placed on engagement with users as the focal point of the ecosystem, not only business stakeholders.

**Active Engagement with the European Community and Beyond**

Traditionally, EU projects in the networking area have not been strongly urged to engage with the public, but focus their attention on the impact for European Industry. Given the Societal relevance of the Internet in supporting the Digital Economy, we encourage that future projects have wider and more specific public engagement
and community reach plans, engaging user communities, industrial bodies, the research community, policy makers and the Internet governing bodies. This approach will encourage working beyond the usual outputs in the form of periodic reports and standard workshops that do not reach the relevant audience. Re-focusing the dissemination and impact criteria during project evaluation would incentivize projects to target long-term growth and innovation in Europe. We feel that today impact and dissemination play mostly a role at satisfying short-term industrial or business use-cases, which are heavily biased by industrial partners during review process of project proposals for impact.

Lastly, we encourage the inclusion of research and development organisations in China, India, Brazil and similar developing countries which are shaping the future of the network usage trends. Indeed, we now live in a globalized world, meaning that EU project should compete with their US and Chinese counterparts, both in terms of agenda but also in terms of their reach and impact.
Recently, the networking scene has been shaken by a new paradigm coming from USA named Software Defined Networking (SDN) and its corresponding protocol OpenFlow.

OpenFlow was recently said to be the networking buzzword of the year. As curious as it gets, the SDN concept is both criticized by some and used as snake oil by others.

European projects don’t escape to this trend. There are already some directly OpenFlow-oriented projects running, and some others around this technology or the SDN concept are expected to see the light soon.

It’s important to discover if the SDN paradigm is something that can become by itself a target topic/research field for the European Research and Development agenda. Let’s present some facts/issues.

Most of the conclusions shown in the following paragraphs are personal opinions which have been gathered in our work with the protocol and in our experimental deployment https://tnc2012.terena.org/core/presentation/42. SDN constitutes since 2010 the core part of our research group’s midterm strategy. Other sources of information have been the following: FP7 projects which deal with OpenFlow, the Ofelia-Change Summer School and the Open Networking Summit in Santa Clara to which I assisted, and informal information exchanges and chats with other researchers.

A) FACTS

A.1) A change of paradigm

SDN represents a change in the way networks can operate. From a decentralized Internet, where relatively low capacity nodes take decisions in a cooperative way, where best effort is still the rule in many cases, we are said to move to a centralized control and operation system where nodes are no more than high-speed forwarding devices and all the features needed to run by the network can be installed and programmed. In many cases, nowadays connecting a box to the Internet means supporting (which implies studying, implementing, trying and supporting customers) many protocols that are seldom all used. The promise is to purchase only the needed features, or code them by yourself.

It’s important to note that many classical manufacturers have discovered that at some extent SDN was also available in their portfolio. This means that the SDN concept is adapted in different ways to existing technologies, which makes more difficult to see the real novelty of the concept.

Indeed, some kind of programmability of network elements is already available in major manufacturers’ equipment. The SDN concept’s promise is a non-proprietary protocol for
configuring network elements backed by major manufacturers, and a corresponding ecosystem for application development.

A.2) A change of ecosystem

SDN represents also a change in the ecosystem. Boxes only need to support a specific set of commands and be able to forward quickly frames between ports. Indeed, there is much place for customization in the OpenFlow protocol, so differences between implementations should be expected not only in the performance and price field but in additional functionalities as well. This also means stepping out proprietary Software Development Kits (SDK), Application Programming Interfaces (API) and walled gardens, which in the past required licenses or specific pieces of hardware to be purchased. In the actual ecosystem, a Network Operating System offers a high level API to the northbound interface where applications are expected to run. In the southbound interface OpenFlow is proposed as the protocol to be used. This means that we move from a single vendor case to a ecosystem where we can find hardware that is configurable by means of a standardized protocol, a Network Operating Systems (NOS) and Applications (more on that later). Actually, as in computer systems, a special bond appears between NOS and applications.

A.3) Standardization

The only standard that is actually available for SDN is OpenFlow. The standardization is the task of the Open Networking Foundation (ONF, http://opennetworking.org): a nonprofit organization that gathers most, if not all, the mayor industrial players in the networking area. This includes companies that, among others, offer services, Internet connectivity, chip manufacturers, system integration... The public objective of the ONF is to quickly standardize the protocol, including in it as less as possible to keep compatibility. Although the protocol itself is freely available and open, the whole process of producing it is closed and only available
to partners of the consortium. The yearly fee is (at the time of writing) $30,000. Universities are not admitted as members, only individuals appointed by members are allowed to participate on a per case basis and at individual level. This raises the issue of how to define the adequate target and scope of the work to be done. There have been some efforts in the IETF, IRTF and ITU to foster interest in this area, but although ONF publicly states that there are initial contacts with them, no real activity is noticeable.

An effect of this quick standardization process is that most manufacturers stopped producing hardware after the 1.0 version of the protocol. The last version of the protocol, 1.3, is expected to be implemented by manufacturers unless they wait to version 2.0. Exact information on this is difficult to obtain.

Until now, we have been used to propose changes or amendments to protocols and submit the results to the corresponding bodies. If industrial interest was fair and the proposal was sound, there were some possibilities to get them accepted in the mainstream definition, so, the effort done was available for evaluation, or at least for assessment.

There are other parts of the ecosystem that are susceptible for standardization, for example the Northbound interface.

**A.4) Scope of utilization**

Some of the early opposition to the SDN concept, and more specifically to the OpenFlow protocol is related to its original scope: Supporting Future Internet Research. However, nowadays it is widely accepted that the scope has broadened. On the one hand, the protocol has been expanded to support IPv6; WAN applications like MPLS or PBB and interesting features to implement new applications have been added. On the other hand, some companies (like Google or Verizon) have publicized their use in areas such as data centers, backend communications and mobile applications.

There is a clear difference in the scenarios. Some think in OpenFlow as a low level control-plane interface for Ethernet-based (even remotely related) flows that coexists with other protocols with an area of application that lies down in the provisioning, partitioning and virtualization of the network substrate. Others think in OpenFlow as a control plane that is usable from the service level.

**A.5) Missing features**

There are still some missing features in OpenFlow. It’s expected that most of them are being tackled at ONF, but this is something difficult to assess. There are limitations or issues that are already being investigated by research groups with public funding. Other features are still clearly identified as open issues and have not, at least publicly, been studied.

**B) Issues in SDN research**

Next, some open issues when dealing with SDN research in Europe are highlighted.
B.1) Scope of SDN research

If publicly funded research is expected to be done in the SDN field, it should fit in the following areas:

Basic SDN research

If the objective of the research is to improve OpenFlow, it’s difficult to write proposals, to evaluate the proposals and review the results. If the proposal comes from partners that participate in the ONF, it would be clearly aligned with the ONF strategy. Sadly, it will be difficult to assess its adequacy in the evaluation unless the evaluator is also a member of the ONF, due to the closed nature of work in the organization.

Moreover, in the case that the project is funded, if the results are not accepted by the ONF it’s not easy to assess the effort that partners have made in ONF.

If the basic research objective is to investigate in alternatives to OpenFlow or another definition of the SDN concept, it should carefully (which implies a scientific approach) demonstrate limitations of actual protocol and approach and be backed by very heavy industrial partners in order to assure some kind of impact. It’s expected that these efforts should probably be undertaken with the support of alternative standardization bodies, or at least be clearly aligned with them. Nevertheless, the success of such an effort is difficult to assess.

Another kind of projects could be related to the design or production of other pieces of equipment or software which can be reused at the lowest level of the SDN stack, complementing the actual offer or adapting available technologies to this new paradigm. This could include ad-hoc solutions, that for example try to generalize the concept of OpenFlow to other low level technologies.

Setting up the SDN ecosystem

As explained before, the full SDN scenario is still in its infancy. If we consider OpenFlow as a technology that will be available, it’s still possible to develop the next layer of the SDN ecosystem. It’s possible to perform research in the area of Network Operating Systems, giving them features currently unavailable but needed in some areas of application or defining new APIs. It’s even reasonable to think in low level applications that could extend functionality of the SDN like AAA or multidomain capabilities. Another kind of research around tools to ease, verify, evaluate and assess the quality of the application development could be also proposed.

Developing applications over SDN

This third area of work is built over the previous layer: The expanded NOS and application development tools. It can be understood as solving or optimizing the solution of old problems in a novel way with benefits that can range from performance increase to energy efficiency, just to name a few. It’s also very advisable that a new breed of applications in every field of activity will become now technically or economically possible.
In this case, it’s important to assess that under the “SDN-based” label there is a solution which is shown to be really sound which gets a real benefit from adopting this technology, and it is not only a buzzword use.

A clear case of a not suitable approach is a very disparate consortium, with no SDN experience that proposes not only how to solve a problem with a “SDN” solution, but also as a side effect to propose a whole new architecture for SDN.

B.2) Scope of Standardization

As explained before, the standardization in the SDN area is difficult to address. It’s therefore important to define which the expected outcomes of the standardization efforts are. ONF managed aspects of standardization should be identified, and a strategy to get an assessed feedback on the convergence of proposed research and those aspects should be devised.

There are other areas in which standardization efforts can appear in SDN related projects that are knowledge area specific and should not evaluated under the SDN area.

It’s important to note that limitations of the actual OpenFlow protocol stated during a proposal should be taken as “features” that are missing in this protocol, and not limitations of the proposal. For example, in early versions of OpenFlow and corresponding implementations QoS support is missing. This should not hinder a proposal unless QoS support is key for the success of the project. Important and easy-to-detect limitations are most likely being addressed by ONF.

B.3) Converge or not converge (on ONF)

This is an interesting question that arises when speaking about SDN with developers and researchers. Probably the right answer is to converge in the unavoidable item: the OpenFlow protocol which defines the Lingua Franca to be spoken by hardware (which is likely to be somewhat stable and in need of a clear interoperability). Open Source components to create a complete ecosystem are very likely to appear and the final preponderancy is clearly unknown at this time. Anyway, the community is known to have embraced an Open Source Computer Operating System, so perhaps an Open Source Network Operating System is no badly placed to succeed.

B.4) New Business opportunities

SDN is a promising area for new business opportunities. Applications for specific services can be created by small sized companies, which don’t require big investments in equipment. As a matter of fact, there are small European companies designing control planes for commercial clients. Another area is related to the manufacture or adaptation of switches to this protocol.

B.5) Organizing Research on SDN at the European Level

At this time, and as far as it can be seen from the outside, the research efforts on Europe are not totally independent when it refers to OpenFlow, as there is a community of OpenFlow
related projects and researchers. There is an OpenFlow FIRE, Ofelia, which is well known to all of them, and some NRENs and Geant are planning to investigate and propose OpenFlow deployments. But it’s foreseeable that proposals around a broad SDN concept will soon see the day. Because of this, it’s advisable to gather efforts being done around the SDN field of knowledge and try to articulate it, creating a Think Tank that could propose missing parts, establish a repository of European produced Open Source, create a base of early adopters/users that could validate new ideas or code and create SDN Awareness in companies and user communities.

The need of developing a curriculum about SDN at the Master level in cooperation with involved academic institutions quickly appears, and will be undoubtedly taken into account.
exCERN by Olivier Martin
Consultation on Future Network Technologies Research and Innovation in HORIZON 2020

Better late than never, here are a few random comments about the evolution of the Internet coming from an “old” Internet guy who followed the development of this technology more or less since its beginning back in the early 1980s as explained in a recent article titled “The hidden prehistory of European Research Networking”

This article is mostly historical, I however, I also authored a series of Internet related articles that are available from my personal Web site: www.ictconsulting.ch

"Internet evolution scenarios" O. Martin, March 2010 [doc], [pdf], published in the NEC’2009 conference proceedings

"Where is the Internet heading to?" O. Martin, May 2009 [pdf] an abridged version of the article submitted to the CHEP’2009 conference proceedings has been published by IOPSCIENCE in the Journal of Physics: Conference Series

"Where is the Internet heading to?" O. Martin, May 2009 [doc], [pdf] submitted to the CHEP'2009 conference proceedings

"State of the Internet & Challenges ahead" O. Martin, March 17, 2008 [doc], published in the NEC'2007 conference proceedings

"The ongoing evolution from packet based networks to hybrid networks in research & education networks" O. Martin, February 8, 2006 [doc], published in the NEC2005 conference proceedings

Now, back to the Horizon 2020 consultation, I do not believe that anybody can predict how “the” Internet will evolve, in particular the mobile Internet. I deliberately dodge the Internet of Things (IoT) aspects as I do not think it will be an integral part of the Internet, if only for security reasons, however it may use partly or fully Internet related technology. I rather see the IoT as a set of “islands” accessible through secure gateways. There are obviously immense business opportunities there for services and products.

Back to the real Internet, there are still far too many dogmas and it is rather sad to see how innovators can become conservative to the point of steadily losing influence!

This comment is mainly directed to the IETF, whose work I do not follow as closely as before and I may therefore be completely wrong, but also applies to many standards making organisations, e.g. ITU, ISO, OGF, W3C.
IEEE is in my view the only one exception that continues to produce industrial standards at a reasonable pace.

Given the inability of the IETF, during the last 10 years or so, to produce standards that are actually used, an undue number of new Standards, Forums. Foundation (e.g. Open Networking Foundation/ Openflow), Consortium, etc. have emerged following the old CCITT model\(^1\) rather than the open and free participation IETF model that has been at the basis of the phenomenal success of the Internet in the 1980-2000 period.

The new rule seems to be slow-down and complicate the standardization process rather than to accelerating it. The despairing failure of IPv6 is one compelling example but there are many others like implementation of Quality of Service (QoS) and lack of commonly agreed inter-provider mechanisms for automatic charging, provisioning, MPLS, etc. Being too dogmatic and sticking too much to the basic Internet principles like, end-to-end, transparency and end-to-end security, the IETF that is supposed to provide the basic standards failed to adapt to the new situation created by the OTT\(^2\) providers. Other examples of IETF failures are inter-domain Multicast, multiplicity of TCP variants that are for most of them available under LINUX and have quite different behaviors, reluctance to standardize NATs because of the violation of the “sacred” end-to-end and transparency principles. Indeed, it is rather sad to see that NAT44 is fairly recent whereas commercial NAT implementations date back to the 20\(^{th}\) century, mostly for residential ADSL, and I suppose cable TV too, customers. The graceful IPv4-IPv6 dual-stack based transition will not happen, however, the emerging IPv6 world will be connected to the IPv4 world, if only by NAT64.

Excerpts from “State of the Internet & Challenges ahead”:

“4.3 The fading influence of the academic community over the evolution of the Internet

The Internet was mostly specified and developed by the academic community and it has long been an undisputed fact that the development of the Internet protocols was led by the academic and research community; however, with the commercialization of the Internet there has been growing divergences between the commercial and the R&E Internet and it is clear that the influence of the academic community has been fading out.

This may be due to the fact that there are many conflicting commercial interests at stake. Under these conditions, it is quite remarkable that the consensus building model exemplified by the working style of the IETF has been resisting fairly well to pressures of all kind, although it is no longer working as smoothly as in the past. Another reason is that there are many other forums, e.g. World Wide Web Consortium (W3C), Open Grid Forum (OGF), Optical Internetworking Forum (OIF), ITU-T (International Telegraphic Union), MPEG (Moving Pictures Experts Group), etc.

