Infrastructures PPP for a Smart Connected Future

A European ICT Industry Initiative for Horizon 2020

Context and Objectives

The application of advanced Information and Communication Technologies (ICT) in Europe is currently estimated to be providing 50% of all European productivity growth. Many new jobs are being created in all industry sectors through the deployment and use of advanced ICT services and networks. In parallel, the high speed broadband connectivity being deployed to European citizens is giving Europeans more and more access to information and inclusion in social, environmental, governmental activities and unprecedented access to entertainment content.

However, this revolution of information and services is accelerating so fast that positive action has to be taken now to ensure that the European infrastructures can undergo a compete paradigm change to become the ubiquitous high-capacity high-speed pervasive intelligent network infrastructure that will be the basis of social, economic and industrial growth and development by 2020.

All of the European industrial growth drivers, like smart grid, smart cities, factory automation, environmental technologies, automotive industry, and aerospace industry demand and expect seamless services where the underlying is capable of optimising their individual services to the highest quality, reliability, security and availability requirements.

It is critical that Europe takes a specific initiative now to stimulate the development of the ICT infrastructure 2020 and, in this way, to ensure the competitiveness of both the European ICT industry and all the industrial sectors requiring advanced ICT services as part of their competitive profile.

The additional benefit is that preparing and providing the new infrastructure will also empower European citizens by giving them access to the most advanced capabilities for the benefit of their social wellbeing and to enable their inclusion into all aspects of European Life in accordance with the Digital Agenda.

The Strategic objectives of this initiative are:

- To reinforce the European industrial leadership in Network and Information Systems
- To accelerate the adoption and use of advanced ICT services in Europe
- To attain European leadership in uptake and use of ICT technologies
- To advance the critical communications infrastructure in Europe and its implementation
- To drive the integration of the services and the intelligent infrastructures for highly optimised service provision across heterogeneous network technologies
- To be the global leader in the "Big Data" economy and services

To achieve these objectives the European ICT industry is proposing to have a focused initiative, in partnership with the European commission, to harmonise and align the strategic investments necessary over the next 7 years to achieve the maximum impact in terms of success for European industry and benefits for European society and citizens.

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Motivation and Focus

Our vision and major trends for 2020

The clear vision shared by all is that the communications environment of 2020 will be infinitely more rich and complex than the networks and services of today. We are advancing towards 2020 with an initial driver of dramatically growing demands for data throughput for all services. These demands for bandwidth and high-speed connections are emerging from all users. As soon as universal high speed access is available, the demands on the core networks for performance will explode. In addition the numbers of devices that will be connected is also exploding and dramatically increasing the demands on the networks and infrastructures. We must now anticipate these growth characteristic and start the revolution in terms of infrastructure that will be needed to cater for these explosive growth scenarios.

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

The hyper connected world

Our world in 2020 will be fully interconnected. We can expect that practically everything from the house plants needing water to the quality of the air we breathe will be measured, instrumented, and sensed for every possible parameter. Once we have gathered all this information we will want to do things with it. So our world will be analysed, processed, modelled to the extent where we will have a double existence in the real and virtual worlds.

In our vision we can foresee that by 2020 we will live in an enhanced ICT world where Virtual meets Real. Knowing this, we can see how the service across the real/virtual boundary will be the drivers for many of the parameters that must be totally renewed before 2020.

If we consider, for example, the demands of Augmented Reality in terms of the amount of information that will be provided to the users in a short time in a specific location we can immediately see needs to dramatically improve the wireless interface and have a 5th Generation wireless that exploits many different network technologies to provide high bandwidth services at high quality of Experience. If we then expand this scenario by considering large scale crowds accessing such services then we are into designing a new architecture for the networks and infrastructures that intelligently understand user needs and trends and dynamically reconfigure connectivity and information availability in real time to satisfy literally millions of customers.

Our expectation is that in 2020 the Internet infrastructure will be capable of connecting everything: people, things, processes, content, knowledge, information, goods, in a flexible but powerful way.

