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The 5G Infrastructure Public Private Partnership (5G PPP)

First Wave of Research & Innovation Projects

CONTENTS

The 5G Infrastructure Public Private Partnership (5G PPP)

First Wave of
Research & Innovation Projects

PROJECTS

The 5G communications network and service environment of 2020 will be infinitely richer and more complex than today. The user experience will not only be more involving but also more immersive, supporting all aspects of social interaction, work communication, health monitoring, device and environment management, and even assisting your economic wellbeing too. The challenge now is to provide a 5G infrastructure that has the inherent capacity, capability, reliability, availability and security to provide this seamless life support in a timely and sustainable way. This new network infrastructure must be capable of connecting people, processes, computer centers, content, knowledge, information, goods, and other things at high speed according to a multiplicity of application specific requirements. And while the amount of communication each person does is expected to increase dramatically, the amount of connected things communicating is expected to be 10 times higher than the number of connected human users by then. 5G is not just an evolution – it is a revolution and must be designed to handle this dramatic increase in communications from the start.

Because of the recession and intense competition around the world, the European Union is committed to keep strengthening Europe's role in communications and to develop more European-built Internet infrastructure and services. Issues such as how to support 10 to 100 times more traffic per end user without increasing resource costs or energy usage, and how to provide the highest quality of service and security, need to be answered in European terms.

To achieve these goals, the European Commission, together with industry manufacturers, telecommunications operators, service providers, SME and researchers, initiated the 5G Infrastructure Public Private Partnership.

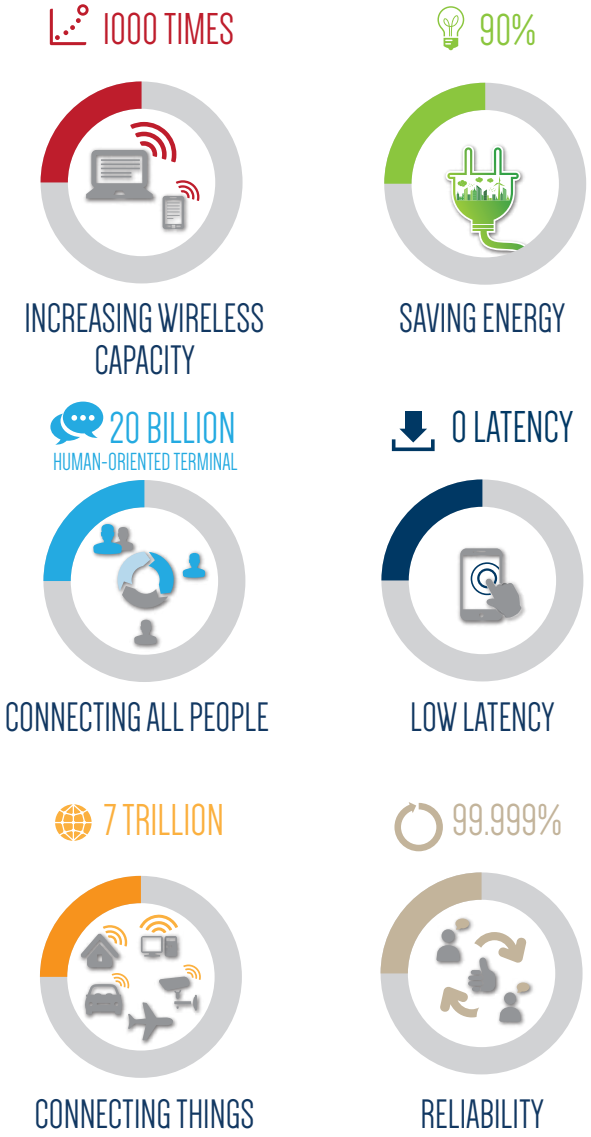
Introducing the 5G Infrastructure Public Private Partnership (5G PPP)

The 5G Infrastructure PPP, in short 5G PPP, is a joint initiative between the European Commission and the European ICT industry. The Commission is planning to invest 700 million € and the industry will leverage this investment by a factor of 5, bringing the total investment into the 5G PPP to more than 4 billion €, to rethink the infrastructure and to create the next generation of communication networks and services. The 5G PPP is aiming at securing Europe's leadership in the areas where Europe is strong or where there is potential for creating new markets such as smart cities, e-health, intelligent transport, education or entertainment & media. The 5G PPP initiative will reinforce the European industry to successfully compete on global markets and open new innovation opportunities.

The 5G PPP will deliver solutions, architectures, technologies and standards for the ubiquitous next generation communication infrastructures of the coming decade.

The main goals of the 5G PPP

The goals for the 5G Infrastructure PPP are as follow:



The first projects of the 5G PPP

The 5G PPP is planned to be organised in three or four phases, encompassing research (current stage), optimisation (2016-2017) and large scale trials (2019-2020). It aims to deploy 5G as from 2020, which will require before 2020 to develop a series of ground-breaking technologies, global standards and to agree on relevant spectrum bands.

On the 1st of July 2015, the projects from the 1st phase of the 5G PPP started with a joint meeting in Paris, France. This was a major milestone to get research investment focused in a very coherent way on the challenges associated with having a communications infrastructure capable of coping with all future demands by 2020.

The first call for projects has resulted in 19 projects being selected addressing a rich cross section of the research challenges leading to a 5G infrastructure by 2020.

The shared belief is that the vast majority of future communications will use wireless access technologies. This puts tremendous requirements on these projects to find ways to maximize the efficiency of the wireless interface, optimize the use of scarce resources – such as spectrum and energy – and dramatically increase the throughput capability of the infrastructure. The 5G Infrastructure will have to cope with everything from billions of small devices in the Internet of Things domain to billions of heavy data consumers enhancing their lives and activities with real-time multimedia content. The new approach must be fully convergent as well as there will be no arbitrary distinction between fixed and mobile – there will be simply a seamless infrastructure satisfying everyone's communications needs in and invisible, but totally dependable, way.

The 19 projects described in this brochure is the first global response from Europe to these challenges.