This process is happening despite, or because of, the “heroic” efforts of a few IETF and IAB “purists” to control, together with the academic community, the Internet standards process according to the original Internet design principles, e.g. the “end-to-end” principle & address transparency, native Multicast, IPSEC, DNSSEC, etc.

Even though these principles are architecturally clean and sound, they are extremely difficult to deploy and they no longer match the needs of the commercial internet, furthermore their too narrow interpretation could lead to sub-optimum communications:

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\(^1\) Expensive participation fees

\(^2\) Over The Top
First of all, “end-to-end” means different things to different people. For some purists, it means that the actual data transfer must take place between the intended hosts. Therefore, an intervening transparent Web cache, for example, as well as NATs and/or Firewalls are breaking this “intangible” Internet dogma, whereas all the redirection and caching mechanisms implemented across the Internet have been proven to be invaluable.

However, “end-to-end” also means that the network must be kept as dumb or transparent as possible in order to keep the intelligence at the edges which, in turn, will facilitate the transition to next generation Internet protocols. A good example of this is TCP, which suffers from some well-known deficiencies in some operational environments such as long-distance very high-speed networks, where most proposed changes only affect the sender side thus making transition incremental and therefore extremely easy.

Nonetheless, despite all the supposed advantages of a completely “dumb” network, Internet routers, if not at the core at least at the edges, have to deal with the issue of “fairness” between flows, both UDP and TCP, as well as maximum resilience against Denial of Service (DoS) attacks, port scans, etc., which can only be implemented by fairly smart and sophisticated routers.

Although this fact does not break the “end-to-end” principle, per se, it shows the limit of academic concepts versus operational reality. Indeed, today’s high-end routers are just as complex as many super-computers.

Admittedly, the end-to-end principle is also used to differentiate the Internet, as a whole, which is completely “decentralized”, some would even say “disorganized”, from the classical Telephony network which is highly centralized and hierarchical, with most of the controlling and signaling functions performed in a separate network.

For a full discussion of Internet Transparency, please refer to RFC2775, however, it is essential to keep in mind that, back in 2000, when this most interesting RFC was written, there were still some hopes that NATs, which were almost unanimously considered as architecturally “horrible” would not proliferate. Early 2008, it has become evident that NATs will continue to proliferate and that one MUST take advantage of them to facilitate the transition to IPv6."

There seems to be two separate Internet worlds:

- the “invisible”, i.e. the almost “service-less”, Internet provided by the Internet Operators, the major ones being the former PTT incumbents like British Telecom, Deutsche Telekom, France telecom, Telefonica, Telecom Italia, to name a few. This part of the Internet is using the basic IETF standards. It also encompasses, the “campus” and the “enterprise” Internets
- The OTT, i.e. the world of Internet services, like Google, Akamai, more generally CDNs, Skype, Facebook, Twitter, NetFlix, P2P³ (the prominent example there is BitTorrent), IPTV, etc.

For most Internet users, the “true” Internet is the OTT world which is mostly proprietary contrary to the Internet infrastructure that is using common standards, in particular IPv4 at the network layer, TCP at the transport layer, DNS⁵ for naming, and BGP⁶, the only successful inter-domain IETF protocol without which the Internet would not have been possible because of routing loops, etc.

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³ Content Distribution Networks
⁴ Peer to Peer
⁵ Domain Name Service
⁶ Border Gateway Protocol
The problem with today’s “degeneracy” of the Internet is that the profits of the former Telcos\(^7\) are plummeting at the time where huge investments are necessary in order to cope with the spectacular growth of the, smartphones based, mobile Internet, but also with the capacity increase of the wired Internet with ever-increasing access speeds and the corresponding requirement to introduce 40Gb/s then 100Gb/s technology in their core backbones.

Big words like smart-*, self-*, holistic, IoT, VANs\(^8\), PANs\(^9\), MANETs\(^10\), etc., are often used to describe the future Internet, under the assumption, actually rather an almost religious “dogma” that there must be one and only one Internet is essentially not challenged by anybody. Therefore, being a provocateur I ask the question why?

After all, the Internet is fragmented by regions, languages, regulations, etc. Keeping a single “homogeneous” Internet, technology wise, i.e. IP, looks like the “Esperanto” dream that is nonetheless following a slow but steady course as it became the 64th Google foreign language! Interconnection between networks is clearly easier at layer 3 than at layer 4 but it is easier to gateway between different networks at layer 4 (transport).

The general feeling inside the Internet community is that it is absolutely essential to keep a single worldwide Internet and I actually do not disagree with that as long as it does not delay progress and innovation. In that sense, I liked very much one of the 4WARD tenets “Let 1000 networks bloom”.

As things are going, the lack of IPv4 addresses obtainable from the Regional Internet Registries (RIR) will be happening very soon and there are signs that an IPv4 trading market is developing, current price levels are 10 USD per IP address for /9\(^11\) and bigger address blocks and the price is sure to rise. At the same time some Internet Operators are deploying, so called, “Carrier-grade” NATs, thus further delaying the need for IPv6.

Where will we be in 2020?

I strongly advise to read Geoff Houston presentation made during the last RIPE meeting in Ljubljana (Slovenia) titled: “Internet Futures: a personal glimpse into a future of the Internet” where the following statement is made on slides 14-15 “Hopefully we have figured out this IPv6 transition by 2017! But we are now at High Risk”

Side remark, I was invited to attend the last RIPE meeting where I had the pleasure to meet a number of "old" Internet guys like Geoff Houston (APNIC) and Ruediger Volk (DT) and both of them almost laughed at me when I asked whether IETF’s PCE\(^12\) related RFCs were in use in operational Internet networks. Apparently, they all use proprietary solutions! If I understood him correctly, Geoff Houston, went as far as saying that the main purpose of today’s IETF work was to delay the adoption of new standards and that most of the work was actually dilatory as the participants had conflicting “hidden” agendas!
I had actually noticed that the IETF had not been very efficient in the past 15 years, for me the last major architectural change was the introduction of MPLS and IPv6 is a complete shambles.

Nonetheless, the IETF standards work continue to be impressive and covers a wide range of subject, the problem is apparently that many new IETF standards do not find their ways into commercial products! So, we seem to be moving back to a more and proprietary world how can we get out of this destructive trend? Commodity routers are clearly one way possible way forward especially at the edge of the networks but whereas they can be helpful in terms of reducing costs they do not solve the end-to-end issues.

Back to the Internet players, i.e. Telcos and OTT suppliers, question, the OTTs are making lot of money while the Telcos are crying misery, which is only partially true. However, they would like to get rid of some OTT providers, e.g. CDNs but also Clouds, by providing in-network compute and storage resources. The “eternal” problem there is whether the network must follow the KISS\textsuperscript{13} principle or should a control plane be retrofitted, along the old telephony model, enabling new applications and business models (e.g. bandwidth on-demand)?

Strangely enough, even the Telcos do not agree between themselves as increasing the complexity of the network implies increased OPEX costs and the advantages can easily outweigh the disadvantages.

The solution therefore is that Telco should try to compete directly with OTTs by becoming innovative through subsidiaries. There is no reason why Akamai and a few others should keep a kind of monopoly on CDN and there is ample room for innovation. I would even go further by stating that the potential degree of innovation is inversely proportional to the “dumbness” of the network.

Regarding Clouds there are big issues regarding their interoperability, the handling of data in conformity with national and international laws. The observation is that given the number of new entrants the risks of a cloud “bubble” are extremely high.

Opportunities for the European ICT industry are numerous especially given the irresistible trends towards a “Greener” ICT world, the almost borderless room for innovation in the OTT space, e.g. e-Health, Smart-*\textsuperscript{4}, Commodity routers, Large scale NATs\textsuperscript{14}, innovative network appliances facilitating interconnections with the emerging IPv6 world, mobile Internet that is still in its infancy with immature protocols and products, innovation in efficient content distribution (Information-Centric Networking, new peer-to-peer schemes).

I am unfortunately lacking time to elaborate further on many of the issues above but the central questions are: migration to IPv6, i.e. will it happen? OTT vs. dumb Internet, more evolved Internet core with management plane (that seems unavoidable, however, additional complexity should be kept to a minimum), other in-network facilities such as compute and storage may prove to be efficient but are unlikely to be sufficient to eliminate OTT providers which would be undesirable anyway as this is through then that most recent innovations came. I do not know exactly how Web 2.0 came about but strangely enough NOT through W3C, and through agreements between the few Internet browsers suppliers!

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\textsuperscript{13} Keep It Simple Stupid

\textsuperscript{14} NAT64 as well as NAT44
ETNO/ORANGE FRANCE TELECOM by Yvan Meriau
Information about the respondent

- I am answering as: Association of European telecom operators
- Country of location: Belgium (Headquarters)
- My/ my organisations’ main activity is Policy group for European electronic communications network operators
- The name of my organisation is: ETNO (European Telecommunications Network Operators’ Association)

Q1 Which sector are you representing? What are the strengths and size of your market in Europe and/or worldwide?

- ETNO represents 41 operators in 35 European countries beyond the boundaries of European Union.
- ETNO members’ total revenue from European operations amounted to a total of €225 billion. 48% of turnover originates from fixed line operations and 47% from mobile services (2009).
- ETNO member companies collectively employ up to one million people throughout Europe.
- Investments by ETNO member companies account for two-thirds of total investment in the European telecoms sector.
- ETNO members’ total investment in 2009 amounted to €27.2 billion, representing an average of 12% of turnover from European operations.
- ETNO members account for two thirds of NGA deployment across Europe. 43% of investment is devoted to mobile and 57% to fixed operations, including broadband networks. Mobile investments represent 11% of turnover while investment in fixed operations accounts for 14% of turnover.

Q2 How would you describe (in less than one page) your ideas and/or plans for future R&D challenges/topics relating to Network Technologies?

In the coming years, the ever-increasing demand from customers will impact the network, and new technologies will be introduced for transmission, switching, routing, naming/addressing, storage and execution. To ensure industrial impact, Horizon 2020, and particularly NetFutures, should address these new technologies but also the architectures for the networks to be operated with these new technologies in conjunction with the legacy ones.

More specifically, needs for advanced networking will increase drastically in coming few years with dramatic increases in the number of connected objects, higher data rate, demands for pervasive access to information from users, delinearised content, etc. This will make users’ behaviors strongly network-dependent.

The future networks will thus have to support very demanding future connectivity characteristics and to bind connectivity with smart mediation. Telcos will complement their role of network service provider with a new role: infrastructure service provider integrating network, storage and execution services. All these new infrastructure components will have to be studied together so as to guarantee an optimized architecture and engineering. Since all these features will evolve in different timescales, Horizon2020 - NetFutures - has to implement a flexible program responding to industrial and market needs.

- Network technologies, protocols:
  - Innovative solutions for coping with the mobile and fixed data explosion, addressing the dramatic multiplication of connected objects, innovation for supporting the escalating performance expectations, all within the context of external constraints such as regulation, sustainable development, evolution of usages,…, while leading to cost reductions (optical access, wireless access, heterogeneous access networks, …).
  - Developing new delivery paradigms behind current internet/IP model to better match future content-oriented networks, e.g. ICN (Information-Centric Networking) architectures and CDN (Content Delivery Networks).
  - Define new resource control protocols adapted to Software Defined Network...
Architecture and urbanism evolution/disruptions:
- Optimize the distribution of network functions across operator domains, and allow physical infrastructure components being structured according to logical networks to +cope with service, management, organizational, green, secure, etc., requirements.
- Define network mediation functions and more generally networking intelligence to increase value when closely related to the infrastructure.
- Enable transition from network connectivity to a pervasive execution infrastructure encompassing network, storage and execution functions able to execute in optimized way future application services
- Facilitate the convergence of fixed and mobile networks themselves, combining both an optimal and seamless quality of experience for the end user together with a cost- and energy-optimized network infrastructure.

Network control and management and network services
- Simplify as much as possible design, operations, administration and maintenance of networks (e.g. SON mechanisms)
- Enhance flexibility of network control versus network topology using virtualization based SDN (Software-Defined Networking) with OpenFlow-like mechanism to impact positively network architecture and open the way to high scale, cost and resources effective applications as needed eg for cloud computing or IoT
- Build Network Service enablers and associated framework (discovery, subscription …)
- Define very simple KPIs for measuring QoS (and even QoE) from a customer point of view.

Network and ecosystem framework:
- Invent new business models which exploit the value of the infrastructure to the benefit of the application sectors, taking into account cooperation, competition and regulation constraints and the technical impact of network openness and associated interface definitions.
- End-to-end system modeling (architecture, energy-efficiency, electromagnetic exposure, traffic, QoS, Security,…).

Q3 How do you see the potential role of your organisation in HORIZON2020 in connection to the network technologies design, experimentation and/or deployment? What are your research priorities?
ETNO members have always been heavily involved in the Commission's Research and Development framework programs and particularly on the thematic of network, infrastructure and services of DG INFSO. We will continue to do so if the pillar "Leadership in Enabling and industrial technologies" will address the topics which we take hold and will establish instruments fostering the involvement of industrial players.
Our research priorities about the network thematic are those expressed in our response to question 2 above

Q4 Which network technologies requirements and expectations, do you consider important to inspire innovation and bring most benefits to your (business) development in the future?
In a context of digital revolution, the development of internet is core to the economic and technological growth in many application sectors. These ever increasing requirements of connectivity and data transfer will deeply impact the evolution of communications networks and services infrastructure. This will challenge both the traditional business models and uses. Moreover, in this context of increasing complexity, it is essential to ensure safety (resistance to attack and ensuring the confidentiality of exchanged data), dependability (robustness, resilience) and optimal quality of service in multiple and heterogeneous networks that contribute to the services proposed to the user.

It thus seems desirable to us that the Horizon 2020 program allows, facilitates and encourages the establishment of Industrial "big challenges" transverse to the various fields of ICT (Information and communication technologies) proposed in the Leadership in Enabling and Industrial Technologies (LEIT) of Horizon2020. (1.1.1 A new generation of components and systems, 1.1.2 Next generation
computing, Future Internet 1.1.3, 1.1.4 Content and information management technologies, interfaces and robots Advanced 1.1.5, 1.1.6 Micro-and nanoelectronics and Photonics)

We are then encouraging the development of the following transverse major industrial challenges:

- **Sustainable Broadband internet**
  - **green ICT**: reducing environmental impact and energy consumption generated during the phases of design, production and use of components, networks, services and products
  - **Broadband connectivity**: increasing bandwidth (optical and radio)
  - **Resilient and autonomic networks**: New network architectures and elements, networks management and control mechanisms
  - **Interoperable and flexible virtualised infrastructures**: comprising computational and storage resources (cloud), together with network components and services, offering a consistent interface and able to adapt to user requirements
  - **New economic model**: with specific emphasis on collaborative and open models, such as federations and marketplaces.
  - **Smart Network**: develop through a functional enrichment (storage, performance, service enablers...) the value and attractiveness of European networks towards service providers / content providers. To stem the value drain towards the larger OTT players and / or consumer electronics actors is particularly at stake.