The new infrastructure technological challenges

Based on our vision that the new infrastructure is a holistic support system for communications and services, we can see that it will be a very complex system that needs stepwise developments in many aspects to be ready for the 2020 challenge.   We can see that by 2020 the challenges include:

- New Architectures 1: In our scenario the network resources will be virtualised and application interfaces have the ability to work with the virtual interface to demand and agree parameters for the performance of the services in real time. This means we need an integrated service/infrastructure architecture where the infrastructure can translate all the service demands into physical support and actual delivery for the services with high Quality of Experience.

- New Architectures 2: The capability to reconfigure the network elements, using Software Defined Networks (SDN) approaches, to vary the configuration of the network in response to demands means we must have an architecture where strong robust algorithms will ensure continuous and efficient operation of the infrastructure. This architecture will address the problem of providing processing, storage and network capacity where and when needed on a demand basis.

- New Architectures 3: we need to separate applications from the constraints of todays infrastructure and means of communication, through new architectural and technological solutions based on the virtualisation of the network resources.

- New Architectures 4: The network shall be designed to integrate heterogeneous technologies (Wireline, Wireless and satellite) and transport schemes (unicast, multicast and broadcast) to optimise the deployment/operational cost and maximise its resiliency with respect to man made and natural disasters.

- A new generation of mobile infrastructure: 5G - while the term 5G might imply staying with the cellular model we need to stress that this actually involves much more, including different wireless technologies, high frequency short distance communications and satellite communications under coordinated and shared spectrum usage, etc., and all these factors will be essential for addressing the speed and scale challenges even before 2020.

- The big data challenge involves new mathematical and statistical tools enabling knowledge engineering to identify, collect, collate, process and present the network and infrastructure data in a consumable form for novel applications and services to use. This also has an impact on networks as the logic for bringing data and computing together for efficient analysis creates yet another optimisation puzzle.

- New efficiency paradigms not only in terms of the optimisation of resources in the infrastructure (computing, storage, transport, etc., etc.,) but also ensuring that each and every element is an environmentally and energy efficient as possible. Sustainability must be a key dimension of the infrastructure evolution for "opex: reasons as much as environmental ones.

This list of challenges is obviously not complete and many of these need to be subdivided into more specific challenges that are addressable in modular form.

It cannot be stressed enough that the infrastructure needed for the rich services scenario of 2020 is so advanced compared to today infrastructure that only a specific initiative to accelerate the infrastructure revolution in Europe will ensure that European society and industry – and particularly the European ICT industry - will be competitive in 2020.

A focussed approach

It is a fact that Europe has been, and still is, lagging behind its main competitors in terms of ICT R&D Investment[1]. In this case it is all the more critical that our investment into having the necessary infrastructure coming on line by 2020 is done in a coherent and focussed way to maximise the achievements and returns from our work. This ambition is shared by Industry, the European commission and the national authorities. All parties want to achieve maximum impact from out H2020 investments.

Our call includes setting the European ICT focus so that the needs of the key European industries are addressed and, in this way, we will ensure the sustainability of these European industries' businesses as well as the leadership of the European ICT industry.

A critical aspect of having a focussed approach is the need to understand and assess the proposals for project under this initiative in terms of how they contribute to achieving the overall vision. Involvement of different industrial sectors in the work – particularly as concepts need to be validated - should be inherent in the programme.

Drivers of change

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

Advanced Applications: Like the previously quoted augmented reality, we foresee future applications needing to understand the user context in terms of the infrastructure available so that the user experience can be ensured despite the limitations of the physical infrastructure in the user location. Future services agreements will include performance/delivery parameters and the infrastructure must be intelligent enough to understand and commit to these.

Big data: The big data scenario includes many new roles for data aggregation but also anticipates the impact on the infrastructure if millions of sensors stream data continuously into the infrastructure and expect it to be processed continuously. Much of this data will be generated for a primary business model but then may be used in novel ways to generate further value. In many cases the data owning companies may not realise what assets they have in their data and entrepreneurs may help them to identify and commoditise the additional value.