Key numbers – Phase I

PERIOD

2014-2016

19 PROJECTS

1 COORDINATION & SUPPORT ACTION

15 RESEARCH & INNOVATION PROJECTS

3 INNOVATION PROJECTS

165 ORGANISATIONS INVOLVED

EU FUNDING

128 million €

EDITORIAL

The 5G Public-Private Partnership (5G PPP) within the Horizon 2020 programme of the European Union is the biggest research program in the world on 5G, which will be the future global communication network. 5G research in Europe is building up on research projects started already in the previous Framework Programme of the EU (Framework Programme 7); they already paved the way towards the vision and basic concepts of 5G. Research in the 5G PPP has a very wide scope far beyond classical telecommunication. The current 5G PPP vision and technical requirements are described in a 5G vision document, which was first published at the Mobile World Congress 2015 in Barcelona in March 2015[1].

In December 2013, the 5G PPP Contractual Arrangement was signed by the EU Commission, which is representing the public side, and the 5G Infrastructure Association, which is representing the private side in the PPP. Indeed, Public-Private Partnerships in Horizon 2020 are intended to be industry driven, to strengthen the European economy and the impact on future global standards based on research in Europe. The Association is bringing together many different stakeholders from industry, network operators, SMEs, R&D centers and universities. It is built on elected members by the Networld2020 European Technology Platform in order to support criteria on openness, transparency and representativeness of the sector[2].

The overall objective of the 5G Infrastructure Association is to promote R&D in the networks industry in order to strengthen the networks industry in the European Union, to foster technology skills in Europe by attracting students, and to increase the competitiveness of the European industry by providing new tools and capabilities for manufacturing in Europe. In addition, the Association is working to mobilise the community and in particular SMEs in European collaborative research projects. It is the facilitator of the 5G PPP research program on the private side.

Networld2020 is developing on a regular basis the Strategic Research and Innovation Agenda (SRIA) for the communication networks sector and in cooperation with the Association also the respective SRIA for 5G. This takes the interests of the wider community in the communication networks sector and market driven requirements into account.

From that perspective the Association is representing and addressing the interests of its members and associate members as well as Networld2020's members towards the European Commission, other public authorities and stakeholders. The Association is cooperating with the EU Commission to develop the 5G work program in Horizon 2020, through a dedicated "Partnership Board" which discusses the work program and other activities of common interests to promote 5G PPP and its results globally.

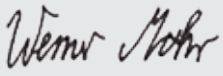
In addition, the 5G Infrastructure Association is helping to address other issues, which are not directly related to technical issues, because the development of future networks also requires to contribute to topics like standardisation, frequency spectrum, other regulatory issues, how to address vertical sectors and international cooperation to support the development of globally accepted standards. The association has already established Memoranda of Understanding (MoUs) with counterparts in China, Korea, Japan and North America.

WERNER **MOHR**

Chairman of the Board of
the 5G Infrastructure Association

The 5G PPP Contractual Arrangement defines key performance indicators (KPIs), which also measure the impact of 5G PPP on the global 5G development. 5G Infrastructure Association is supporting these activities by means of dedicated working groups and activities.

The 5G Infrastructure Association is looking forward for a successful cooperation with 5G PPP projects, Networld2020 and other stakeholders.



[1] Available for download at https://5g-ppp.eu/wp-content/uploads/2015/02/5G-Vision-Brochure-v1.pdf.

[2] Information on the NetWorld2020 European Technology Platform is available at http://www.networld2020.org/.

FOREWORD

MARIO **CAMPOLARGO**

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Networks, Content and Technology

Europe's best research talents set the bar higher for 5G!

With the launch of this first wave of EU-funded projects to develop 5G under the umbrella of the 5G Public-Private Partnership in the Horizon 2020 Programme, Europe has got a sharp edge in the race to the next generation of communication infrastructure.

Out of a total of 83 submitted proposals, 19 projects have been selected. I can say with pride that they are all of an exceptional quality and high level of innovation, reflecting the intensity of the competition between research teams in Europe and the undivided industrial support to the 5G PPP

I strongly believe that the current portfolio of projects represents the best possible balance of topics taking into account the available budget of €128 million. The projects indeed address the main priorities expressed by the telecom sector, as the core community acting in the context of the 5G PPP. This is the first of several calls which will take place between now and 2020. The successive selections of projects will be geared to further extend the range of research areas that need to be covered, and to move progressively to demonstration and large scale trial activities.

As the industry aims at a first commercial deployment around - or shortly after - 2020, this first wave of projects should be instrumental to set the pace for standardisation and spectrum planning cycle which will occur over the 2016-2019 timeframe. These are important milestones that the Commission will follow closely also from a policy perspective, making sure that we have the right regulations and policy measures in place.

The next challenge is now to consolidate the launched projects into the promised programmatic approach to 5G pursued under the 5G PPP so as to achieve the maximum impact through an efficient and bold collaboration between teams. This must be done in full coordination with developments in other regions of the world. Our ambition must be to lead at international level.

Congratulations again to all those that are involved in these ambitious projects. Europe is on track to consolidate its position as a powerhouse telecom innovation!

5G-ENSURE

5G Enablers for network and system security and resilience

TECHNICAL AND RESEARCH CHALLENGES

The need for a new security architecture is motivated by the fact that 5G is a platform that goes beyond telecoms and which will be far more decoupled from specific hardware and physical control of the network. 5G-ENSURE aims to deliver a reference security architecture for 5G which can be used by all 5G projects, and to support its use by providing a useful and useable initial set of security enablers addressing core concerns. The key security enablers considered in 5G-ENSURE are

- Authentication, Authorization and Accounting.
- Privacy.
- Trust.
- Security Monitoring.
- Network Management and Virtualization Isolation.

MAIN OBJECTIVES

The overall objective of 5G-ENSURE is to become the reference project for everything that concerns security in 5G while contributing to 5G resilience. As such, this project will be focusing on 5G Security Architecture able to generate the necessary trust and confidence for 5G to be widely adopted and deliver its promises through applications enabled. To achieve this overall ambition, the following objectives will be targeted:

- Collect, analyse and prioritize 5G security requirements.
- Define a security architecture for 5G.
- Specify, develop and test an initial set of security enablers for 5G.
- Demonstrate the potential of 5G Security enablers developed in the context of 5G representatives' showcases.
- Advertise and exploit the Project's results and offering to the 5G PPP community and beyond.
- Foster 5G Security Vision by delivering a 5G Security Roadmap.
- Act as pre-standardization consensus builder.