- **Trustworthy and Safe digital world**
  - **Security components**: components dedicated to security, advanced low-cost autonomous sensors
  - **Components security**: design and evaluation of security components, security properties of computing components, security protocol stacks (RFID...)
  - **Software security**: security of software foundation (secured OS, virtualization and partitioning, security middleware), formal proof of security properties, secured management of scalability
  - **Security of ICT systems**: robustness, resilience, security of hardware / software / hybrid architectures for embedded systems, management of complex systems, end to end security, emergence of hybrid / complex systems, cloud computing
  - **Identity management**: management of digital identity, authentication, authorization , and accountability

- **Big-Data : Data valuation and intelligence**
  - **Networks of communicating objects**
  - **Big database**: storage, heterogeneous and unstructured data management, data mining, computational power
  - **Data crossing**
  - **Private life property rights and individual rights respect**: data access, anonymisation, privacy and data traceability.

Q5 Which cross sector synergies in relation to the network technologies research are of strategic importance to generate growth in your business sector?

In the digital revolution context, the core and diffusing ICTs character (especially obvious when quoting the Internet) needs no further proof. The organisation of H2020 itself reflects this core and diffusing character of ICT since roughly €8 billion is allocated to ICT along "LEIT" and the ICT component of "Societal challenges" is estimated at €4 billion.

Consistent with their commitment to the Future Internet PPP, ETNO companies wish to support the digital transformation of society. Our focus areas are health, smart-cities (transport, utilities, mobility), education and culture (digital books, online press, audiovisual content), retail and trade (logistics and online sales).

Q6 How do you think that the network research community should best engage with the user community?

The user has to understand the major role played by the network in providing services in order for him to understand why network access is not free (!). For better and large adoption by user, the network
must become invisible in daily use and services must be simpler and more user-friendly. The research community working on the thematic of networks must ensure that the fluidity of service from one access to the other is well implemented.

We can also conceive that the establishment of test platforms for services and development of applications over new network technologies will allow application developers to anticipate the potential improvements brought (speed, latency, features ...) and take a light but distinctive competitive lead.

**Q7 Which constituencies and methodologies in relation to network technologies research are most important to maximise the impact of research and innovation in HORIZON2020?**

As an association of industries, ETNO has for times observed that the scientific excellence is the dominant characteristic in the evaluation of projects implemented under the FP7 to the detriment of the projects with potentially greater impact and increased competitiveness. It appears that the projects prioritized for funding are the ones with strong scientific appeal and the consortium structure best fit to go through with the academic research. But these features do not guarantee that the resulting inventions would meet their market needs. Furthermore, this selection system can retain several competing projects on the same segment (e.g. four projects on the radio over fibre) without the necessary selecting research related to the deployment of the results achieved so far is (e.g. heterogeneous home network ...).

Last but not least, once an invention born in a research project, especially when it comes to network infrastructure, its adoption by the market requires not only a quasi-mandatory standardization step, but also an innovative integration into the existing infrastructures or within a global target architecture and finally a comprehensive test that performance is not degraded by a transition to an industrial scale. This innovation required in the implementation phase and the research needed on the scalability of results is not adequately recognised or appreciated in the proposal review phase.

Solutions to these flaws would be:
- A project portfolio type of management;
- Calls for projects where the impact criterion would dominate and favour the selection of "integration projects" of technologies and inventions from projects further upstream.

The ideal target would be to achieve an articulation of the essential steps in the chain of innovation through complementary instruments within Horizon2020

- Management using **project portfolios**
- **Explore and Invent**: "Excellence in Science" and upstream resourcing project into "Leadership in Energy and Industrial Technology Enabling"
- **Standardizing, integrating, scaling and testing**: programs and technology integration project in LEIT
- **Innovate**: experimentation platform and use projects in and around LEIT "Societal Challenges"
- **Disseminate ICT in society and upgrade**: scale pilots and trials in the case of LEIT "Public procurement" and "Societal challenges."

**Q8 How should research developments in network technologies in HORIZON2020 be measured against delivering EU industrial leadership worldwide, sustainable economic growth and high-quality jobs creation in Europe?**

For each step in the chain of innovation, it is desirable to have indicators relevant to the purpose and innovative implementation.

This could be:
- **Explore and Invent**:
  - scientific publications, patents, demonstrators
- **Standardize, integrate, scale and test**:
  - Output of project: contribution to standardization work,
  - Production of frameworks (frameworks) and open specifications,
  - Development of software components,
  - Demonstration of scalable implementable technologies
  - 2-5 years later: measurement of industrial impact through the use of results in products or marketed services.
- Innovate, disseminate ICT in society - upgrade:
  - number of implementations and commercial uses,
  - number of deployments and / or commercial developments from the pilot
NEM ETP Contribution by Jean-Dominique Meunier
1. Which sector are you representing? What are the strengths and size of your market in Europe and/or worldwide?

The NEM platform is an industrial initiative (supported by the European Commission) representing the sector of Networked Media. Such sector has a strong interest to all technologies which re-enforce immediate and large bandwidth connections between audiovisual content producers, servers and consumers.

The NEM has identified a list of strengths characterizing its sector in Europe:

**Diversity of cultures their heritages and languages**
Europe is built of a variety of peoples with different cultures and cultural heritage. Europe inherits from the Greek and Latin civilisations, whilst it has been influenced over more than twenty centuries by many other civilisations, resulting in our cultural treasures of today. All European citizens share a significant common cultural framework that alleviates their communication, collaboration and living-together. We need only look to the longest lasting record of collaborative European research for proof of this statement.

**Large archives/collections of highest quality content**
Europe’s long cultural history and diversity is the source of Europe’s vast collection of works, notably the archived cultural media content. There is probably no other place in the world where the density of art and intellectual production has been higher. Our archives (print, sound, film, video and other media) form the precious base for Europe’s audio-visual business. Moreover, the availability of such stocks encourages the cultural community and the industry to maintain their cultural leadership by making these treasures available to all and by developing the preservation and distribution technologies to do so.

**Common societal mind-set**
Owing to their common history and educational traditions, European citizens have a common mind-set for societal conciseness and problem solving (despite all their individual cultural and linguistic diversities). We understand Europe as our common heritage and future; we realise the challenges of climate change and the need for green energy and production; we have agreed on a common European Commission and common policy in numerous domains.

**Collaboration has a long-standing tradition**
Collaborative research emerged in the Western part of Europe and has now spread, with strong momentum, to encompass the new EU countries. Cultural differences bring cross fertilisation in the approach to new topics, notably in the research domain. There are plenty of examples from space exploration, through the aircraft industry to the Large HADRON Collider (LHC) at CERN. Position Paper on Future Research Directions Opportunities for an Innovative Europe
High level of education (schools, universities, research centres, training of skilled personnel)

Education is a very strong point of Europe, well recognised at the international level. The dense network of universities and technical schools, which, for a long time, have been developing contacts and co-operation, is a strong asset from which all citizens take advantage, through the training of skilled personnel and through the availability of relevant and well-structured expertise that can then be applied to our industrial production. More than any other resource, education is the pillar of Europe’s prosperity and wealth.

Awareness of environmental issues and societal challenges

There are big (societal) challenges facing the global community. In practically all cases, modern ICT can significantly contribute to counter these challenges: from humanitarian interventions in cases of natural disaster and the problem of fighting poverty to the alleviation of the effects stemming from global warming or to helping the elderly or people with disabilities to live more safely and have assistance in their familiar environment. Europe has already proven its ICT capabilities in these new domains, and beyond in the classic network technologies such as GSM or DVB, both of which were developed in Europe. The tsunami alert system installed in the Indian Ocean is also a prime example. In combination with other technologies such as sensing water waves, ICT resulting from collaborative R&D work in Europe has created a decisive solution that could save many lives in the future. Europe is cognisant of the potential of ICT for industrial export and is already placed at the forefront of applying ICT to new societal challenges. Further research should help to maintain and foster this position in initiatives concerning the application of ICT to energy savings, the ageing population, Internet for all (e-Inclusion), security, health issues, changing cities, integration of users (user centric approach), etc.

Pursuit of sustainable approaches

Europe’s most important task is to take advantage of all the assets listed above in a form that these assets can be exploited effectively for the benefit of the European community. It is a positive consequence of Europe’s current political construction that relevant structures for initiating research programmes have been installed that, in turn, provide the basis for the implementation of a common and efficient approach to research and technical development. In fact, this model has been followed by others world-wide. The coordinated European approach is now a rule for all topics that should best be addressed at European level, to the benefit of all citizens in our Information and Knowledge Society.

Europe provides the legal framework for efficient exploitation of these assets

By establishing collaborative R&D programmes, the European Commission has created the legal framework for developing technologies which allow the exploitation of our cultural and industrial assets across national borders. European researchers have thus a long-standing tradition in collaborative projects – this by itself is a great asset in the global competition for technological and societal leadership.

Intensified international cooperation to increase significance of European technologies and standards in the world

Although there are examples to the contrary, Europe is potentially weak in getting its solutions and technologies accepted and exploited at a global level. In recent years, there has been some success, however, the way in which Europe’s technologies penetrate the global market may need to be broadened from a small path to a wide avenue. Europe’s influence in global businesses may need the development of bilateral cooperation with many countries that, in actual fact, are demanding Europe’s technology, notably Europe’s ICT technology.
This is a very long process that has already started, but there is still a long way to go. One solution could be to follow this motto:

*Put Europe at the forefront of sustainable and green ICT solutions*

2. How would you describe (in less than one page) your ideas and/or plans for future R&D challenges/topics relating to Network Technologies?
   
   **N.B. This could encompass any topic from basic research to innovation and experimentation.**

A connected society
In the not-so-distant future, everybody and everything will be permanently connected to a network. For example, connected ‘things’ as well as ‘people’ will be able to provide information that will help to create or enrich content: intelligent objects, while connected people will be able to express and share their experience, attitude. **Network bandwidth and quality** will increase significantly with fibre networks reaching closer to the end-user’s point of access. Increasing bandwidth capacities of LTE/4G mobile networks will enable users to access high definition and even 3D/holographic content on the move. In addition, increasing uplink bandwidth will allow for new types of services such as online content storage, 3D videoconferencing, and tele-immersion.

We can summarise this future network paradigm as:

*Anything, anytime, anywhere on any device.*

User interfaces and immersive experiences
In the near future, we will see a proliferation of 3D, immersive and beyond-HD experiences, with interfaces becoming even more intuitive, including speech, tactile and multisensory interactions. The 3D and immersive experiences of this future are rich with intuitive interactions and will create new business services such as tele-immersion and tele-medicine, as well as for more traditional entertainment applications. Adding geo-location will enable Augmented Reality applications to become more broadly accepted and used, for example in tourism and cultural sectors. Intuitive interaction and ease of use is paramount in this future.

We can summarise this User Interfaces and Immersion paradigm through:

*Experiencing content is king – rich, connected, immersive, intuitive experiences are the future.*

User and usage data
The success of this Internet of services will reside in our European ability to design and deploy a **converged service** means that will give access to all types of information found or to be found on the Internet: health, transportation, pictures, music, movies, power, sensors, social, etc. The Internet of Services is user-centric. To reach this objective, the Future Internet infrastructure components must be secured against intrusion, hacks and misuse. The privacy of each actor must be guaranteed and controlled especially in order to allow network authorities mandated by law, to trace illegal behaviours of connected individuals or service providers.

Content will be transformed into smart content by adding metadata during the content creation process or during exchange. However as users will move from one device to another, and also from their home to outside, it is mandatory that their respective smart user profile is transparently accessible from everywhere, for an easy and intelligent usage. Set-top boxes at home) will play a key role for enabling **virtualisation implementation** because they will offer the link to services and data accessible on the Cloud.
3. How do you see the potential role of your organisation in HORIZON2020 in connection to the network technologies design, experimentation and/or deployment? What are your research priorities?

NEM is moving towards a **Technology and Innovation Platform**, creating an innovation partnership geared around the grand societal challenges. This includes use of NEM technologies and research outputs, as well as design driven and business model innovation, to fast-track solutions and to deliver innovative products and services. We would like to play a proactive role in making **Innovation Partnerships** happen and assist the EC in implementing its 2020 Strategy and in particular the Innovation Union and Digital Agenda. We propose the following key actions:

**Innovation Partnership: From NEM value-chain to NEM innovation-chain**

NEM members cover the whole value-chain from R&D, corporate R&D, Education and Academia, Academic research, SMEs, corporations, industry and equipment manufacturers, content and service providers. In the online world smaller entities can innovate without the need of large infrastructures and it is therefore even more important to support SMEs and create innovation policies that put SMEs into the driving seat of European growth. To complete our value-chain into a powerful Innovation Position Paper on Future Research Directions Opportunities for an Innovative Europe-chain, we are in the process of involving and partnering with innovation catalysts including:

**Education**: business schools, to complement our high quality academic members and together help design curricula to improve entrepreneurial skills

**Access to Finance**: Venture Academies and Business Angel communities, to bridge funding gaps and bring together SMEs and other NEM innovative companies with VCs/BA. A much wider exploitation of some of the currently available European funds should be pursued; among others: risk-sharing financial capacity, structural funds, and cohesion funds.

**Broader Innovation**: Innovation forums, Executive Coaching Professionals and Associations, to help corporations and their executives think through and deliver business model innovation. The concepts of “Open Innovation” and “Viral Innovation”, where research, technology development and implementation of technology results (overall new innovation concepts within the Innovation Europe policy) should be exploited to their maximum extent.

**Large Scale User Trials**: test-beds and living labs, to test innovations in larger scale experiments and reach a broader European citizen base for acceptance testing.

**Social Innovation**: not-for-profit organisations that facilitate and support social innovation, social entrepreneurs and citizen organisations, to use NEM technologies for societal challenges.

**Design**: not-for-profit and other organisations working between art, design and technology, to facilitate product and service design and improve user acceptance

**SME support and improved targets**

Support for better access to private funding, though important, needs to be balanced by easy access to public funding and research programmes, particularly for SMEs and start-ups. Our NEM SME group has identified four targets specific to SME Innovation, during early
think-tank debates. These help deliver faster innovation and better support innovative SMEs in Europe: 1) create research programmes suitable for SMEs and simplify participation rules and governance (faster, simpler research funding procedures and support at national/regional/EU levels) 2) stimulate and assist SMEs to participate in larger EU R&D cooperation initiatives such as European Technology platforms and public-private partnerships 3) take a wider view of SMEs, to identify cross-sector programmes and open innovation models across global value-chains and 4) share best practice between researching and non-researching SMEs.

Proactively engaging with the EU to build Innovation Chains and Partnerships
We are in the process of creating a cross-ETP innovation workgroup, to combine best practices and facilitate Innovation Partnerships that use a systems approach to deliver cross-sector innovation. We also believe that the cultural, art and design sectors are key catalysts in building innovative products and services and increase user acceptance. We are pleased that design and the need for a European Design Leadership Board have been identified. We recommend that this is extended to include actors such as artists working on NEM technologies and creative media industry players, and organisations that facilitate the interactions between art, design and technology. NEM can help engage these communities with our members and together with key stakeholders from non-profit and social entrepreneurship sectors in an inspiring and results driven way.

In terms of research, NEM has issued the list of prioritized items below:
4. Which network technologies requirements and expectations, do you consider important to inspire innovation and bring most benefits to your (business) development in the future?