New usage models: The increased use of cloud computing and cloud services shows market willingness to use the infrastructure to store and process their data – both personal and commercial. As security and privacy techniques improve we can expect this trend to continue. This also has direct impacts on the infrastructure not only in the dimensioning and distribution of cloud facilities, but also

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[1] http://www.ictventuregate.eu/wp-content/uploads/2011/01/The-2010-report-on-R-D-in-ICT-in-the-EU.pdf

in the availability and reliability of ubiquitous access to the Internet with sufficiently high throughput rates and high Quality of Experience. The provision of high availability and reliability of communication networks, as well as high security, is vital for mission critical applications. We can see the trend already now that more and more critical infrastructures in our societies and economies are dependent on the Internet and communication networks.

New market parameters: Europe has very low prices for Internet access and an almost universal price versus speed type of competition in the market. In the lifetime of this initiative we foresee a new maturity in the internet services market where the competition will move to new factors such as quality, reliability, availability, openness, eco-responsibility and security/trust level and many other factors will become much more critical rather than the current focus on price only. In the storage context, users may require clear information on where their information is stored and assurances that it does not fall under different legal domains.

Infrastructure: the necessary Initiative

With this initiative the European ICT industry are committing to assemble competences at European level and initiate collaborative research to develop the infrastructure of advanced Networks and Information systems that will place Europe at the forefront of the global networked society.

The accelerated design development and deployment of the ubiquitous high-capacity high-speed pervasive intelligent infrastructure which is the focus of this initiative will set European business, government and society on the road to a bright and competitive future.

The focus of the initiative will be the ubiquitous high-capacity high-speed pervasive intelligent infrastructure for work and leisure which includes supporting specific approaches such as the smart cities of tomorrow with their modern administration systems.

We must plan for giving European citizens reliable superfast ubiquitous access to intelligent and adaptable ICT services that will enhance their personal and professional lives. This plan should also address how the innovations in ICT can be integrated into the processes of just about every other sector while achieving economies of scale and efficiencies in the use of resources and infrastructure. We must enable M2M interaction at large by further developing the required fundamental technologies in the ICT arena.

To get the maximum benefits for Europe, we propose that this ICT research initiative should be focused on a limited number of "ICT Grand Challenges" where Europe has strength, competence and the opportunity to have a significant impact on a global scale:

1. **To provide capabilities for Big Data and Innovative Services**
2. **To provide Fast, Reliable and Green Networks and Infrastructures**
3. **To provide an Inclusive, Trustworthy and Secure Digital World**
4. **To provide dependable/resilient networks which are becoming increasingly critical infrastructures**

We propose this initiative could be realised by establishing a pan-European partnership between the public and the private sector to align the research activities on Network and Information

Systems within Horizon2020 with a clear strategy, based on measurable goals and identifiable impacts.

The scale of the initiative

It is estimated that the level of change required and the timeframe for implementing the infrastructure changes foreseen means that this initiative needs commitment from all parties to have a consistent but flexible approach. The vision should be the driving force use to determine the relevance and importance of all activities within the initiative and all parties must commit to see activities through to completion.

Given an acceptable set of terms and conditions for this initiative as a PPP under H2020 rules, we can envisage the complete programme having a value in excess of 2B Euro over 7 years with the actual proportions of the investments depending on the funding models that will be adopted for H2020.

Actions and outputs

The initial set of ideas on typical actions at a programme level within such an initiative includes:

- Definition of a consensus vision of "Smart Connected Future", including technological architecture and business benefits
- Definition of a strategic "Smart Connected Future" roadmap with sector actors.
- Definition of an innovation/exploitation strategy;
- Development of critical technology evolutions and elimination of technological roadblocks;
- Appropriate use of large scale experiments and European demonstrators for proof of concept and viability testing;
- Preparation, early in the process, of a standardisation roadmap;
- Liaison with relevant fora where research on next generation of networks and information system is going to be performed;
- Liaison with international players taking into account planned US and Asia initiatives in this domain;
- Establishment of an IPR strategy, ensuring European presence in the IPR landscape;
- Engaging dialogue with sectors and application providers to quantify./estimate migration paths and strategies
- Facilitate deployments and adoption of results, products and solutions by public authorities, citizens and SMEs :
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Of course this would be in addition to a coherent set of projects addressing the technological challenges and roadblocks

Articulation with other initiatives

In keeping with the approach of having a focussed approach, it is the interest of the industrial participants that this initiative is complementary to national and pan-European activities.