APPLICATIONS

5G-ENSURE will gather use case input from external sources and, if possible, establish liaisons with one or more external 5G-related projects or activities (e.g. other projects running in the PPP). Since the inputs from external sources will mainly be business and technology driven, 5G-ENSURE will also define additional realistic use cases that highlight the relevant security and privacy issues.

IMPACT

5G-ENSURE will deliver strategic impact across technology and business enablement, standardisation and vision for a secure, resilient and viable 5G network. 5G-ENSURE will provide the necessary security architecture and enablers to expand the mobile ecosystem into an entirely new networked society, attracting new types of users and providing operators with a platform for novel business opportunities.

PROJECT COORDINATOR

Petteri Mannersalo
VTT TECHNICAL RESEARCH CENTRE
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5G-EXCHANGE (5GEX)

Multi-domain Orchestration for Software Defined Infrastructures

TECHNICAL AND RESEARCH CHALLENGES

The current market fragmentation results from having a multitude of telecommunications network and cloud operators each with a footprint focused on a specific region, while lacking inter-operator collaboration business models, services and supporting tools. This makes it infeasible to deploy and offer cost-effective infrastructure services spanning multiple countries. Existing services and inter-operator collaboration tools are very limited and cumbersome. Our challenges are to invent technical and business solutions to autonomous orchestration of services across multi-domain and multi-technology environments.

MAIN OBJECTIVES

5G Exchange (5GEx) will enable efficient business and technical cross-domain orchestration of services over multiple administrations as well as multi-domain orchestration over single administrations. Such orchestration shall allow instantiating end-to-end networks and services into multi-vendor and heterogeneous technology resource environments. In order to overcome the traditional separation of network resources from compute and storage, 5GEx will realize composite services by seamlessly combining networking with computing and storage across domains. Service deployment, activation and further management can be viewed as the efficient mapping of service elements onto an abstracted model based on a virtualised substrate belonging to multiple operators. The goal of the 5GEx project is the automated assignment and mapping of virtualised service elements, which represent service and network functions and components, to the underlying (physical hardware) resources across domains. 5GEx cross-domain business models and orchestration shall optimise 5G business and operational policies and KPIs including substrate utilisation, OPEX reduction and revenue maximisation. Business-wise, 5GEx will create opportunities for operators to buy, sell, and integrate infrastructure services in an automated and cost-effective manner. 5GEx will build a working end-to-end system and deploy a proof-of-concept prototype, which includes the concept of a “Sandbox Exchange”. Sandbox Exchange will enable new ways of experimentation and use case validation close to an operating environment facilitating the transition from experimentation, to piloting and further to real-world operation. 5GEx will contribute to the relevant standard forums and Open Source communities.

APPLICATIONS

5GEx will focus on a number of use cases for demonstrating the set of functionalities required for multi-domain and multi-technology perspectives, reflecting future realistic scenarios enabled by 5GEx. The use cases have been categorised according to the target service scope to be provided: (i) the Connectivity problem, (ii) the Network as a Service demand, and (iii) the Network - Storage - Computing as a Service request.

IMPACT

5GEx will go beyond the state of the art by (i) achieving a 90-minute service setup; (ii) integrating monitoring instances in the multi-operator architecture; (iii) optimally embedding -in terms of resource utilisation and revenue- service requests into the set of virtualised resources mapped into multiple operators domains while matching each service SLA requirements; and (iv) defining novel business, coordination and information models, trading mechanisms and pricing schemes.

5GEx also aims to experiment and validate the devised mechanisms and architecture of the multi-domain orchestrator into a Sandbox Exchange which will integrate of 5GEx testbeds.

PROJECT COORDINATOR

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5G NORMA

NOvel Radio Multiservice adaptive network Architecture for 5G networks

TECHNICAL AND RESEARCH CHALLENGES

The technical approach followed by 5G NORMA is based on the innovative concept of adaptive (de)composition and allocation of mobile network functions, which flexibly decomposes the mobile network functions and places the resulting functions in the most appropriate location. By doing so, access and core functions no longer (necessarily) reside in different locations, which is exploited to jointly optimize their operation whenever possible. The adaptability of the architecture is further strengthened by the innovative software-defined mobile network control and mobile multi-tenancy concepts, and underpinned by proof-of-concept demonstrations.

MAIN OBJECTIVES

With 5G NORMA, leading players in the mobile ecosystem aim to underpin Europe's leadership position in 5G.

The key objective of the project is to develop a conceptually novel, adaptive and future-proof 5G mobile network architecture. The architecture will enable unprecedented levels of network customisability, ensuring stringent performance, security, cost and energy requirements to be met; as well as providing an API-driven architectural openness, fuelling economic growth through over-the-top innovation.

To show the value of the architecture both to the wireless industry and to the users in society, the project will conduct a socio-economic analysis –closely interacting with the use case analysis– to evaluate and quantify the benefits of 5G NORMA innovations.

Furthermore, the 5G NORMA consortium will also demonstrate the feasibly of the key innovations developed in the project, in particular the service and context dependent adaptation of network function as well as the software defined mobile network control.

APPLICATIONS

The 5G NORMA architecture will provide the necessary adaptability to efficiently handle the diverse requirements and traffic demand fluctuations resulting from heterogeneous and changing service portfolios. By overcoming the 'one system fits all services' paradigm of current architectures, 5G NORMA will allow adapting the mechanisms executed for a given service to the specific requirements of such service, resulting in a novel paradigm of service and context dependent adaptation of network functions. Anticipated services span from mobile broadband including fixed-mobile convergence over vehicular communications, emergency services and industrial control to massive machine type communication and sensor networks respectively the Internet of things.

IMPACT

5G NORMA will ensure economic sustainability of network operation and open opportunities for new players, while leveraging the efficiency of the architecture to do so in a cost- and energy- effective way. Additionally, 5G NORMA targets to foster pre-standardization by building up consensus on specific aspects of the 5G mobile network architecture.