In line with the items listed above, the following items have been identified:

Networking and delivery infrastructure
In the NEM domain, networks underlie all the services and applications. But in normal operating conditions the user should not have to configure the network to suit an application and should not even need to know how the signal is routed. To achieve that goal, current network technologies need much improvement. The size and complexity of the internet is

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*Topics for which the NEM Community see[s] a specifically high importance in FP8. Results derived from the open survey performed in April/May 2011.*
growing very fast, both in terms of volume of traffic and the numbers of users (not only human users but also inanimate devices). Human users increasingly demand services that are real-time, simple, secure and personalised. Accommodating these requirements presents the main challenge for the future internet.

**Intelligent Delivery**

Intelligent delivery of content in general and of video in particular, is an important topic for research as this will impact the majority of the future traffic over the Internet. With the breakthrough of countless media services on the Web, media consumption patterns have changed. Watching television programmes (on a TV set or on a PC) is often accompanied by the usage of other Web-based services and the second (mobile) screen. Especially connected TV needs to take into account Web access, mobile devices and social media and social networking practices. The full integration of TV and Web content however remains a big challenge from a content and application side, but also from the delivery side: A rich set of tools is required covering management and delivery of the actual AV content, metadata handling and enrichment, as well as seamless synchronised delivery to different devices (including second-screen devices).

**Delivery - centric network architectures** that extend or go beyond today's content-centric networking investigations: besides the identification, retrieval, caching, and securing of named content, the timing constraints for the delivery should also be taken into account as a focal element in the overall architecture, especially for video. Depending on the video encoding techniques used, the network can perform trade-offs between quality and latency, reaching an optimal QoE for the end-user. A related research challenge is a comprehensive network quality concept which could include e.g. smart quality agents in multimedia networks with algorithms for realtime monitoring and control of the service quality.

**Intelligent adaptation of the content flow** to the underlying transport and momentary congestion status of the network, be it wire-line or wireless: today's adaptive rate video delivery mechanisms mostly rely on intelligent client decisions. In the future, an additional intelligence component in the network, and the necessary communication semantics and protocols between intelligent clients and network elements can further optimise the adaptation and delivery process.

**Cognitive video delivery** by further extending the adaptation capabilities with a learning component, and other elements of cognitive networking, will allow the delivery process to improve over time, based on high level policies and reasoning processes.

Finally, the **Interworking between content search and discovery** with delivery capabilities and constraints can provide interesting opportunities for research as it can combine the "what" with the "how" of the delivery process.

5. **Which cross sector synergies in relation to the network technologies research are of strategic importance to generate growth in your business sector?**

NEM in the process of creating a cross-ETP innovation workgroup, to combine best practices and facilitate Innovation Partnerships that use a systems approach to deliver cross-sector innovation. NEM also believes that the cultural, art and design sectors are key catalysts in building innovative products and services and increase user acceptance. We are pleased that design and the need for a European Design Leadership Board have been identified. NEM recommends that this is extended to include actors such as artists working on NEM
technologies and creative media industry players, and organisations that facilitate the interactions between art, design and technology. NEM can help engage these communities with our members and together with key stakeholders from non-profit and social entrepreneurship sectors in an inspiring and results driven way.

6. **How do you think that the network research community should best engage with the user community?**

The global evolution of people’s perceptions regarding networked electronic media technologies (devices, services,…) leads us to a vision of future media:
- More immersive: 3D, holographics for entertainment content as well as video-conferencing and games should take advantage of these new technologies.
- More personalised: people having access to more and more information and access to the right information at the right moment, need more generalised context awareness and information profiling. In addition, information is becoming obsolete very quickly, so there is also a need to propose information rating services.
- More collaborative: people are used to communicate and share content through social networking and to work more and more in a collaborative way. This implies that a combination of content sharing and interpersonal communication services becomes necessary.
- Anything, anytime, anywhere on any device: People use several types of devices depending on location and personal context. There is a need to be able to provide any service on any type of device, whatever the connectivity.
- All these services should obviously be in line with people’s behaviour:
  - People are attracted by new technologies which answer a need (e.g. iPhone, DVB-T)
  - People are becoming Green and will use services which lower energy consumption
  - Elderly people are TV centric in the same way as young people are smartphone centric
  - Wireless technologies are accepted best from a usage point of view but are badly accepted from a health point of view.
  - Future high bandwidth connectivity (FTTH and LTE) will boost NEM applications and will be widely used in Europe
  - Digital Home complexity will need high level Customer Relation Management in order to help people to configure their home network Position Paper on Future Research Directions Opportunities for an Innovative Europe
  - Privacy is a key factor that need to be addressed from a technical point of view as well as from a regulation point of view

All those important changes put the users at the centre of innovation. This implies to re-enforce the need for a strong link between innovation and the communities of users.

7. **Which constituencies and methodologies in relation to network technologies research are most important to maximise the impact of research and innovation in HORIZON2020?**

Our experience enables us to leverage the momentum developed in the Net!Works, ISI and NEM European Technology platform communities on networking issues. NEM expresses it willingness to joint initiatives by these ETPs to consolidate and reinforce the priorities for future network research through coordinating the release of global white papers and fostering the evolution of coherent platform Strategic Research Agendas and then promoting them on a cross-platform and cross-sector basis. It is the way to ensure that content dimension will be
taken into account on future network technologies. As mentioned several times, what will be a network without content and without users?

8. How should research developments in network technologies in HORIZON2020 be measured against delivering EU industrial leadership worldwide, sustainable economic growth and high-quality jobs creation in Europe?

The straightforward measurement will be the uptake and use of developed technologies in a worldwide context and the economic success of European industry as a direct consequence.

www.nem-initiative.com
www.nem-summit.eu
Proposal by Patrick CANDRY  (Barco n.v., Belgium)

Title
Collaboration Between Professionals (CBP)

Contribution
Summary: There is a strong and growing societal need (climate, energy, environment, economy, productivity, physical security) for effective remote collaboration between professionals. Examples: (1) healthcare, multi-disciplinary meetings between medical experts, (2) collaborative design and engineering sessions, and (3) international business review meetings.

Communication between people is very complex and all the aspects of natural human communication must be addressed to achieve a high quality of experience (QoE) in a remote collaboration setting.

N-way effective remote collaboration requires that real time rich visual information (people, objects, environment, documents), rich auditory information and touch, are accompanied with the correct non-verbal signals and cues (e.g. eye contact, proximity, gesture, gaze direction, position,...). Latency should be minimal and not disturb the natural experience. The threshold to use these communication systems must be very low and should be possible from the normal work environments as standard offices and meeting rooms, and from the home office.

Remote collaboration systems for professionals with a high QoE will require multimedia and communication infrastructures with 100x to 1000x the current performance levels. This will require a dramatic increase in network performance.

The complete description is available in the uploaded document: "Call for public consultation on Future Network Technologies Research and Innovation in HORIZON2020_Barco.pdf"
Call for public consultation on **Future Network Technologies Research and Innovation in HORIZON2020.**

Mr. Luis Rodríguez-Roselló, Head of the Unit "Network Technologies" in the Directorate General Information Society and Media of the European Commission

**BARCO n.v.**  
**President Kennedypark 35**  
**8500 Kortrijk**  

contact: patrick.candry@barco.com

14 May, 2012
1. Which sector are you representing? What are the strengths and size of your market in Europe and/or worldwide?

Barco (www.barco.com) is a Belgian based multi-national technology company active in professional ICT markets. The company has its own facilities for Sales & Marketing, Customer Support, R&D and Manufacturing in Europe, North America and Asia Pacific and is active in 90 countries with ~3.500 employees worldwide, 60% of which are located in Europe (Belgium, Germany, France, Italy, and UK). Today, more than 80% of R&D and about 60% of manufacturing (in terms of FTEs) is taking place in Europe. Barco posted sales of 1.041 million EUR in 2011.

Barco designs and develops visualization solutions for a variety of selected professional markets: medical imaging, media & entertainment, infrastructure & utilities, traffic & transportation, defense & security, education & training and corporate AV.

In these markets Barco offers user-friendly imaging products that optimize productivity, business efficiency and safety. Its innovative hard- and software solutions integrate all aspects of the imaging chain, from image acquisition and processing to image display and management.

Barco products are key technological enablers for larger Healthcare, Security, Aeronautics, Enterprise or Entertainment systems; they are typically used by large system integrators such as Philips Healthcare, Siemens, EADS, Thales, Dassault Systems, Volkswagen, Agfa Gevaert, etc. to build safety critical and/or high added value end-user solutions in which the quality of visual/graphic content is key.

The worldwide professional display and digital signage market is a ~$15bn market with a CAGR in the range of 10%. The market size mainly consists of visualization systems (e.g. displays and projection) however we see an increasing demand for networked visualization. The main players are mostly large non-European players (for many of them also active in Consumer Electronics such as Sony, Panasonic, Mitsubishi, JVC, Samsung, NEC, etc.) and smaller but global niche players such as Barco in Europe and Christie in North America.

The strong presence of Japanese and Korean companies derives from the heavy hardware centricity of the market that has prevailed until now and was favorable to vertically integrated business models. With an increasing value of professional visualisation systems now shifting to networked applications and cloud based services, and taking into account the trend in hardware commoditization, the opportunity exists for non-mass manufacturing players to play a leading role in new value creation and capture a larger part of the market revenues. In such model, Europe has key strengths, being the home of the largest system integrators & solution providers and the largest B2B market place.

Barco is an intermediate actor in the value chain, building on external components and both internal and external technologies to develop products & systems of high added value.

Barco’s major strengths across its market segments are its close relationships with system integrators, solution providers and end-users, combined with technology leadership (existing over 70 years and holding a strong track record of technological innovation), and strong brand.
2. How would you describe (in less than one page) your ideas and/or plans for future R&D challenges/topics relating to Network Technologies?

As mentioned above, networked visualization holds an enormous potential for increasing the professional visualization systems market and enabling Europe to play a prominent role in it. The “Collaboration Between Professionals (CBP)” R&D topic described below proposes to address such challenge in a user-centric and solution driven way.
There is a strong and growing societal need (climate, energy, environment, economy, productivity, physical security) for effective remote collaboration between professionals. Examples: (1) healthcare, multi-disciplinary meetings between medical experts, (2) collaborative design and engineering sessions, and (3) international business review meetings.

Today’s multi-party video-conference systems and high-end telepresence solutions, as the “Cisco Telepresence” and the “HP Halo Video Collaboration Studio”, fail to emulate reality to a level that allows effective remote collaboration between professionals. The constraints on the current technologies are limiting the level of immersion to a too low level. Other important drawbacks of the current high-end telepresence solutions are the need for dedicated expensive rooms, the too high complexity to use and the high cost. The complex and strict required set-up needs IT-support to keep the systems running and up to date. This is causing important barriers and frustration to use these systems.

Immersive experience:
Communication between people is very complex and all the aspects of natural human communication must be addressed to achieve a high quality of experience (QoE) in a remote collaboration setting. "The vision of immersive communication is to enable natural experiences and interactions with remote people and environments in ways that suspend disbelief in being there. [3] N-way effective remote collaboration requires that real time rich visual information (people, objects, environment, documents), rich auditory information and touch, are accompanied with the correct non-verbal signals and cues (e.g. eye contact, proximity, gesture, gaze direction, position,…). Latency should be minimal and not disturb the natural experience. The threshold to use these communication systems must be very low and should be possible from the normal work environments as standard offices and meeting rooms, and from the home office. The complexity of the technology should be hidden as much as possible, therefore multimodal biometrics should support the user authentication and the user-display interaction should be based on ease of use gesture-, touch- and voice-control. Language barriers can be solved with language translation as an always-on feature.

Visual information:
Providing to each viewer a strong visual immersive experience requires glasses-free 3D viewing. The supporting capturing and display systems must be able to capture and display the light field in a large field of view. The light field displays should have life-size and resolution corresponding with 20/20 vision. For the image capturing plenoptic cameras are required instead of the conventional 2D cameras. Real-time sharing of documents, video, audio and images with the ability to annotate is also required. Such systems will require huge amounts of data to capture, encode, transport, decode and display. The endpoints will also have a wide diversity in resolution, computing power and transmission capacity. These endpoints could be meeting rooms with multiple high resolution 3D screens, offices with desktop displays and 3D displays integrated in walls or furniture, or tablets and smart phones.

Auditory information:
Immersive audio capturing and rendering becomes more important with an increased number of participants or when emotion has an important role. When the user is surrounded by several collaboration screens then immersive audio rendering becomes very important.

Touch, haptic feedback:
The ability to physically interact with remote objects is required in several remote collaboration settings. The nature of the haptic information imposes specific requirements on the communication between the operator side and the teleoperator side, e.g. time delay and packet loss have a harmful influence on the performance and can destabilize the overall system.

Remote collaboration systems for professionals with a high QoE will require multimedia and communication infrastructures with 100x to 1000x the current performance levels. This will require a dramatic increase in network performance. The network technology requirements and expectations are summarized in paragraph 4.
References:
3. How do you see the potential role of your organization in HORIZON2020 in connection to the network technologies design, experimentation and/or deployment? What are your research priorities?

The topic described above fits in Barco’s roadmap. Barco can especially contribute to the following areas which are in connection to the network technologies design, experimentation and deployment:

- Development of the use cases:
  Multiple scenarios need to be developed in collaboration with end-users, aiming at making collaboration as rich as face-to-face meetings and at the same time as simple to set-up and use as an audio teleconference. Different sectors (e.g. Healthcare and Enterprise) need to be explored in parallel to ensure commonalities in the systems architecture and underlying technology platform.

- Development of the requirements for the new network functionalities:
  Achieving the necessary degree of immersion and quality of experience will require a significant increase in network performance (wired and wireless) at the endpoints: at offices, at homes and for the mobile users. It has especially to be explored how joint developments in capturing and visualization technologies, high resolution imaging rendering software, adaptive codecs and network protocols can deliver optimal use of the available bandwidth at any time, contextualizing the use of the platform through constant awareness of the location of users, type of end-points, type of network connection, etc.

- Development of applications and cloud services:
  Not only the network, endpoints and devices need to be available there also need to be applications offering the quality of experience expected by the users. Applications need therefore to be developed taking especially into account the drawbacks of current telepresence systems. Building on networked visualization features, also new architectures need to be considered whereby the use of cloud resources play a prominent role in order to optimize performances and operating costs.

- Participation in the experimentation, demonstration and testing.
  Quality of experience is extremely important, therefore intensive experimentation and multiple iterations will be necessary with the different technology platforms.

- Development of new business models:
  New business models can possibly be developed such as Visualization-as-a-Service (VaaS) by making use of the potential of networked systems and cloud resources.

- Roadmapping:
  Joint roadmaps will be necessary to prepare for the long-term viability of the eco-system, balancing future capabilities of collaboration end-devices versus capabilities and cost evolution of network connectivity.
4. Which network technologies requirements and expectations, do you consider important to inspire innovation and bring most benefits to your (business) development in the future?

• **Transportation of the high resolution 3D images will require endpoints with bandwidth connections of many Gbit/s at an affordable cost.**

The necessary high quality of experience for remote collaboration between professionals will require a dramatic increase of the size of the raw visual and auditory data. It is expected that this will require new video and audio compression standards. For instance a 40 Mpixel image with 16 views will require a bandwidth of 76.4 Gbit/s and for 100 views a bandwidth of 360 Gbit/s is estimated in the assumption that only a 20:1 compression is possible.

The table below shows the uncompressed and compressed data rate estimations for HDTV, 4k and 40 Meg images for single view, 16 views and 100 views.