Industry commitments

The ICT industry in Europe needs and wants this initiative to ensure Europe actually is well on the way to having a ubiquitous high-capacity high-speed pervasive intelligent infrastructure by 2020. Without it, it is unlikely the European ICT sector, and the impacted application sectors, will be globally competitive.   In this context the European ICT industry is willing to commit to collaboration on the preparation, implementation and participation in the programme.

This commitment is given in the expectation that Industry can have a meaningful role in overseeing the programme to ensure the commitment can be honoured.

The commitment also undertakes to facilitate an open approach to addressing the challenges with active encouragement to all players across the European ICT sector, large enterprises and SMEs, academic institutions and user organisations to get involved and help finding solutions and promoting uptake of the results.

What cannot be committed is the participation of any individual organisation in any stage of the process where company specific decisions or situations may take precedent. We must also ensure the H2020 IPR conditions are not such to actively discourage industrial participation.

ICT Grand Challenges:

Critical technologies and technological roadblocks

This section elaborates our grand challenges to identify the first examples we see of the technological challenges and potential technological roadblocks that must be addressed as a matter of priority under this initiative.

1. Big Data and Innovative Services

Big data value is based on advanced technology trends that will facilitate a new approach to understanding the world and making decisions. We now have lots of information; more than two zettabytes of data worldwide , from people, social networks, mobiles, companies, authorities (Open-Data) which people want to share. When we merge this with the dramatically increasing information from "things" and sensors we are swamped with information. Lots of this data is unstructured.

 Europe needs intelligent systems that can process this data in real time and provide instant decisions. It needs new techniques to understand this data and identify the value in it; it needs entrepreneurs who will see the value to be found in processing big data. Much of this data will reside in the cloud and EU can expect more than 2 million new jobs linked to Cloud Computing by 2015.

In the Horizon2020 timeframe, we foresee that a complete new value sector will emerge where many organisations, including lots of innovative SMEs and start-ups, will generate new knowledge and correlate this information in clever ways and will enable many business and societies to benefit. This will create many new jobs and add to European GDP. This development will be enabled by the holistic approach of developing and providing the necessary infrastructure in cooperation with the services and content industry.

The infrastructure changes we foresee will support new usages that will increase the innovation capacity of businesses and the quality of life of people. Simple ideas like aggregating data from different sources to track a phenomenon will become possible for the first time. This idea can use the common infrastructure in the case of critical usage (police, emergency, defence).

If you take the idea that the Data is available to everyone, everywhere, and all the time then the immediate consequence is that the infrastructure must be provisioned for everyone having access at all times. The idea of no requests being unsatisfied is a huge demand on the infrastructure. Further elaboration of these requirements highlights the need for applications having interfaces to request the infrastructure resources they need. As we expand this concept we see that Infrastructures must "learn" from users (principle of "intelligent or smart query") and, in turn, drive the optimal configuration of the infrastructure in order to adapt to users requests and even anticipate them.

This requires a holistic approach to Network virtualization and elasticity of virtual resources and the provision of Virtual interfaces for physical objects. Infrastructures must support software abstraction (this is not a service middleware) and the creation of contextual semantics according to business domains, software ontology, and dictionaries of simple information. New techniques like Agent based software architectures would allow agents to be used for interpreting ontologies
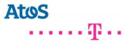
2. Networks and Infrastructures

The demands and needs for advanced networking will increase drastically in coming few years in line with the dramatic increases in the number of connected objects, the ever-increasing data rates, and the demands for pervasive and continuous access to information from users. Already many service models are based on immediate access to, and reliable streaming of, content to the point where personal copies are no longer needed, like in cloud computing. This makes users' behaviours strongly network-dependent. The future networks will have to support very demanding connectivity characteristics (immediate, ubiquitous, reliable, secure…) and to support connectivity with smart mediation.

Our vision is that over the next ten years, telecom and IT infrastructure provisioning will evolve and merge into a common and integrated network infrastructure which will based on undedicated and programmable hardware that will offer resources for transport, routing, storage and computing. Network equipment will become "computing equivalent" equipment that gathers programmable resources based on virtualization technologies. The capability to reconfigure the network elements, using Software Defined Networks (SDN) approaches, to vary the configuration of the network in response to demands means we must have an architecture where strong robust algorithms will ensure continuous and efficient operation of the infrastructure. This architecture must also address the problem of providing processing, storage and network capacity where and when needed on a demand basis.