PROJECT COORDINATOR

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5G-XHAUL

Dynamically Reconfigurable Optical-Wireless Backhaul/Fronthaul with Cognitive Control Plane for Small Cells and Cloud-RANs

TECHNICAL AND RESEARCH CHALLENGES

5G-XHaul proposes a converged optical and wireless transport solution able to flexibly connect Small Cells to the core network. Exploiting user mobility, our solution enables the dynamic allocation of network resources to hotspots. To support these novel concepts, the main technical and research challenges are the development of:

1) Dynamically programmable, high capacity, low latency, point-to-multipoint mm-Wave transceivers, cooperating with sub-6-GHz radios.
2) Time shared optical network offering elastic bandwidth allocation, cooperating with advanced passive optical networks.
3) Software-defined cognitive control plane, able to forecast traffic demand in time and space, and accordingly, reconfigure network components.

MAIN OBJECTIVES

Small Cells, Cloud-Radio Access Networks (C-RAN), Software Defined Networks (SDN) and Network Function Virtualization (NVF) are key enablers to address the demand for broadband connectivity with low cost and flexible implementations. However, Small Cells, in conjunction with C-RAN, SDN, NVF pose very stringent requirements on the transport network.

5G-XHaul will develop wireless solutions for dynamic backhaul and fronthaul architectures alongside very high capacity optical interconnects.

APPLICATIONS

Designing the transport network for dense urban scenarios, with massive deployments of Small Cells, is a key use case for 5G-XHaul. We envision a dense layer of Small Cells located 50-200 metres apart and 2-6 metres above street level, e.g. mounted on lamp posts, building walls, or bus shelters. The Small Cell layer is composed of the access part, which can be Remote Radio Heads (RRHs) in the case of a C-RAN architecture, or full Base stations (BSs) in the case of a dense and distributed RAN architecture, and is backhauled using a combination of mm-Wave and Sub-6-GHz wireless technologies.

The Small Cells may be wirelessly backhauled to the macro-cell site, where usually optical fibre is available, or connected to a central office node using passive optical networks (PON). Time shared optical networks (TSON) provide high speed and flexible connectivity in metro and core networks.

5G-XHaul technologies will be integrated and evaluated in a city-wide testbed in Bristol (UK).

IMPACT

In order to provide efficient backhauling for future mobile networks, the industry has identified mm-Wave as one of the most promising technologies. A major technological impact of 5G-XHaul will be to shape the design of future mm-Wave systems by means of novel transceiver architectures and experimental validations.

In the optical domain novel solutions are needed to increase the flexibility of provisioning connectivity, monitoring and troubleshooting the network. The TSON technology defined in 5G-XHaul is a key stepping-stone towards the vision of Backhaul as a Service.

Finally, 5G-XHaul will directly impact the adoption of SDN techniques in the wireless and optical domains.

PROJECT COORDINATOR

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CHARISMA

Converged Heterogeneous Advanced 5G Cloud-RAN Architecture for Intelligent and Secure Media AccessProject name

TECHNICAL AND RESEARCH CHALLENGES

CHARISMA brings together 10G-wireless (via mm-wave/60-GHz & free-space optics, FSO) access and 100G fixed optical (OFDM-PON) solutions through an intelligent cloud radio-access-network (C-RAN) and intelligent radio remote head (RRH) platform with IPv6 Trust Node routing featuring very low-latency traffic management. Low-cost Ethernet is used across the front- and backhaul, with virtualised end-user equipment (vCPE), intelligence distributed across the back-, front-hauls and perimetric data transports.

Ad-hoc mobile device interconnectivities (D2D, D2I, C2C etc.), content delivery network (CDN) and mobile distributed caching (MDC) offer an energy-efficient (better than x20 improvement possible) information-centric network (ICN) architecture. Furthermore, caching provides efficient utilization of scarce resources by lowest common aggregation of data and/or localised execution of communications.

Also, CHARISMA will exploit network programmability and virtualisation technologies to achieve multi-tenancy and enable rapid adoption of emerging network applications.

MAIN OBJECTIVES

CHARISMA proposes an intelligent hierarchical routing and paravirtualised architecture that combines two important concepts: devolved offload with shortest path nearest to end-users and end-to-end security service chain via virtualized open access physical layer security (PLS).

The architecture of CHARISMA focuses on two goals: low-latency (<1ms) and security that are key for the development of future converged wireless/wireline advanced 5G networks. CHARISMA will design and implement a cloud infrastructure solution with increased spectral, energy efficiency and enhanced performance.

APPLICATIONS

The CHARISMA solution aids the development of many applications requiring the transmission of sensitive personal data such as: e-health, remote medicine, wellness monitoring, etc., and that rely on low-latency and low-jitter connections, using high-speed and high-bandwidth communications.

Thus, further to the development of 5G for traditional mobile communications, new applications for Smart Cities and the Internet of Things/Everything are envisioned, giving critical emphasis to end-to-end security.

IMPACT

CHARISMA proposes a set of technologies targeted to accomplish the H2020 objectives. Combining radio and cabled technologies is key to achieving ultra high-speed broadband penetration targets, thus a synergistic combination of FTTH and 5G technologies is required.

Additionally, through its Open Access operational model, CHARISMA reinforces public-private- partnerships to promote the deployment of a single and secure Open Access NGA architecture. Offering Provider/Tenant isolation, it can be operated by multiple Service Providers via virtual slices. CHARISMA offers the latest techno-economic tools and NFV/SDN frameworks while optimising CAPEX and fostering competition.

PROJECT COORDINATOR

Eduard Escalona
FUNDACIÓ I2CAT

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Fundacio i2CAT/ Fraunhofer-Gesellschaft zur Foerderung der Angewandten Forschung E.V/ National Centre for Scientific Research “Demokritos”/ APFutura Internacional Soluciones SL/ InnoRoute GmbH/ INCITES Consulting SARL/ JCP-Connect/ University of Essex/ COSMOTE Kinites Tilepikoinonies AE/ INTRACOM S.A. Telecom Solutions/ Telekom Slovenije/ Portugal Telecom Innovaçao e Sistemas SA/ Ethernity Networks

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COGNET

Cognitive networks

TECHNICAL AND RESEARCH CHALLENGES

- Collect and process “Big Data” from the 5G network in real time.
- Develop new algorithms utilizing machine learning to learn from the collected data and apply this to the network management.
- Improve the scalability, resilience and security of 5G network.
- Make measurable improvements to the networks as recognized through KPIs.