<table>
<thead>
<tr>
<th>Resolution (Mpixels)</th>
<th>Frame rate (frames/sec)</th>
<th>bits per pixel</th>
<th>single view</th>
<th>Uncompressed data rate (Gbit/s)</th>
<th>Compressed data rate (Gbit/s) (20:1)</th>
<th>16 views</th>
<th>Uncompressed data rate (Gbit/s)</th>
<th>Compressed data rate (Gbit/s) (20:1)</th>
<th>100 views</th>
<th>Uncompressed data rate (Gbit/s)</th>
<th>Compressed data rate (Gbit/s) (20:1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.07 (HDTV)</td>
<td>25</td>
<td>36</td>
<td>1.66</td>
<td>0.009</td>
<td>24.09</td>
<td>1.75</td>
<td>156.5</td>
<td>7.78</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.09 (4K)</td>
<td>48</td>
<td>36</td>
<td>15.3</td>
<td>0.744</td>
<td>244.6</td>
<td>12.23</td>
<td>1523</td>
<td>78.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>50</td>
<td>36</td>
<td>72</td>
<td>2.8</td>
<td>1112</td>
<td>57.6</td>
<td>7048</td>
<td>343</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

• **Heterogeneous endpoints will interact simultaneous with heterogeneous content.**

The endpoints will cover the range from meeting rooms with multiple high resolution 3D displays to portable devices with a 4” to 10” diagonal displays connected to high capacity cellular networks or wireless LANs. Specific processing in the cloud and cloud services will support the diversity in computing capacity of these different endpoints. The content will cover the range from very high resolution 3D engineering or medical content to sub SD content. High QoE requires low latency (<15ms) and two-way transmission of haptic information requires a latency <1ms. Specific protocols might be necessary. Interoperability will require standardized solutions for compression, transport and interaction.

• **Security**

Large amounts of sensible data (e.g. medical-, engineering- and business-data) will be exchanged over local and wide area networks and this will require a high level of information security (integrity, auditing capability, access control, user authentication, availability). The security system should not hamper or delay the communication and interaction between the users. The implementation of the security technology should have a very low threshold level for the users and the underlying technology should be hidden as much as possible. Multimodal biometrics should support the access control and user authentication.

• **Cost**

The initial cost and the operational cost should be at an affordable level. Cost of bandwidth usage may well be a critical factor as bandwidth usage is expected to be important (see above). It is the vision that such systems should be as simple and potentially inexpensive to use as today’s audio teleconferencing services.

BARCO n.v. 7 / 11
5. Which cross sector synergies in relation to the network technologies research are of strategic importance to generate growth in your business sector?

To generate growth in the mentioned business sector it is of strategic importance that in relation to the network technologies, research of the following topics is addressed:

• End-devices for immersive collaboration, such as glasses-free 3D displays, plenoptic cameras for the 3D capturing, integration of cameras in displays and portable devices, biometric solutions and haptic solutions must be developed.

• Specific processing (e.g. processing of 3D images) in the cloud and cloud services to support the diversity in computing capacity of the different communication endpoints must be developed.

• Advanced adaptive codecs for a wide variety of rich content must be developed.

• Psycho-social research and involvement of psychologists and sociologists into the project is required to define the requirements for effective remote collaboration with a high quality of experience.

• Standardization: it is key to the success of the initiative that interoperability of the different systems and subsystems is addressed in the right way. Support of standardization efforts from the relevant bodies is necessary.

• Significant R&D efforts need to be undertaken at component and sub-system levels. It is to be noted that Europe holds significant knowledge in these areas and support is therefore expected from the Components & Systems Directorate.
6. How do you think that the network research community should best engage with the user community?

We support the application-driven approach for collaborative research projects, where consortia show no gap in the coverage of the value chain; this holds the largest potential for creating real value at the end of the process to both solution providers and end-users.

A pragmatic iterative approach with a strong end-user involvement for the definition and testing of the use-cases should be enforced.
7. Which constituencies and methodologies in relation to network technologies research are most important to maximize the impact of research and innovation in HORIZON2020?

Constituencies:

There is a need for companies like ours to get facilitated access to the network technologies research community so as to be able to propose new use cases in an easy way and get feedback on the evolution of the network capabilities and cost models.

Many European companies are only now starting to explore the possibilities offered by future networks, virtualization and cloud services as a mean to achieve the necessary business transformation for the facing increased competition.

Horizon2020 should aim at helping those companies which will in turn benefit the network and telecom industries.

Methodology:

A pragmatic iterative approach with a strong end-user involvement for the definition and testing of the use-cases should be enforced, see also paragraph 6.
8. How should research developments in network technologies in HORIZON2020 be measured against delivering EU industrial leadership worldwide, sustainable economic growth and high-quality jobs creation in Europe?

• Measurement of the business size of related new services and new products.
• WW market share of European companies in the related business.
• The need to travel for face-to-face meetings should be reduced by effective remote collaboration solutions. Therefore the reduction of travelling (miles, cost, time), and consequently the reduction of the impact on the environment, can be measured per industry sector.
EARPA by Ben Rutten
**Future Networks: Future Network Technologies Research and Innovation in HORIZON 2020**

**EARPA Response to the EC consultation, 15 May 2012**

EARPA would hereby like to answer the European Commission’s consultation on “Future Networks: Future Network Technologies Research and Innovation in HORIZON 2020”.

1. **Which sector are you representing? What are the strengths and size of your market in Europe and/or worldwide?**

As you may already know, EARPA is the association of automotive R&D organizations. It brings together the most prominent independent R&D providers in the automotive sector throughout Europe. Its membership counts at present 39 members, ranging from large and small commercial companies to national institutes and universities. For more information, please visit our website at [www.earpa.eu](http://www.earpa.eu).

With an increased demand for mobility and the need for lowering footprint of transportation, the automotive sector is a main actor in finding solutions to the European grand societal challenges. Today, the automotive industry can be understood as one of the most important end users of the results generated by the network research community. The automotive sector is expected to play a very important role when addressing the grand challenges related to smart mobility and energy efficiency. EARPA members largely support the automotive industry thanks to their R&D activities.

EARPA believes it has the required expertise to provide inputs to the above-mentioned consultation with the support of its Task Force Electronic and Communication Systems (TF E&C) experts. Our Task Force was started in 2011 with the objective of addressing new activities in these fields and currently brings together 19 partners of EARPA. Activities under this Task Force include the discussion of research topics of common interest, the development of common positions related to the importance of electronic and communication systems in the automotive sector, the definition of possible articulations of these systems for different functionalities of the vehicles and the coordination of research activities promoted among the members.

2. **How would you describe (in less than one page) your ideas and/or plans for future R&D challenges/topics relating to Network Technologies?**

Electronics and communication systems have become a vector for the development of environmental friendly, safe and versatile vehicles. Nowadays, electronic components constitute a third of the total development costs of a new vehicle and this trend is likely to increase further in the next years. Additionally, the increase in the communication capabilities between the vehicles and the infrastructure will enable newer services for mobility and safety. But, there are still challenges to be addressed at the level of electronic and communication systems in order to keep their constantly increasing deployment in the automotive sector.

For this, it is needed to:

- To develop methods and tools to integrate new functionalities in the vehicles and the infrastructure;
- To develop methods and tools for ensuring that new functionalities fulfil the needs of safety, security, reliability and work load;
- To standardize platforms, communication protocols, validation techniques and criteria;
- To implement bridging activities, which demonstrate the possibility of transferring knowledge and functionalities gained in other research activities.
3. How do you see the potential role of your organisation in HORIZON2020 in connection to the network technologies design, experimentation and/or deployment? What are your research priorities?

EARPA is the organisation for R&D entities, which include universities, research centres and industrial partners which do not manufacture any product. The partners of the Task Force have identified their capabilities and limitations. Fruit of this, the following fields of activity are defined:

- **Concepts and Architectures**: The Task Force has not the objective of defining new architectures for electronic or communication systems, as this task should be part of a bigger group of members and very close to standardisation entities. However, EARPA partners can bring relevant support in technology transfer. One of our objectives is to identify architectures which are already in use in other fields and which could be applied for automotive use. Additionally, a relevant objective of our Task Force is to participate in the standardization process of new architectures.

- **Interfaces and Platforms**: The objective here is to develop tools based on standardized standards which enable the deployment of new apps and services. This is a field of activity where EARPA can provide strong support. Our members have development capabilities for the implementation of these interfaces and tools.

- **Applications and Services**: New applications and services is an area where EARPA can provide relevant input. They can support industry in the definition of new apps and services and identify future requirements applicable to the other areas.

- **Verification and Validation**: This is also the natural field of action of EARPA. Verification and validation activities are typical activities which are subcontracted research centers or engineering companies, and this is the core field of activity of most of our Task Force members. EARPA can bring expertise in these fields and is interested in the development of new trends, techniques and procedures for verification and validation purposes of Electronic and Communication systems.

4. Which network technologies requirements and expectations, do you consider important to inspire innovation and bring most benefits to your (business) development in the future?

EARPA considers important two set if technologies:

**Set 1. Network technologies allowing adaptive services and tools for dynamic management of automotive control systems**

The successful adoption of cooperative telematics applications requires adaptive middleware (services and tools) to facilitate application management (customization, configuration, assurance, and diagnostics). Automotive control systems rely on multiple (dozens, and sometimes hundreds of) independent software components that communicate, locally or remotely via a network (e.g. CAN, FlexRay, Ethernet). They must adhere to strict real-time performance constraints and gracefully handle error conditions; their behaviour must remain reliable under all conditions and they are often reused in various circumstances.

**Key research activities:**

- To address (evolving) requirements and expectations of multiple application (service) providers (OEMs, Tier-1 service providers, communication operators);
- To design and develop services for:
  - diagnostics and monitoring, e.g. collecting data samples and assessing system behaviour by recognizing generic patterns and applying associated metrics
  - distributed service provisioning, e.g. enforcing system behaviour by remote deployment of components and monitoring probes;
- To design and develop configuration tool chains that are able to:
  - specify and collect application goals concerning structural (composition) as well as behavioural aspects (real-time requirements, quality guarantees); the application's functional and non-functional specification, as well as the different configurations are captured by models
  - resolve these independent goals into a coherent application composition that can be deployed onto a network of embedded control systems
- validate adaptive system behaviour and forward system feedback into the configuration tool chain;
  - to open a gate to cooperative systems, vehicle to vehicle, infrastructure to vehicle, vehicle to infrastructure

**Set 2. Techniques for the verification and validation of the upcoming generation of vehicle electronics and networks – in the context of verification and validation area**

The goal of the automotive industry is to achieve 100% reliability of electronic components, although in reality this is never possible. Durability of these components are directly related to reliability and, as more and more electronic components depend on each others (in terms of connectivity), it becomes imperative that improved techniques are devised for verification and validation techniques.

As the automotive industry increasingly relies on the electronic systems, these systems become responsible for the safety of the passengers. Traditional verification and validation techniques, where the functionality of the system is usually tested, might not cover the full range of risk scenarios required for the system. Therefore, it is also necessary to include novel techniques in order to validate the safety requirements of those systems. In addition, as the number of electronics increases, the bandwidth becomes limited. Therefore, newer communication protocols will become necessary (e.g. FlexRay or Ethernet as a possible replacement for CAN). The validation of these more complex networks will require extra efforts and more formal methods.

**Key research activities:**
- Standardisation of the processes of bench validation, integration validation and full vehicle validation in combination of numerical models and statistical methods.
- Standardisation of Software and Hardware in the Loop techniques.
- Analysis of the validation vs quality ratio. Identification of a minimum set of tests which provide a great portion of estimation of the quality.
- Analysis and standardisation of “Highly Accelerated Lifetime Testing” or “Multi-Environmental Over-stress Testing” techniques to optimize the reliability of the electronics early in the design cycle.

**5. Which cross sector synergies in relation to the network technologies research are of strategic importance to generate growth in your business sector?**

Information and Communication Technologies, including network technologies is a key sector which could contribute to the growth & maintenance of the worldwide leadership of the European automotive sector, by the provisioning of unique services in the frame of smart mobility.

Under the umbrella of EARPA, and according to the capabilities of its partners, it is important to highlight:

- The development of methods and tools for ensuring that new functionalities fulfil the needs of safety, security, reliability and work load.
- The standardisation of platforms, communication protocols, validation techniques and criteria.
- To implement bridging activities, which demonstrate the possibility of transferring knowledge and functionalities gained in other research activities.

**6. How do you think that the network research community should best engage with the user community?**

**7. Which constituencies and methodologies in relation to network technologies research are most important to maximise the impact of research and innovation in HORIZON 2020?**

For EARPA, the automotive industry can be understood as one of the most important end users of the results generated by the network research community. The automotive sector is expected to play a very important role when addressing the grand challenges related to smart mobility and energy efficiency.

For this reason, it is considered that the best solution is a bottom-up model where, the end users (including the automotive industry, but also infrastructure operators and mobility agencies) specify the requirements for the next generation of network technologies. These requirements could be easily converted into research and innovation topics to be implemented during the different HORIZON 2020 calls. The network community could lead the implementation of activities addressing these topics in collaborative projects where some end users also take part.
8. How should research developments in network technologies in HORIZON 2020 be measured against delivering EU industrial leadership worldwide, sustainable economic growth and high-quality jobs creation in Europe?

The best evaluation criteria for activities in the networks field is the direct measurement of the number of project results application into newer standards, protocols and the provision of newer services thanks to the newer technologies.

This evaluation criterion is very ambitious as it is not always easy to apply. But, we must take into account the kind of network technologies which are being requested for mobility and transportation services and how they are going to be used, mainly characterised by the need of fast implementation. Intelligent Transport Systems include newer concepts which request the creation of newer architectures and networks as a basis for the later development of tools and services on top of them. Entities with business addressing the tools and services areas are already requesting the architecture and communication layers so that they can develop their products. This request will bring fastest deployment and, when talking about impact measurement, one should look at directly on implementation’s results.

Contribution written by the EARPA Task Force Electronic and Communication Systems team

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European Automotive Research Partners Association

Founded in 2002, EARPA is the association of independent automotive R&D organisations. It brings together the most prominent R&D providers in the automotive sector throughout Europe. EARPA has 37 members ranging from large and small commercial organisations to national institutes and universities.

EARPA, as the platform of automotive researchers, aims at actively contributing to the European Research Area and the future EU RTD funding programmes. EARPA works in a close cooperation with the automotive industry, the automotive suppliers, the oil industry as well as the European Institutions and the EU Member States.

EARPA is independent from any external body or institute and is only funded by its members’ fees and is governed by an Executive Board and a General Assembly.

Our Mission

EARPA’s mission is to promote awareness and understanding of the specific role and contribution of R&D providers in the automotive sector and reinforce the high tech character of the automotive industry as well as its potential for future innovation and new opportunities.

EARPA works in a close cooperation with industrial automotive partners, suppliers, universities and other research organisations to develop the future of R&D in Europe. Such cooperation varies in its forms from exchanging ideas and knowledge in joint meetings to set-up networks, roadmaps and carry out joint research projects. The current EU R&D funding programmes, as well as the future Horizon 2020 programme are of particular interest for EARPA members as a mean to achieve such cooperation, as well as further support the European Automotive industry. Accordingly, other European stakeholders such as ACEA, EUCAR, CLEPA, CONCAWE, FERHL, ERTICO, ECTRI and POLIS are important EARPA partners.