To address the challenges in **wireless access technologies** and network evolution we aim to have a new generation of mobile infrastructure "5G" standardised by 2020. This new generation must include many different wireless technologies, high frequency short distance communications, satellite communications, under coordinated and shared spectrum usage, etc., as all these factors will be essential for addressing the speed and scale challenges even before 2020.

Other mobile, wireless, radio and satellite technological advancements and trends we must capture include:

- Up to Multi-Gbps mobile data rates at high Quality of Experience

- "Always on" services without battery draining.

- Self-optimized ultra-dense deployment of access points (small cells)

- Flexible spectrum usage and spectrum sharing among stakeholders

- Smart combination of wireless, wireline, satellite technologies to optimise the network's CAPEX, OPEX as well as environmental foot print

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The biggest change in the **optical access technologies,** in terms of network evolution, will be the migration to SDN systems where already in the access networks the network elements will be reconfigurable in real time to cater for user needs.

This SDN approach will be a key mechanism in the core network and it will be controlled by intelligent and flexible systems for the **network management and operation**. The novel engineering will be to combine the benefits of a highly integrated management and control system that support the virtualisation of the network resources with the benefits of advanced autonomic network management across network elements. Another new dimension will come into the management scenario as the **big data and analytics for network operation** can be integrated into the management system.

Another network trend that will have a major driver of change will be the evolution from big centralised data server farms to devices employing cloud based distributed computing and data. In fact the increasing computing power of new mobile devices will create a new challenge on how best to distribute SaaS service functions and contents between data centres and devices.

The current issue of Cloud interoperability should generate integrated prototypes within the next two years and this experience will be key in enabling the next phase of the network architecture evolution by enabling the distributed approach to in-network storage and computation services.

3. *Trustworthy and Secured Digital World*

To be inclusive the digital world must have access points that even the most unfamiliar with new technologies can access and use the information on line, this requires new generations of user friendly intuitive interfaces and economical devices. In the same vein, these users must be protected and able to trust the services they access even if they have no concept of information protection. Universal management of identities and privacy rights must be ingrained in the systems at all levels.

Given these models of pervasive networks and ever more complex automated services gathering and processing data, there is a clear need for specific attention to security, privacy and trust so that all players in the new era are secure and their property is safe. The goal to enhance preparedness, strengthen the resilience of critical infrastructures, as well as to foster a cyber-security culture in the EU has been highlighted for attention, but the range and quality of security measures needs to be dramatically scaled up to address the revolutions expected in data and networks and to protect the use of ICT for many critical infrastructures in our society and economy.

Specifically our vision includes development and demonstration of first integrated prototypes of:

- Transverse management of trust and security

- Robust security and trust in data and usages (truth verification, dynamic identity management and access control, etc)

- New concepts for strengthening cybersecurity systems (behavior analysis, weak signals detection, etc)

- Trusted cloud computing (with assurance levels) through multi-layer (hypervisors, virtual appliances, security abstraction layers) and multi-lateral (distributed placement of firewalls, IDS/IPS),

- Adaptive composition of defence mechanisms with automated security supervision, and rich and trusted identities for cloud (privacy guarantee, spheres/communities).

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This work will allow for the scenario where data flows everywhere and authenticates itself but abnormal events are detected and processed. The strategy is no longer to close accesses but to restrain the damage and minimise risks.

KPIs, proof of concepts, experiments and demonstrations

The approach to this initiative will be to identify, as part of each challenge and objective, key performance indicators that will reflect the phased incremental planning and the continuous building on results through consecutive strategic goals that will guide the programme towards the 2020 vision

We expect that first proof-of-concepts demonstrations of many technical issues and new services will be achieved by 2015-2016.

Vital enablers for the new infrastructures, such as the virtualization of network functions should be ready for standardization in the 2015-2016 timeframe.

A new paradigm for Information Centric Networks (ICN) enabled routers will emerge in the 2016-2017 timeframe.

As 2020 approaches most of the technical challenges will have been address to the point of the solutions moving from the research into the development phase within the ICT industry.