MAIN OBJECTIVES

CogNet aims to research and develop a real-time network management platform with the capability to scale to address the requirements of the future 5G network.

More specifically :

- To collect and preprocess big data from the 5G network.
- Develop, a system for self management of network nodes while supporting federated network management.
- Application of Machine Learning algorithms to address.
  a. demand prediction and provisioning allowing the network to resize using virtualisation
  b. network resilience issues including identifying network errors, faults or conditions such as congestion or performance degradation.
- Identifying serious security issues such as unauthorised intrusion or compromised network components and liaise with autonomic network management to formulate and take appropriate action.

APPLICATIONS

CogNet is developing a number of use cases for 5G network management such as:

- Prediction of demand parameters for services and bandwidth.
- Creation of ‘on demand’ resources to reflect demand through Network Function Virtualisation.
- Improving error and fault detection and mitigation, thus improving network resilience and Quality of Service.
- Improving network security and fraud detection & prevention.
- Detection of performance degradation and address this through resource provisioning and adjustments to network topology.

IMPACT

- Allow the development of 5G networks which are largely self managing.
- Facilitate “Internet of Things” technology.
- Improve the performance of the network through allowing the network scale to the demand according to time and location.
- Improve the QoE of the network as perceived by the end users, through better accessibility, higher speeds and improved security.
- Improve energy efficiency and reduce costs.

PROJECT COORDINATOR

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COHERENT

Coordinated control and spectrum management for 5G heterogeneous radio access networks

TECHNICAL AND RESEARCH CHALLENGES

The exponential growth of mobile traffic, drastically increasing of network complexity, and the strong need for inter-network coordination of wireless network resources call for breakthroughs in control, coordination and flexible spectrum management in 5G networks. The COHERENT project deals with challenges in inter-network coordination of 5G heterogeneous radio access networks, by introducing software-defined networking design principles into radio access networks. It will develop common control interfaces and software-development kits to enable programmable control and coordination in heterogeneous mobile networks. The programmable control in 5G radio access networks will provide mobile operators a flexible and cost efficient way to implement new low layer control functions, provision wireless resources, manage different types of radio access networks, and thus to support open innovation in 5G mobile networks.

MAIN OBJECTIVES

The COHERENT project aims to research, develop and showcase a unified programmable control framework for 5G heterogeneous radio access networks. The project will focus on three innovations in control and coordination of 5G networks:

- Software defined networking for radio access networks, to enable a scalable and flexible control and coordination framework for complex resource coordination and spectrum management in 5G networks.
- Efficient radio resource modelling and management in programmable radio access networks, with well-defined control interfaces and protocols to greatly simplify the management of heterogeneous mobile networks, to be verified by various 5G use cases.
- Flexible spectrum management, based on the awareness of spectrum usage through the COHERENT control framework, to support different spectrum access schemes, including but not limited to, Licensed Shared Access, License Assisted Access, and flexible duplex in 5G radio access networks.

APPLICATIONS

Applications of the COHERENT concept will cover radio access coordination, network virtualization, RAN sharing and flexible spectrum management in 5G heterogeneous radio access networks, as well as the smooth integration of 5G networks with private mobile radio systems.

IMPACT

The expected impacts of the COHERENT project fall into two main categories: to develop the key enabling technologies for 5G mobile networking infrastructure by supporting the cost-efficient emergence of novel classes of network services and applications; to improve the flexibility and the spectral and energy efficiency of the access network infrastructure and to pave the way for holistic end-to-end mobile network function virtualization solutions.

PROJECT COORDINATOR

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EURO-5G

Supporting the European 5G Initiative

TECHNICAL AND RESEARCH CHALLENGES

As a key facilitator of the 5G PPP governance processes, the Euro-5g project will take actions to ensure openness, fairness and transparency through all the 5G PPP activities.

Euro-5g will also launch and maintain a intensive communication and dissemination program to highlight the 5G PPP results.

MAIN OBJECTIVES

The primary objective of the Euro-5g project is to facilitate effective and efficient co-operation and integration between all projects of the 5G PPP, the European Commission, the 5G Infrastructure Association, Networld2020 ETP, related projects from EUREKA, and related national initiatives to maximize the European momentum towards, and benefits from, the future 5G integrated, ubiquitous and ultra-high capacity networks.

The metrics for evaluating the success of 5G PPP will be based on the KPIs included in the 5G PPP Contractual Arrangement signed by the 5G Infrastructure Association on behalf of the European ICT Sector and the European Commission in December 2013.

This project is closely linked with the 5G Infrastructure Association and will strive to ensure there is a seamless integration of the European industrial policies, as generated by the Association, with the work plans of the projects under this program so the results will be as useful and relevant as is possible.

APPLICATIONS

Euro-5g will facilitate working groups spanning the projects of the 5G PPP and the Networld2020 community to develop informed positions on pre-standards and spectrum that will feed into European and Global discussions in these areas. The ambition is to ensure that 5G standards emerge where they are useful and effective in stimulating uptake and that sufficient spectrum is available and its use optimised by 2020 for 5G communications.

Euro-5g will monitor and analyse international 5G activities and will facilitate respective activities (e.g. meetings, workshops etc.) and work together with the 5G-Infrastructure Association and the European Commission to have good international relations with these global initiatives with a view to ensuring global interoperability.

Euro-5g will also involve highly qualified experts to produce innovation roadmaps and capture the experimental requirements for the next phases of the 5G PPP.

IMPACT

The Euro-5g project will contribute directly to the 5G PPP goal to maintain and enhance the competitiveness of the European ICT industry and to ensure that European society can enjoy the economic and societal benefits these future networks will bring.

PROJECT COORDINATOR

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FANTASTIC-5G

Flexible Air iNTerfAce for Scalable service delivery wiThin wIreless Communication networks of the5th Generation

TECHNICAL AND RESEARCH CHALLENGES

The main challenge for FANTASTIC-5G is to develop a modular air interface which is able to support all the anticipated use-cases with highest efficiency and scalability without being overly complex on the network side. To this end, the project will develop the technical AI components (e.g. flexible waveform and frame design, scalable multiple access procedures, adaptive retransmission schemes, enhanced multi-antenna schemes with/ without cooperation, advanced multi-user detection, interference coordination, support for ultra-dense cell layouts, multi-cell radio resource management, device-to-device) and integrate them into an overall AI framework where adaptation to the high degree of heterogeneity 5G will face will be accomplished. Our work will also comprise intense validation and system level simulations. The ambition is to outperform a system involving dedicated air interfaces.