EARPA actively supports various European Technology Platforms (ETPs) and Joint Technology Initiatives (JTIs) in their efforts of defining common visions for the future RTD and creating as well as implementing European strategic research agendas. Among others, EARPA members are active in the following European Initiatives which are overlooking/have impacts on different automotive R&D aspects: ERTRAC, ARTEMIS, BIOFUELS, Hydrogen and Fuel Cell Platform, iMobility Forum, MANUFACTURE and EPOSS. As an independent platform, EARPA participates in strategic consultations at EU level related to public interest and social matters regarding mobility, environment, energy and safety in the automotive area. Being well integrated in both national and European research structures, EARPA and its members are able to promote and support closer links between national and European research programs.

Our Organisation

EARPA is functioning thanks to its members’ annual contributions and is composed of three main bodies:

- First, the General Assembly, in which all members are participating, governs the Association.
- Second, the Executive Board, to which the management of the association is delegated, initiates activities and carries out the representative tasks. Mr. Affenzeller (AVL) as chairman of this board is EARPA President.
- Third, the EARPA Secretariat based in Brussels which is managed by EARPA Secretary General, Ms. Attané.
Our Work

To achieve its goals, EARPA provides to its Members and its counterparts (EU officials and other stakeholders) the following elements:

1. A better visibility in Europe thanks to its central point of contact: i.e. its Secretariat based in Brussels available for its Members and other EU stakeholders.

2. Targeted information on the development of future EU RTD funding programmes and procedures, initiatives for projects and joint programmes, networking activities as well as information on on-going projects of interest. This information is provided thanks to various supports such as newsletters, flyers and other confidential documents, all easily accessible for our members via EARPA intranet.

3. A platform for discussion and exchange of views for R&D providers through for example its nine Task Forces.

4. A strong network with the relevant European Institutions and industries thanks to regular meetings such as its annual events and workshops

5. Support or initiation of new networks, projects and consortia by bringing interested parties together and facilitating meetings, thanks to its Task Forces.

6. Additional public exposure of its members through its communication effort (public website, presentations at events, etc.) towards EU & industrial representatives as well as the general public.

Our Structure

EARPA organisation is based on its Task Forces which are responsible for developing EARPA opinions and positions as well as defining EARPA objectives and strategy in relevant R&D areas. Through its Task Forces, EARPA provides a forum for its members to address issues of common interest.

Our Members

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EARPA has the following Task Forces:

1. Safety
2. Materials, Design & Production
3. Noise, Vibration & Harshness
4. Modelling & Simulation
5. Advanced Combustion Engines & Fuels
6. Hybrid and Electric Systems & Components
7. Urban Mobility
8. Electronic & Communication Systems
9. Project Management

Our Membership

EARPA Membership is open to R&D providers, commercial and non-profit. Independence of the automotive industry and experience with EU projects are the two criteria for the membership. If you are interested in joining EARPA, please do not hesitate to contact our Secretariat. To have more information, please visit our website: www.earpa.eu
Comments on the Future Network Technologies research in HORIZON2020

Dear Mr Rodriguez-Rosello

Thank you for the invitation to comment on the upcoming future research framework concerning future network technologies.

Currently I am, after my retirement from TeliaSonera affiliated to the Senior Faculty of KTH, to the school of Computer Science and Communication (CSC), and to the multi-disciplinary Centre for Sustainable Communications (CESC). I am also active in a foundation with the mission to support research and experimentation in communication and mediation – with the focus on rural areas. I have also, as you know some experience from FP6 and FP7, both in projects and of evaluations.

In this context we are experimenting with and analyzing of the effects of new ICT in several ways: From how ICT can influence people’s behaviour in more sustainable directions, to experiment with new network architectures and societal applications in very rural and sparsely populated areas in order to achieve a more sustainable life in those areas.
First some general comments, before I address the more specific comments of the call for comments:

The development of the applied network and transmission technology is very regular and predictable, in the sense that we can predict rather well what technology offers to what cost: how the speed, wavelength utilisation etc will increase in the time span of HORIZON. The same is true – to a lesser degree – also for OSI layers 2 and 3.

Obviously, what will make difference, in this time span, for industry and society is what we use the technology for and in what context. In particular new and disruptive usages that changes the incumbent rules and practices.

The challenge is how a research program can help and further this development. Large and incumbent actors tend rather to administer and maintain the present than to foster change. And the problem gets worse as large programmes tends to both favour and rely on large actors. The FET instrument does address this problem of the “research program ecosystems” to some extent, but we need more instruments like this to meet the challenges.

Another aspect of what drives major innovations is that they are normally driven by users given access to technology, and making use of it in unexpected ways - today’s Internet being a good example. It is encouraging that this is recognised in the proposals, as the importance of cross sector synergies and multi-disciplinarily is mentioned. These are issues we also struggle within our activities.

In this context it is also encouraging that in particular societal and sustainability aspects are stressed as important cross sector aspects for future networks research. The problem here is obviously to involve the real stakeholders to create these synergies without too much influence of incumbent ICT. (E.g it is not collaboration of the CIO of the hospital and the account manager with the incumbent telecom company that will create new methods to treat illness or preserve wellness).

Secondly, the requested more specific comments:

Which sector are you representing? What are the strengths and size of your market in Europe and/or worldwide?

CSC and CESC are research organisations, and part of KTH, Stockholm. CESC in particular have the mission to research how ICT can be used to create a more sustainable society. To this end the research combines several sectors of research as network and communication technology, media and mediation, architecture and strategic environmental issues, sociology and anthropology.

(http://cesc.kth.se/)
How would you describe (in less than one page) your ideas and/or plans for future R&D challenges/topics relating to Network Technologies?

Communication networks are critical infrastructures of the society, in the same manner as other supporting structures as the power grid, road system, etc. They are utilities enabling other activities, productivity gains and benefits are difficult to trace directly to the supporting structure - even if they are both huge and obvious. Data communication, e.g. Internet, has had a great impact on industry and economy, both in creating new usages but mostly so far to rationalise existing activities.

However, the large potential which is in finding new ways to produce services and to organise work and enterprises is not yet released. New ways to build and organise society and societal services are still to come. This is also a strategy to address acute problems as the climate, energy and environmental issues, as well as societal challenges.

How to use ICT for this, and effect of doing this is an area for research and experimentation. The way forward is both to combine academic disciplines and to involve and collaborate with actual users and stakeholders in experimentation. HORIZON2020 could help with provisions for this.

From an industrial view this is an emerging area for business, and from a societal view this is a strategy to both more effective and efficient fulfil societal obligations.

How do you see the potential role of your organisation in HORIZON2020 in connection to the network technologies design, experimentation and/or deployment? What are your research priorities?

We are already involved experimentation and deployment of novel network technologies. The intention is both to assess and demonstrate the use of the technology and to research and understand the societal impact of the use – in particular from sustainability perspectives.

The experiments range from devising apps guiding users to make more environmental friendly choices in everyday life, to using lambda technology to establish overlay networks for societal services in rural and sparsely populated areas. These experiments are pursued openly and in collaboration with various stakeholder organisations. The HORIZON programme would obviously be a wider arena to find potential collaborators, stakeholders etc.

The Centre for Sustainable Communications (CESC) has currently formulated four focus areas:

- People, practices and behaviours in a sustainable ICT society
- Sustainable solutions for ICT in cities
- Sustainability impacts of ICT and media
- Methods and ICT tools for sustainability assessments
(Not necessarily restricting the project portfolio)
Which network technologies requirements and expectations, do you consider important to inspire innovation and bring most benefits to your (business) development in the future?

One example is: The predicted increases in performance and decreases in cost makes technology more available and do enables novel first/last mile network structures, also in very small scale. This is of interest in very sparsely populated areas, which are underprivileged not only what concerns broadband access but also access to societal services at large. This is a challenge of both social and economical sustainability.

Together with regional development agencies are we presently planning and initiating experiments using new lambda networking technology in the northern inland regions of Sweden, which are indeed extremely sparsely populated. The approach is to help and enable local communities/villages to establish their own local optical first mile, connect them to transit networks. This structure is not only used to provide vanilla broadband, but several other service networks are overlaid using lambda technology. These networks are intended to carry societal services in a wide sense allowing for advanced mediation techniques (i.e. not only Internet). This sharing of infrastructure allows for a shared economy advantages.

The research aspect in this is not only to demonstrate technology, but more important to follow and research how this can contribute to the survivability of the community, sustainability of rural living.

Another example is how “big data” and information defined networks (IDN) can be used to make more sustainable choices and develop more sustainable practices in densely populated cities. The objective is to assist individuals to be informed and to be able to make rational decisions, and also as decision support for governing levels.

Which cross sector synergies in relation to the network technologies research are of strategic importance to generate growth in your business sector?

Besides the obvious cross synergies between ICT and sustainability research in general, synergies with areas from social science and humanities (SSH), in particular those researching individual and group behaviour are of interest.

More generally, involvement of user communities is important. In particular those involved in providing societal services, which is very general and spans e.g. health care, education, culture and authorities and governing in general. The value and aim for this collaboration is to achieve more effective and efficient means to produce and provide those services.

The growth aspect of that is simply that new applications share the common platform provided by network technology, and the shared economy makes advanced technology more available – opening more business opportunities using new technology.
How do you think that the network research community should best engage with the user community?

Involvement of new communities, users as well as research communities, do not happen spontaneous but have to be actively encouraged and supported. Possible should some new format, similar to NoE, be devised or should room for these activities be encouraged and allowed in FET/Strep/IP.

Such activities could in turn be helped and concerted by activities exploring trend and applications windows and arranging some sort of consulting or concertation meeting with relevant communities.

User communities could also be involved through collaboration with other development programs. E.g. in our rural experiments and initiative we have collaborated with users in projects funded via the LEADER programme.

Which constituencies and methodologies in relation to network technologies research are most important to maximise the impact of research and innovation in HORIZON2020?

Given our focus on a sustainable society two areas in which to experiment and research the impacts can be identified: On one hand densely populated areas as large cities, having acute issues with transport, energy, social inclusion, etc, and how to plan for and solve these issues in a sustainable way. The other area is at the reverse end, the underprivileged rural and sparsely populated areas, with issues of survivability.

Our methodology in both constituencies is rather to make innovative use of existing technology and study the results of this, rather than to develop new technology.

How should research developments in network technologies in HORIZON2020 be measured against delivering EU industrial leadership worldwide, sustainable economic growth and high-quality jobs creation in Europe?

I have no general solution to this. The problem is that what can be evaluated is how projects, or programs, meet their measureable targets by completion (i.e. project/program quality in an ISO9000 sense). The potential economic or world leadership successes come much later and are difficult to trace to specific developments or projects.

A possible step forward may be to enhance the “peer-review-like” process used today to evaluate project and programs, to also include peers from user communities, other stake holders and from “cross sectors”.

Anders Rockström
Affiliated Senior Faculty
KTH
IoT Cluster by Ovidiu Vermesan
IoT Cluster Contribution
By Ovidiu Vermesan

- Which sector are you representing? What are the strengths and size of your market in Europe and/or worldwide?
  
  Research and Industry.

- How would you describe (in less than one page) your ideas and/or plans for future R&D challenges/topics relating to Network Technologies?

The end users' embracing of smart phones, social networking addiction, and every day and anytime/anywhere attitude and expectations in access to resource demanding content like video streams, has in the last few years created an exponential growth in mobile "IP traffic". Internet of X-traffic will add to the traffic increase. A 2020 forecast gives the prediction of an additional 10x increase in the number of devices, a 30x increase in the traffic volume, and a 50x increase in the number of applications.

- Key network capabilities related to the main scenarios, e.g. supporting mobility, security, service differentiation, network optimisation, operator collaboration/virtualisation, etc. Internet mobility, virtualization, and backward compatibility.

- Internet architectures: resilient and trustworthy and designed to support open access, increasing heterogeneity of end-points (multimode devices, people, things) and networks (self-adaptive, self-healing networks, opportunistic networks, networks of networks), with the need of a seamless and generalised handover. Networks sustaining a large number of devices, many orders of magnitude higher than the current Internet, handle the large irregular information flows, and be compatible with ultra-high capacity end-to-end connectivity.

- Network management and operation frameworks to support generic service platforms, organisation of information exchange, addressing and naming, personal networks, scalability issues, agile connectivity, and the explosion of traffic and endpoints.

N.B. This could encompass any topic from basic research to innovation and experimentation.

- How do you see the potential role of your organisation in HORIZON2020 in connection to the network technologies design, experimentation and/or deployment? What are your research priorities?

Potential role to the network technologies design and experimentation

Research priorities:
Mobile Networks:
Ubiquitous fast broadband access: convergence and interoperability of dynamic heterogeneous broadband and mobile network technologies; broadband networks with optimised traffic exchange between heterogeneous core, metro and edge networks, wired
and wireless, in multiple operator and service provider domains, seamless transparent end-to-end connectivity.

Topics:
Control and Elasticity
Accountability
Virtualization and cloud computing
Self-management
- Capacity (More Transport Capacity, Making Technology Compatible)
  - User friendly
  - Secure, safe, trustworthy
- Auto and self-management, cooperation and cognition in the network
- Network aware, network agnostic, content aware

Heterogeneous networking:
- Technology-bridging protocols
- Self-adaptive protocols
- Control and management
- End-to-end security in heterogeneous networks
- Engineering and design of new network devices

Which network technologies requirements and expectations, do you consider important to inspire innovation and bring most benefits to your (business) development in the future?


Opportunistic spectrum use and spectrum sharing. Spatial domain utilization to improve the capacity. User location information and location awareness. Existence of multiple radio access technologies. Exploitation and acquisition of channel state information and channel statistical behaviour information. Traffic pattern knowledge including long-term monitoring and prediction. Network topology awareness in a mobile device.

Which cross sector synergies in relation to the network technologies research are of strategic importance to generate growth in your business sector?

Seamless end to end multimedia communication across a complex combination of network constituents such as personal area networks, body area networks, wireless sensor networks, home networks, fixed access networks, mobile access networks, metro networks and core networks is one of the future trends and the architecture should support personalised rich media networking, machine to machine communication, wireless sensor networks, adaptive connectivity, context aware networks as well as personal and body area networks. It should also be wireless friendly, natively support mobility, be spectrum and energy efficient, support future very high data rate connections as well as heterogeneous wired/wireless access domains. Routing and location independent
addressing or naming, dynamic peering, signalling, resource virtualisation, and end to end content delivery techniques are related research issues.

The main challenges are support of mobile broadband applications, manageability and scalability including quality of service support, security and trustworthiness as well as support of advanced high quality content including 3D applications.

In this context the synergies between the semiconductor industry, communication, network technology and software industry are of strategic importance.