MAIN OBJECTIVES

FANTASTIC-5G objectives are:

1. to develop a flexible and scalable multi-service air interface.
2. with ubiquitous coverage and high capacity where and when needed.
3. being highly efficient in terms of energy and resource consumption.
4. being future proof and allowing for sustainable delivery of wireless services far beyond 2020.
5. To evaluate and validate the developed concepts.
6. and build up consensus on reasonable options for the standardization of 5G.

The project deals exclusively with lower carrier frequencies (< 6 GHz).

APPLICATIONS

5G is mainly about two ambitions:

1. Respond to the strong growth of requested data rates (evolutionary effect).
2. Enhancing the business model of operators by widening the pool of services (revolutionary target).

While supporting the former, FANTASTIC-5G targets to make the latter a reality. For doing so the project has set up 5 core-services which either in itself or by combination realize real-world use cases. The key differentiator between these core services are the respective service defining KPIs:

1. Mobile Broadband (MBB): throughput/ user rate, latency, mobility.
2. Mission Critical Communications (MCC): latency, reliability/availability.
3. Massive Machine Communications (MMC): number of connected devices, low cost, low energy.
4. Broad- and Multicast Services (MBS): number of connected devices.
5. Vehicle-to-Vehicle and Vehicle-to-Infrastructure Services (V2X): high mobility.

A key element common to all the core services is ubiquitous coverage.

IMPACT

Many key players participating to 3GPP standardization are collaborating within the project. So, FANTASTIC-5G is well positioned to strongly facilitate the (pre-)standardization process for 5G by comprehensively comparing technology options and starting to build up consensus.

PROJECT COORDINATOR

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FLEX5GWARE

Flexible and efficient hardware/software platforms for 5G network elements and devices

TECHNICAL AND RESEARCH CHALLENGES

Flex5Gware will perform research, development and prototyping on key building blocks of 5G network elements and devices both in the hardware (HW) and software (SW) domains. These research, development and prototyping activities entail many system design challenges that will be solved through disruptive approaches and resulting technologies. Precisely, in Flex5Gware, design and development of analogue components to enable massive MIMO (Multiple Input Multiple Output) in mmWave (millimeter wave) spectrum bands will be carried out. In the mixed signal and conversion stages domain, important research and results will be obtained related to crucial 5G components like full duplex communications (simultaneous transmission and reception), high-speed broadband converters, etc. In the digital domain, drastic progress in the area of building HW components will be achieved for important features like FBMC (Filter Bank Multi-Carrier) transceivers, LDPC (low-density parity check) codes, etc. Moreover, a sophisticated, HW-agnostic, SW platform will be developed, capable of deciding the optimal splitting of functionality between HW and SW. This will yield powerful HW/SW systems, with interface abstractions, for flexible control and management, across heterogeneous wireless devices and access networks.

MAIN OBJECTIVES

The overall objective of Flex5Gware is to deliver highly reconfigurable HW platforms together with HW-agnostic SW environments, targeting both network elements and devices, and taking into account the need for increased capacity, reduced energy footprint, as well as scalability and modularity for enabling a smooth transition from 4G mobile wireless systems to the 5G era.

APPLICATIONS

Design requirements for 5G wireless networks and applications are expected to differ markedly from previous generations. Exponential growth in mobile data traffic, combined with a rapidly increasing diversity of traditional mobile devices, and new low-bitrate and low-power machine-to-machine devices, require enhanced HW/SW platforms for greater flexibility and efficiency.

Flex5Gware research will aim to improve technology in several key areas, including:

- quality of experience (e.g., capacity, latency, resilience).
- energy efficiency.
- scalability, modularity, versatility and reconfigurability for multiple radio access technologies.

IMPACT

Flex5Gware will evaluate and demonstrate the developed 5G technologies, through proofs-of-concept, which will be showcased in main events. The consortium includes large industry leaders, (infrastructure providers, semiconductor manufacturers and network operators), leading research institutions and academia, and active SMEs. This highly specialized consortium will bring disruptive HW/SW results that will impact and pave the way for the future 5th generation of cellular networks. Flex5Gware will also collaborate in the definition of 5G wireless systems together with the other 5G PPP projects, by providing the HW/SW implementation standpoint.

PROJECT COORDINATOR

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METIS-II

Mobile and wireless communications Enablers for the Twenty-twenty Information Society-II

TECHNICAL AND RESEARCH CHALLENGES

METIS-II will provide an overall 5G RAN design, describing an overall protocol stack architecture with all the functionalities and interfaces needed to fulfil the 5G vision. The overall 5G RAN design will be built upon the following key innovation pillars developed in METIS-II:

- Holistic spectrum management architecture.
- Holistic air interface harmonisation framework.
- Agile Resource Management (RM) framework.
- Cross-layer and cross-air-interface access and mobility framework.
- Common control and user plane framework.

MAIN OBJECTIVES

METIS-II pursues the following key objectives:

- Develop the overall 5G RAN design, focusing particularly on designing the technology for an efficient integration of legacy and novel radio access network (RAN) concepts into one holistic 5G system.
- Provide the 5G collaboration framework within 5G PPP for the 5G RAN design and a common evaluation of 5G RAN concepts from both performance and techno-economical perspective. More specifically, METIS-II will further refine 5G scenarios, requirements and key performance indicators (KPIs), develop a performance and techno-economical evaluation framework, and an open-source 5G evaluation and visualisation tool for illustrating the key 5G use cases and RAN design solutions. For all mentioned aspects, as well as spectrum and overall 5G RAN design aspects, METIS-II strives to facilitate consensus building within 5G PPP, for instance through the organization of a series of 5G PPP cross-project workshops.
- Prepare concerted action towards regulatory and standardisation bodies for an efficient standardisation, development and economically attractive roll-out of 5G.