Software vs. Telecom

- How do you think that the network research community should best engage with the user community?
  Yes.
- Which constituencies and methodologies in relation to network technologies research are most important to maximise the impact of research and innovation in HORIZON2020?
  A comprehensive research program for fundamentally new networking architectures in the context of the emerging of different Internet of "X" (Things, Energy, Media, Business), mobile Internet, heterogeneous network environments with increased security and cognitive capabilities. Architectural approaches to provide for flexible design across multiple platforms using evolvable and extensible technology, enable virtualization/cloud at scale across multiple platforms and for different resources, and design for cross-layer functionalities.
- How should research developments in network technologies in HORIZON2020 be measured against delivering EU industrial leadership worldwide, sustainable economic growth and high-quality jobs creation in Europe?
  Develop objective metrics to evaluate the efficacy of the investment in different areas and the measurable results.
Celtic Plus by Jacques Magen
1. INTRODUCTION

Celtic-Plus and its industry stakeholders certainly support the overall objectives of HORIZON2020 for “EU industry [to] translate successful research and scientific breakthroughs into innovative products, services and systems, which will foster EU economic leadership worldwide”. There is also little doubt that national public authorities funding Celtic-Plus projects are in line with the aim that “EU taxpayers will receive value-for-money from research and innovation: in terms of growth, high-quality jobs and a sustainable life and economy”. We believe that Celtic-Plus and its predecessor Celtic have already paved the way for such targets, in line with the overall objectives of EUREKA and of the EUREKA Clusters in the ICT and non-ICT domains.

The Celtic programme goal of “end-to-end integrated telecommunications systems” has evolved and Celtic-Plus is now looking towards a “smart connected world” as this recognises the expanding scope of the ICT challenges. The core of Celtic-Plus projects is still on telecommunications infrastructure technologies, and the programme is still actively working to “develop and deploy leading network infrastructure technologies here in Europe for the benefit of its citizens”.

We agree that significant research effort is required to develop and enhance the technologies underlying network capacity and performance to support the increasing number of connected devices and we are committed to support this in the years to come. National public authorities share these goals as they have granted Celtic-Plus with a EUREKA label until 2019.

There are also more and more Celtic-Plus projects looking at network applications and services. In this respect Celtic-Plus has expanded its “Core Group” to include more IT-related companies. We have also started to build up an interaction with the Future Internet Public-Private Partnership and also with the former EC Unit “Software & Services” (now called “Software & Services, Cloud”). A panel on cloud computing was organized at the latest Celtic-Plus Event held in Stockholm in March 2012.

2. CONTRIBUTION FROM CELTIC-PLUS ON CALL TO ACTION AND NEXT STEPS

WHICH SECTOR ARE YOU REPRESENTING? WHAT ARE THE STRENGTHS AND SIZE OF YOUR MARKET IN EUROPE AND/OR WORLDWIDE?

Celtic-Plus is an industry-driven European research initiative to define, perform and finance through public and private funding common research projects in the area of telecommunications, new media, future Internet, and applications & services focusing on a new “Smart Connected World” paradigm. Celtic-Plus is a EUREKA ICT cluster and belongs to the inter-governmental EUREKA network. Celtic-Plus is open to any type of company covering the Celtic-Plus research areas, large industry as well as small companies or universities and research organisations.

The research areas covered by the Celtic-Plus projects are the following:

- **Get Connected**: Networks Elements and Infrastructure, Network Architecture and Connectivity;
- **While Connected**: Future End To End Service, Future Service Enablers Multimedia enablers Security/safety, trust and identity Business and Societal Issues;
- **Inter-domain**: Multi-disciplinary cross-sector approach, Future Internet related.

“Get connected” mainly refers to adding new efficient (both in cost and power) and effective infrastructure, better suited to new services. “While connected” is about adding new value to networks, including extending service reach and user aspects.
The Celtic Core Group is responsible for the general policy of Celtic and its research activities. The following companies are involved in the Celtic Core Group and represent most major telecommunications and IT companies all over Europe: Alcatel-Lucent, France; ATOS Research, Spain; British Telecom, UK; Deutsche Telekom, Germany; Ericsson, Sweden; Eurescom, Germany; Orange-Labs, France; Gemalto, France; INDRA, Spain; Italtel, Italy; Nokia Siemens Networks, Finland; RAD Data Communications, Israel; Siemens AG, Austria; ST Ericsson, Belgium; Telefónica I+D, Spain; Telenor, Norway; Technicolor (formerly Thomson), France; Thales, France; Turkcell, Turkey; Türk Telekom, Turkey.

By 2011, around 90 R&D projects, involving up to 500 R&D organizations, representing a total R&D budget of over 700 million euro, have contributed to the Celtic programme. Since 2006, the number of SMEs participating in Celtic is steadily increasing. SMEs in Celtic projects account now for about 30% of the total effort and 34% of the partners, while it was around 10% less in the first calls.

**HOW WOULD YOU DESCRIBE (IN LESS THAN ONE PAGE) YOUR IDEAS AND/OR PLANS FOR FUTURE R&D CHALLENGES/TOPICS RELATING TO NETWORK TECHNOLOGIES?**

The Internet has become the global hub for information and communication where different actors, whether businesses, communities or individuals, connect with each other to share their contents in many innovative ways depending on their context.

Celtic-Plus positions itself at the heart of the upcoming digital era with its new “Smart Connected World” concept. The traditional boundaries between networks, service platforms and applications have become increasingly blurring. This is why new holistic views on the whole communications system are needed.

Celtic-Plus projects, also focus on the architecture and challenges of the Future Internet. The basic elements related to network architecture like flexibility, resilience, survivability and scalability of the routing system should be considered to support new applications requirements like strict latency demands and secure reliable transmission of industrial and private information.

New societal challenges are appearing where communication technologies will have to play a large role e.g. in environmental awareness. Similarly, energy efficiency is now a primary target for new communication systems and solutions. ICT technologies and solutions are now tackling interdisciplinary and multidisciplinary domains. This work now addresses issues such as new applications and technologies for reducing energy consumption, and to actively manage and control the best use of energy in sectors like health, transport, energy, e-government, urbanisation, knowledge and culture.

Celtic-Plus projects deal with future end-to-end service scenarios, 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 preserving European values such as individual privacy and confidentiality.

**HOW DO YOU SEE THE POTENTIAL ROLE OF YOUR ORGANISATION IN HORIZON2020 IN CONNECTION TO THE NETWORK TECHNOLOGIES DESIGN, EXPERIMENTATION AND/OR DEPLOYMENT? WHAT ARE YOUR RESEARCH PRIORITIES?**

Celtic-Plus, and its predecessor programme Celtic, have been supporting telecommunications-related industrial R&D projects since 2004. Since then, it has regularly interacted with the EC and more particularly with the Unit in charge of networking technologies. In 2011, a joint Celtic-Plus/FP7 ICT proposers’ day was organized within the Future Network & Mobile Summit in Warsaw; this year the Celtic-Plus proposers’ day is co-located along FuNeMS 2012 in Berlin.

Recently an interaction with the Future Internet Public-Private Partnership was also initiated to share approaches and, hopefully, ensure interoperability of solutions.
Now that the “Network Technologies” Unit is looking within the new HORIZON2020 programme to address “European industrial leadership” with a stronger emphasis on maximizing the impact of research and innovation for EU industry, economic growth and jobs creation in Europe, the relationship between the newly created “Network Technologies” Unit and Celtic-Plus could be revised and possibly enhanced, as we share this common goal.

The Celtic Core Group members are currently working with representatives from national public authorities of the EUREKA countries to renew the strategic priorities of Celtic-Plus for the next few years. When preliminary recommendations are available, and when the strategic priorities of the “Network Technologies” Unit are defined as part of the new DG CONECT organization and the progress in the decisions related to HORIZON2020, then a meeting could be set up to discuss a renewed relationship and complementary activities.

**WHICH NETWORK TECHNOLOGIES REQUIREMENTS AND EXPECTATIONS, DO YOU CONSIDER IMPORTANT TO INSPIRE INNOVATION AND BRING MOST BENEFITS TO YOUR (BUSINESS) DEVELOPMENT IN THE FUTURE?**

Celtic-Plus is widely recognized in the European ICT R&D environment as a key enabler for ambitious and innovative projects dedicated to communications.

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 will 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-centric solutions, is foreseen.

Celtic-Plus projects will significantly contribute to advances on such infrastructure topics as economic fibre solutions, LTE and beyond 4G. Security topics such as beyond DRM, trust, and security, will also 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.

The high importance of the telecommunications sector for the European economy and the increasing technological challenges are the main drivers to carry out further business-oriented research in all areas related to a “Smart Connected World”.

**WHICH CROSS SECTOR SYNERGIES IN RELATION TO THE NETWORK TECHNOLOGIES RESEARCH ARE OF STRATEGIC IMPORTANCE TO GENERATE GROWTH IN YOUR BUSINESS SECTOR?**

New societal challenges are appearing frequently and communication technologies will play an increasing role in addressing these challenges e.g. in environmental awareness and others. Technologies and solutions at multidisciplinary level are more and more required to tackle these challenges. Celtic has been one of the first initiatives closely looking at green Internet on technologies for saving energy for and through ICT systems, and is now working with other EUREKA Clusters on potential multidisciplinary projects when deemed relevant by industry.

In close cooperation with the other EUREKA clusters, Celtic-Plus also supports several multi-disciplinary initiatives that have been started at EUREKA level, e.g. on Cleantech, Food & ICT, Smart Grids. These areas show that diversity of the cross sector challenges may be required in some cases.

**HOW DO YOU THINK THAT THE NETWORK RESEARCH COMMUNITY SHOULD BEST ENGAGE WITH THE USER COMMUNITY?**

There is a growing need to place the “people” at the centre of the interaction and integration required between the society, the economy, the technology and the environment.
This is important for promoting priorities related to health and wellbeing, digital world, and sustainable world, to emphasize the need for new generation networks to solve emerging social issues such as energy shortages, ageing demographics, and natural disasters.

Interaction with users and user communities will be considered for use case and smart application trials. In several Celtic projects, the involvement of users (e.g. municipalities, hospitals, or security services) had been anticipated to verify and improve the project results.

WHICH CONSTITUENCIES AND METHODOLOGIES IN RELATION TO NETWORK TECHNOLOGIES RESEARCH ARE MOST IMPORTANT TO MAXIMISE THE IMPACT OF RESEARCH AND INNOVATION IN HORIZON2020?

As Celtic is promoting business-driven research close to the market the impact of research results can be more easily followed as products or business impact are visible in a shorter time-frame after the project closure. Project impact is checked by reviews and impact assessments some time after the project closure. For high impact project Celtic has introduced project excellence and innovation awards. In order to increase the impact further and to assure that new technology standardisation/ introduction will not stop but further continued several project continuations have been agreed assuring thus a very significant impact (e.g. WINNER+, B21C, 100GET...).

The HORIZON2020 work plan should ensure that core ICT challenges for the medium time frame are captured and addressed in its programme.

HOW SHOULD RESEARCH DEVELOPMENTS IN NETWORK TECHNOLOGIES IN HORIZON2020 BE MEASURED AGAINST DELIVERING EU INDUSTRIAL LEADERSHIP WORLDWIDE, SUSTAINABLE ECONOMIC GROWTH AND HIGH-QUALITY JOBS CREATION IN EUROPE?

The simple parameter that must be used to evaluate this is the commercial success and continued economic well-being of the European industrial players as a consequence of the research and development performed within the research programmes. The Celtic experience can be used in the HORIZON2020 context with suitable adjustment of the timeframes.

Measuring achievements against industrial leadership is done at Celtic in the following ways:

- Assessment of project achievements through review, self-assessments and innovation review after around 2-3 years after project closure.
- Important parameters used are: number/ type of new or improved products; directly generated new jobs from project (e.g. spin-offs, etc.); estimated return of investment (RoI); number of generated patents, standards contributions, other publications (including PhDs etc.)
- For innovation review a more precise RoI, number of new jobs, patent exploitation, standardization impact, etc. is collected

As reliable and sufficient impact information after the end of a project is always difficult to get some incentives for providing this data are needed, e.g. by offering the “Celtic Innovation Award” which is awarded to projects, which have already finished some time ago and proven in the meantime that their result indeed led to significant impact.
SINTEF by Arne Lie
Proposal by Arne LIE (SINTEF ICT, Norway)

**Title**
SINTEF ICT input to HORIZON2020

**Contribution**
There is a clear tendency that mobile wireless communication technology will carry more and more Internet traffic. Challenges in this regard include mobility, capacity, scalability, reliability, and security. Capacity is highly correlated to the frequency radio spectrum. SINTEF ICT believe that there is still gains to be achieved in higher spectrum utilization (e.g. bandwidth efficient modulation, out-of-band suppression like FBMC, higher frequency bands, dynamic spectrum access/Cognitive Radio), better spatial utilization (smart antennas, interference control, topology optimization such as heterogeneous networks), and improved overhead ratio (efficient MAC and signaling protocols). In addition to these research areas, there will also be important to gain control of the traffic itself. Video streaming has become a major traffic class, but is still lacking efficient standardized functionality to adapt the content quality to the networks and terminals requesting such resources. As such, dynamic video rate and quality adaptation will assist in the scaling challenges of the future Internet.

SINTEF ICT believes that energy efficient hardware and software algorithms are key parameters in future networks, not only to ensure market success, but also to fulfill green radio obligations. SINTEF ICT will also focus on Northern sea areas research, such as underwater communications to support general sea monitoring e.g. related to new oil explorations and prospected summer ship traffic between Europe - Asia, ice detection, ship navigation, and environment monitoring.

A key requirement to future network technologies is increased capacity, in
terms of total data rates per area as well as in terms of users. Partitioning of
the frequency resources between several networks and technologies is
another characteristic expected to be seen more often in future networks.
Coexistence mechanisms are of great importance to increase the utilization
of frequency resources shared by different networks and technologies. The
efficiency of such algorithms relies on flexible and intelligent networks with
cognitive capabilities. Cognitive networks are already today receiving
considerable attention both from the research community and from the
industrial community, and through standardization bodies like 3GPP and
IEEE802.xx.

SINTEF ICT, as one of the largest independent non-profit ICT research
organizations in Europe, wants to play a major role in HORIZON2020, as
STREP and IP project partner as well as coordinator. Our contributions will
mainly focus on design and experimentation. The latter may include
simulations and test-bed creation, both with off-the-shelf equipment such as
USRP, and with own designed prototyping. Our research priorities will be
related to research areas such as opportunistic spectrum utilization
(cognitive radio) and self-organizing networks (cognitive networks, SON, ad
hoc, sensor networks). Of particular solutions can be large MIMO
constructions, co-operative networking, and distributed decision-making.
Underwater, terrestrial, and satellite communication are all within our field of
interest and experience.

Europe has the largest concentration of SMEs in the ICT sector. We believe
therefore that HORIZON2020 should emphasize the importance of SME to be
involved in the program. SINTEF ICT is developing methods and solutions
applied to varied industrial and government sectors. The ICT improvements
can benefit more than one sector and there is growth potential in addressing
ICT issues to previously very culturally separated sectors.
1. Which sector are you representing? What are the strengths and size of your market in Europe and/or worldwide?

- Telecommunication R&D
  - SINTEF is a multidisciplinary organization that finds intelligent, profitable solutions for the public and private sectors' needs based on research and development in technology, the natural sciences, medicine and the social sciences. **SINTEF ICT** is one of the strategic areas of SINTEF offering integrated research-based knowledge through access to a broad competence and technology platform within ICT.

- Strength & size:
  - The ICT-institute has vast experience in EU funded research projects. In the Department of Communication Systems the activities covers the whole ISO protocol stack. Example R&I are antennas, front-ends, modulation and coding, mobile networks, sensor networks, and satellite communication and positioning.
  - SINTEF ICT has about 300 employees. Gross turnover 2011 was about 50 M€.

- Clients / applications / markets:
  - Mobile network operators & virtual mobile network operators: These operators increase in number and turnover year by year, both within Europe and on a global scope. Oil companies & oil 3rd party companies (e.g. subsea communication) constitute very large and strong markets. Growing markets include Food source tracking (e.g. using RFID, also fish tracking) :: Health care (sensors, medical body sensor networks) :: Satellite (communication, positioning).
2. How would you describe your ideas and/or plans for future R&D challenges/topics relating to Network Technologies?

- **Future Internet**
  - There is a clear tendency that mobile wireless communication technology will carry more and more Internet traffic. Challenges in this regard include mobility, capacity, scalability, reliability, and security. Capacity is highly correlated to the frequency radio spectrum. SINTEF ICT believe that there is still gains to be achieved in higher spectrum utilization (e.g. bandwidth efficient modulation, out-of-band suppression like FBMC, higher frequency bands, dynamic spectrum access/Cognitive Radio), **better spatial utilization** (smart antennas, interference control, topology optimization such as heterogeneous networks), and **improved overhead ratio** (efficient MAC and signalling protocols). In addition to these research areas, there will also be important to gain control of the traffic itself. Video streaming has become a major traffic class, but is still lacking efficient standardized functionality to adapt the content quality to the networks and terminals requesting such resources. As such, **dynamic video rate and quality adaptation** will assist in the scaling challenges of the future Internet.

- **Internet of Things**
  - SINTEF ICT believes that **energy efficient** hardware and software algorithms are key parameters in future networks, not only to ensure market success, but also to fulfil green radio obligations. SINTEF ICT will also focus on **Northern sea areas research**, such as underwater communications to support general sea monitoring e.g. related to new oil explorations and prospected summer ship traffic between Europe - Asia, ice detection, ship navigation, and environment monitoring.
  - **R&D focus in the years to come**: Sensor networks (both radio and underwater acoustic networks) will be in focus, with enhanced expectations of efficiency and throughput. Satellite systems will continue being a major factor in providing global infrastructure, such as within ATM — air traffic management, and GNSS — global navigation satellite system. We believe new markets will enter into the arena of combined GNSS/mobile products.
3. How do you see the potential role of your organisation in HORIZON2020 in connection to the network technologies design, experimentation and/or deployment? What are your research priorities?

- SINTEF ICT, as one of the largest independent non-profit ICT research organizations in Europe, wants to play a major role in HORIZON2020, as STREP and IP project partner as well as coordinator.
- Our contributions will mainly focus on design and experimentation. The latter may include simulations and test-bed creation, both with off-the-shelf equipment such as USRP, and with own designed prototyping.
- Our research priorities will be related to research areas such as opportunistic spectrum utilization (cognitive radio) and self-organizing networks (cognitive networks, SON, ad hoc, sensor networks). Of particular approach methodologies are large MIMO constructions, cooperative networking, and distributed decision-making. Underwater, terrestrial, and satellite communication are all within our field of interest and experience. Moreover, this includes antenna design, radar systems, positioning outdoor and indoor, and wireless process control and real-time instrumentation.
4. Which network technologies requirements and expectations inspire innovation and bring most benefits to your (business) development in the future?

- On topology
  - The implementation of new satellite systems in high elliptical orbits (HEO) covering the polar regions would bring new opportunities with respect to exploration and exploitation of these areas, requiring new and adapted communication and application driven equipment development. Satellite serving as backbone for permanent or temporary local networks is one example.
  - Underwater (sensor) network systems with mobile (AUV) and fixed nodes spur work to further enhance the underlying solutions with respect to energy efficiency (e.g. power consumption vs. battery lifetime and energy harvesting) and mission operational optimization based upon process modelling interaction and user support.
  - The increasing density of radio based terminals, being either mobile phones or sensor network elements, represent enormous scalability challenges, but also possibilities for interaction with new user groups and new applications where we can build upon or develop new solutions in a wide application domain.
  - The variation in topologies for (heterogeneous) networks will accelerate the need for validating the performance via system simulations like e.g. ns3, where new system components are included when needed to make this possible.
4. Which network technologies requirements and expectations inspire innovation and bring most benefits to your (business) development in the future? (cont.)

- **Wireless capacity (requirement: 500-1000 times increase by 2020)**
  - Advanced multiple antennas/transducer solutions to make it practical, energy efficient and cost efficient
  - Advanced signal processing and coding solutions and algorithms under fixed and mobile nodes.
  - Advanced and novel access/resource allocation solutions (MAC, scheduling, etc)
  - Balancing QoS/QoE among a set of users and applications
  - Allocation of spectrum resources in an efficient and adaptive manner among the parties
  - Interference handling through either avoiding, minimization or cancellation
  - Efficient cooperating networking for operational interactions

- **Heterogeneity**
  - Heterogeneity solutions challenge application QoS and capacity sharing in concatenated networking
  - Capacity sharing/offloading between different networks influences the application performance and fairness

- **Distributed signal processing**
  - Distributed and efficient networking spurring a new level of cooperated signal processing within various types of sensor networks with both fixed and mobile nodes
4. Which network technologies requirements and expectations inspire innovation and bring most benefits to your (business) development in the future? (cont.)

- **Coexistence**
  - A key requirement to future network technologies is increased capacity, in terms of total data rates per area as well as in terms of users. Partitioning of the frequency resources between several networks and technologies is another characteristic expected to be seen more often in future networks. Coexistence mechanisms are of great importance to increase the utilization of frequency resources shared by different networks and technologies. The efficiency of such algorithms relies on flexible and intelligent networks with cognitive capabilities. Cognitive networks are already today receiving considerable attention both from the research community and from the industrial community, and through standardization bodies like 3GPP and IEEE802.xx. This activity will only continue in the years to come, and remain a key topic also in our future R&D.

- **Radio “Cloud computing”**
  - “Cloud computing” with a light radio concept enables innovative solutions with multiple radio interfaces operating in a resource (in space, time, frequency) sharing manner through distributed/centralized processing for each solution.
5. Which cross sector synergies in relation to the network technologies research are of strategic importance to generate growth in your business sector?

- SINTEF ICT is developing methods and solutions applied to varied industrial and government sectors. The ICT improvements can benefit more than one sector and there is growth potential in addressing ICT issues to previously very culturally separated sectors.
- Increased use of ICT in traditional infrastructure will likely have a multiplicative effect. That is, when a platform for basic services like smart metering or electronic patient journals are in place, ideas for new services will spring forth and drive demand for increased network capacity – a synergetic effect. This effect has already been seen with the new generation of smartphones, where the sudden popularity of “Apps” rather than traditional speech and simple data services, is driving demand for new and more capable handsets.
Another form of synergy is achieved when seemingly weakly related applications can be jointly optimized by the enablement of ICT. Smart grids and smart buildings are by themselves improvements, but considering them jointly promises even greater benefits.

The premise is of course a capable, flexible and extendible ICT infrastructure that can grow with the demand.
6. How do you think that the network research community should best engage with the user community?

- It must be encouraged to include user communities in the projects. Depending on the content of the project, this may be done in different ways:
  - SMEs industrialising the technology may be active partners in the project
  - Consumer groups (e.g. hospitals, public bodies and agencies, industry using communication services, etc.) may participate in reference groups and advisory groups connected to the projects
  - Trials including individual consumers may in some projects be included, in others such activities should be planned as a continuation of the projects
- Telecom operators have day-to-day contact with consumers, and depend on the satisfaction of their customers. In many projects they will provide interaction with the mass market
  - Standardisation is an activity that is important for the impact of projects, and in which telecom operators play an important role
- Activities addressing sosio-economical effects of e.g. EU policy, introduction of new technology etc. as well as cost-benefit analysis should in many cases be included in projects (and may also be done in separate activities).
  - May include interviews, user surveys etc.
  - May constitute a way to evaluate the impact of a project
- The Commission should involve the user community through future "calls for consultation" similar to this one, possibly targeting specific user communities
- The importance of R&D within future network technologies for Europe must be communicated to the population within Europe. This may be done as part of dissemination activities within every single project, as well as in communications from the Commission on a more general basis.
7. Which constituencies and methodologies in relation to network technologies research are most important to maximise the impact of research and innovation in HORIZON2020?

- Investment in telecommunication network infrastructure will provide an economic stimulus to growth in the ICT sector as well as contribute dramatically in growth rate in other sectors.
- ICT will be an effective enabling technology in addressing the "Grand Societal Challenges" of climate change, energy shortage, transportation, health and demographic changes.
- Europe has the largest concentration of SMEs in the ICT sector
  - R &I through Horizon 2020 will contribute to strengthen Europe’s place in the ICT sector, thus enabling growth and reduction in unemployment throughout Europe for more than the ICT sector
  - We believe therefore that HORIZON2020 should emphasize the importance of SME to be involved in the programme:
    - It will be beneficial for the SME itself & beneficial for Europe’s development
8. How should research developments in network technologies in HORIZON2020 be measured against delivering EU industrial leadership worldwide, sustainable economic growth and high-quality jobs creation in Europe?

- **High-quality jobs** in the EU are a prerequisite to the development of knowledge, technical progress and value-creation
  - Measured in terms of prerequisites for the jobs, salaries, length of employment, reputation of research and scientists, carrier prospects, job turnover…
- **Industrial leadership** is made possible when there are both technical progress and willingness to implement them in new or existing commercial frames
  - Measured in terms of sales prospects, recognition, reputation of involved companies
- Willingness comes from the economical prospects outweighing a stand-by strategy in the coming years, to ensure **sustainable economic growth**
  - Measured over long period of time after project completion, alternatively look back at previous success stories or failures due too much wait and loss of competitiveness
- The economical prospects result from a complex "system" interplay of several actors both within the EU and outside.
  - Customers: funding agencies, citizens, governments, investors
  - Vendors: research institutions, technology industry
Example of ecosystem: Cognitive Radio

- New products
- Larger market
- Better spectrum utilization
- Enhanced competition

- Lower cost
- Better services
- New services
- New devices

- Lower costs
- Increased value of own spectrum
- New revenues
- Enhanced capacity

- Interference (Decreased value of own spectrum)
- Increased competition
- Higher costs (e.g. interference mitigation)
SINTEF ICT answers to HORIZON2020 consultation

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4. **Which network technologies requirements and expectations inspire innovation and bring most benefits to your (business) development in the future?**

**On topology**

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  - Balancing QoS/QoE among a set of users and applications
  - Allocation of spectrum resources in an efficient and adaptive manner among the parties
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- **Heterogeneity**
  - Heterogeneity solutions challenge application QoS and capacity sharing in concatenated networking
  - Capacity sharing/offloading between different networks influences the application performance and fairness

- **Distributed signal processing**
  - Distributed and efficient networking spurring a new level of cooperated signal processing within various types of sensor networks with both fixed and mobile nodes

**Coexistence**

A key requirement to future network technologies is increased capacity, in terms of total data rates per area as well as in terms of users. Partitioning of the frequency resources between several networks and technologies is another characteristics expected to be seen more often in future networks. Coexistence mechanisms are of great importance to increase the utilization of frequency resources shared by different networks and technologies. The efficiency of such algorithms relies on flexible and intelligent
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"Cloud computing" with a light radio concept enables innovative solutions with multiple radio interfaces operating in a resource (in space, time, frequency) sharing manner through distributed/centralized processing for each solution.

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**5. Which cross sector synergies in relation to the network technologies research are of strategic importance to generate growth in your business sector?**

SINTEF ICT is developing methods and solutions applied to varied industrial and government sectors. The ICT improvements can benefit more than one sector and there is growth potential in addressing ICT issues to previously very culturally separated sectors.

Increased use of ICT in traditional infrastructure will likely have a multiplicative effect. That is, when a platform for basic services like smart metering or electronic patient journals are in place, ideas for new services will spring forth and drive demand for increased network capacity – a synergetic effect. This effect has already been seen with the new generation of smartphones, where the sudden popularity of “Apps” rather that traditional speech and simple data services, is driving demand for new and more capable handsets.

Another form of synergy is achieved when seemingly weakly related applications can be jointly optimized by the enablement of ICT. Smart grids and smart buildings are by themselves improvements, but considering them jointly promises even greater benefits.

The premise is of course a capable, flexible and extendible ICT infrastructure that can grow with the demand.
6. How do you think that the network research community should best engage with the user community?

- It must be encouraged to include user communities in the projects. Depending on the content of the project, this may be done in different ways:
  - SMEs industrialising the technology may be active partners in the project
  - Consumer groups (e.g. hospitals, public bodies and agencies, industry using communication services, etc.) may participate in reference groups and advisory groups connected to the projects
  - Trials including individual consumers may in some projects be included, in others such activities should be planned as a continuation of the projects
- Telecom operators have day-to-day contact with consumers, and depend on the satisfaction of their customers. In many projects they will provide interaction with the mass market
  - Standardisation is an activity that is important for the impact of projects, and in which telecom operators play an important role
- Activities addressing socio-economical effects of e.g. EU policy, introduction of new technology etc. as well as cost-benefit analysis should in many cases be included in projects (and may also be done in separate activities).
  - May include interviews, user surveys etc.
  - May constitute a way to evaluate the impact of a project
- The Commission should involve the user community through future "calls for consultation" similar to this one, possibly targeting specific user communities
- The importance of R&D within future network technologies for Europe must be communicated to the population within Europe. This may be done as part of dissemination activities within every single project, as well as in communications from the Commission on a more general basis.
7. Which constituencies and methodologies in relation to network technologies research are most important to maximise the impact of research and innovation in HORIZON2020?

Investment in telecommunication network infrastructure will provide an economic stimulus to growth in the ICT sector as well as contribute dramatically in growth rate in other sectors. ICT will be an effective enabling technology in addressing the "Grand Societal Challenges" of climate change, energy shortage, transportation, health and demographic changes.

Europe has the largest concentration of SMEs in the ICT sector. R&I through Horizon 2020 will contribute to strengthen Europe's place in the ICT sector, thus enabling growth and reduction in unemployment throughout Europe for more than the ICT sector. We believe therefore that HORIZON2020 should emphasize the importance of SME to be involved in the programme. It will be beneficial for the SME itself & beneficial for Europe's development.

8. How should research developments in network technologies in HORIZON2020 be measured against delivering EU industrial leadership worldwide, sustainable economic growth and high-quality jobs creation in Europe?

- High-quality jobs in the EU are a prerequisite to the development of knowledge, technical progress and value-creation
  - Measured in terms of prerequisites for the jobs, salaries, length of employment, reputation of research and scientists, carrier prospects, job turnover...

- Industrial leadership is made possible when there are both technical progress and willingness to implement them in new or existing commercial frames
  - Measured in terms of sales prospects, recognition, reputation of involved companies

- Willingness comes from the economical prospects outweighing a stand-by strategy in the coming years, to ensure sustainable economic growth
  - Measured over long period of time after project completion, alternatively look back at previous success stories or failures due too much wait and loss of competitiveness
• The economical prospects result from a complex "system" interplay of several actors both within the EU and outside.
  - Customers: funding agencies, citizens, governments, investors
  - Vendors: research institutions, technology industry

![Diagram of ecosystem: Cognitive Radio](image)

- New products
- Larger market
- Better spectrum utilization
- Enhanced competition
- Lower cost
- Better services
- New services
- New devices
- Interference (Decreased value of own spectrum)
- Increased competition
- New revenues
- Enhanced capacity
- Higher costs (e.g. interference mitigation)

Figure 1 Example of ecosystem: Cognitive Radio