APPLICATIONS

By the end of September 2015, METIS-II will define an essential set of 5G use cases, capitalizing on use cases of METIS, other EU projects and organizations like NGMN and ITU-R. To this end, the following methodology is adopted: The use cases from literature are grouped with regards to the three major 5G services (xMBB, mMTC, uMTC), forming three families of use cases. Then, a small number of representative use cases are selected from each family of use cases. A selected use case has to fulfil the following requirements:

- It represents perfectly the use case family it belongs to, from services and requirement points of view.
- It has stringent QoS and traffic requirements.
- The technical solutions needed for covering this use case also serve other similar use cases.

The requirements of the identified use cases are then updated following the NGMN requirements.

IMPACT

The METIS-II project plans to utilize its strong composition and global scope, i.e., containing the leading mobile network operators and leading network vendors including non-European partners, to strongly support regulatory and standardisation bodies. In particular, it is envisioned that METIS-II provides input to the 5G requirements work of ITU-R WP5D, contributes to the preparation of WRC-19, and helps to shape models and assessment methodologies as well as timing and content of 5G study and work items in 3GPP.

PROJECT COORDINATOR

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mmMAGIC

Millimetre-Wave Based Mobile Radio Access Network for Fifth Generation Integarated Communications

TECHNICAL AND RESEARCH CHALLENGES

The use of very high frequencies for mobile communications is challenging but necessary for supporting 5G's extreme mobile broadband service which require very high (up to 10 Gbps) data rates, and in some scenarios, also very low end-to-end latencies (less than 5 ms).

In the project, waveform, frame structure and numerology will be developed and designed as well as novel adaptive and cooperative beam-forming and tracking techniques to address the specific challenges of millimetre wave mobile communications. It will undertake extensive radio channel measurements in the 6-100 GHz range and develop advanced channel models for rigorous validation and feasibility analysis of the proposed concepts, as well as usage by regulatory and standards fora. Seamless and flexible integration with other 5G and legacy radio interfaces will be realized through design and validation of novel inter-networking functions and architecture components.

MAIN OBJECTIVES

The main objective of the mmMAGIC project is to develop concepts and key components for a new 5G mobile radio access technology which is expected to operate in a range of frequency bands between 6 and 100 GHz, here referred to as millimetre wave frequencies. Frequency regions suitable to support the identified 5G use cases will be identified and assessed. This new RAT is envisaged as a key component in the overall 5G multi-RAT ecosystem. The project also aims to accelerate standardisation of mm-wave technologies for 5G so that industry and citizens will benefit from commercialisation around 2020.

APPLICATIONS

mmMAGIC technologies will enable a range of extreme mobile broadband services and applications for mobile users, such as UHD TV and video streaming, virtual reality and ultra-responsive cloud-based applications. Self-backhauling capabilities are also foreseen, in addition to access, thereby creating a holistic, scalable and economically viable integrated 5G solution to meet future needs of operators and users.

IMPACT

The ambition of the project is to pave the way for a European head start in 5G standards and to be a focal point for European and global consensus building on the architecture, key components and spectrum for 5G systems operating above 6 GHz. A careful design of the components and the overall architecture aims at ensuring that the developed solutions are robust, easy to deploy, low cost, energy and spectrum efficient, thereby providing users with exceptional quality of experience in a manner that is economically viable and sustainable for operators.

PROJECT COORDINATOR

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SELFNET

Framework for Self-Organised Network Management in Virtualised and Software Defined Networks

TECHNICAL AND RESEARCH CHALLENGES

1. Enabling and optimising the holistic use of Software Defined Networking (SDN), Network Function Virtualisation (NFV), cloud computing, AI and other related technologies to achieve novel cost-effective real-time autonomous 5G network management.
2. Designing highly usable HoN metrics that can precisely reflect the current network and service operation conditions in relation to the 5G Key Performance Indicator (KPI) requirements.
3. Devising innovative, efficient and scalable proactive algorithms to resolve or mitigate the predicted potential network management issues.

MAIN OBJECTIVES

1. To realise self-monitoring and detection facilities to enable timely status awareness of the 5G network infrastructure in terms of a customisable and extensible set of high-level Health of Network (HoN) metrics.
2. To realise an extensive and distributed 5G Self-Organising Network (SON) autonomic management engine based on new Artificial Intelligence (AI) and related technologies.
3. To realise 5G SON orchestration and virtual infrastructure management.
4. To apply the SELFNET framework in a range of essential 5G SON use cases designed to address major problems in the current network management faced by the network operators.

APPLICATIONS

1. Self-protection of the network against distributed cyber-attacks, viruses and trojans, among other common security threats.
2. Self-healing of the network against network and service failures, achieving a self-repairing feature in the network.
3. Self-optimisation through the dynamic deployment of specific virtualised networking functions such as real-time video processing tools in critical places in order to dynamically improve the network performance and the Quality of Experience (QoE) of the users.
4. A complex hybrid use case in which all the previous self-organising functionalities will be integrated and will interwork together to present a complete scenario where the SELFNET Apps act vertically in solving problems in a coordinated fashion.

IMPACT

1. Enlarge 5G market share for European network operators by providing new intelligence to automatically perform SON functionalities.
2. Strengthen the competitiveness of European service providers with optimised service and application performances, thus attracting more subscribers.
3. Enhance QoE of the end users, bandwidth usage and support for video applications, and more secured and resilient network and services.
4. Reduce OPEX by automation and CAPEX by utilising SDN, NFV and cloud resources, and reduced service creation and deployment time.

PROJECT COORDINATOR

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SESAME

Small cell coordination for multi-tenancy and edge services

TECHNICAL AND RESEARCH CHALLENGES

A fundamental component of SESAME will be the virtualisation of Small Cell and their utilisation and partitioning into logically isolated 'slices', offered to multiple operators/tenants. The main aspect of this innovation will be the capability to accommodate multiple operators under the same infrastructure, satisfying the profile and requirements of each operator separately.

The Light DC execution platform will be used to support the required VNFs that implement the different features/capabilities of the Small Cells. Solutions for aggregation of data, transcoding of video content with optimised delivery in edge networks and caching at the very edge of the network, will enable a reduction in transport time and therefore, provide a crucial route to successfully reducing service-level latency.

MAIN OBJECTIVES

SESAME targets innovations around three central elements in 5G: the placement of network intelligence and applications in the network edge through Network Functions Virtualisation (NFV) and Edge Cloud Computing; the substantial evolution of the Small Cell concept, already mainstream in 4G but expected to deliver its full potential in the challenging high dense 5G scenarios; and the consolidation of multi-tenancy in communications infrastructures, allowing several operators/service providers to engage in new sharing models of both access capacity and edge computing capabilities.

SESAME proposes the Cloud-Enabled Small Cell (CESC) concept, a new multi-operator enabled Small Cell that integrates a virtualised execution platform (i.e., the Light Data Center – Light DC) for deploying Virtual Network Functions (VNFs), supporting powerful Self-x management and executing novel applications and services inside the access network infrastructure. The Light DC will feature low-power processors and hardware accelerators for time critical operations and will build a high manageable clustered edge computing infrastructure.

APPLICATIONS

Three initial target scenarios have been already identified during the proposal preparation as promising fields for the applicability of the CESC concept: i) Enterprise services in multi-tenant large business centres, ii) Enhanced service experience on the move, and iii) Service provisioning in flash events.

IMPACT

The SESAME approach will allow new stakeholders to dynamically enter the value chain by acting as neutral host providers in high traffic areas where densification of multiple networks is not practical. The optimal management of a CESC deployment is a key challenge of SESAME, for which new orchestration, NFV management, virtualisation of management views per tenant, Self-x features and radio access management techniques will be developed.

PROJECT COORDINATOR

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SONATA

Service Programing and Orchestration for Virtualized Software Networks

TECHNICAL AND RESEARCH CHALLENGES

Software Defined Networking (SDN) and Network Function Virtualization (NFV) are emerging as major transformational technologies, evolving the telecom sector with new network capabilities and business opportunities. SONATA addresses the significant challenges associated with both the development and deployment of the complex services envisioned for 5G networks and empowered by these technologies:

- models, methods and tools for programming virtualized services.
- methods, enablers and algorithms for uniform and integrated orchestration of network services, on top of an infrastructure providing connectivity, computation, and storage resources.
- tools for efficient and reliable deployment and management of developed services in a dynamic and scalable manner.
- efficient integration of development and operations (DevOps) of services between multiple stakeholders.

MAIN OBJECTIVES

SONATA targets the flexible programmability of software networks, supporting network function chaining and orchestration. Innovations will make service platforms modular and easier to customize to the needs of different service providers, and introduce a specialized DevOps model for supporting developers. Specific objectives include:

- Reduce time-to-market of networked services, by a) streamlining development with abstract programming models and SDK; and b) applying a DevOps model that integrates operators, manufacturers and third-party developers.
- Optimize resource utilization via orchestration and reduce costs of service deployment & operation, by a) mapping complex services to connectivity, computing and storage resources; and b) automatically re-configuring running/competing services.
- Accelerate the industry adoption of software networks, by a) supporting the full service lifecycle: development, testing, orchestration, deployment, management and operations; and b) defining a roadmap for uptake of its results towards the larger transition to SDN/NFV.

SONATA's open source results to fulfil these objectives will include:

1. programming model and SDK to facilitate service development.
2. service platform with modular orchestration framework.
3. DevOps model for software networks that integrates operators with external stakeholders.

APPLICATIONS

SONATA includes industry use cases and a pilot program for demonstration of its service platform, orchestrator, programming model, SDK and DevOps approach. Key examples focus on Virtual Content Delivery Networks (vCDN) and Mobile Edge Computing (MEC).

IMPACT

SONATA's open source results will have a diverse impact on an expanding telecom sector, including operators, manufacturers and third-party developers:

- reduce time-to-market for networked services.
- optimize network management, reducing OpEx.
- increase reliability and QoS for 5G networks and deployed services.
- decrease barrier of entry and empower third-party developers.

To widen the reach of the project's impact, SONATA will collaborate with key community initiatives, including OPNFV, OpenDaylight, OpenStack, ITU-T and ETSI's NFV ISG.

PROJECT COORDINATOR

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SPEED-5G

Quality of Service Provision and capacity Expansion through Extended-DSA for 5G

TECHNICAL AND RESEARCH CHALLENGES

On the research front, SPEED-5G will investigate and develop different sets of mechanisms and techniques for dynamic capacity and coverage expansion, including:

- Combining radio technologies, spectrum and transmit energy.
- Coexistence and interference control mechanisms using emerging multicarrier waveforms.
- Operation in dirty/grey spectrum.
- Management mechanisms in support of spectrum micro-trading in lightly-licensed bands, which are currently not utilized.
- Techniques in support of centralized / distributed smart resource management.

SPEED-5G will research and develop the appropriate functionalities for addressing the mentioned challenges and a testbed to illustrate the gains that can be achieved. SPEED-5G will undertake a holistic experimentation by extending an existing 5G testbed, in particular w.r.t. spectrum and traffic management features in ultra-dense environments.

MAIN OBJECTIVES

The main objective of SPEED-5G is to achieve a significantly better exploitation of heterogeneous wireless technologies, providing higher capacity together with the ultra-densification of cellular technology, and effectively supporting the new 5G Quality of Experience (QoE) requirements.

In SPEED-5G we will develop new techniques for optimizing spectrum utilization, following three main dimensions:

1. ultra-densification through small cells.
2. additional spectrum.
3. exploitation of resources across technologies.

In SPEED-5G this three dimensional model is referred to as extended-Dynamic Spectrum Allocation (DSA), where several spectrum bands, cells and technologies are jointly managed in order to offer improved QoE and a tremendous capacity increase in a cost-efficient manner.

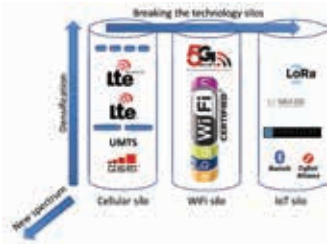
APPLICATIONS

SPEED-5G will address some key 5G use cases, namely

- The ultra-dense deployments of small cells.
- The provision of broadband access everywhere (focusing mainly on indoor and outdoor areas around buildings).
- The support of massive IoT.

IMPACT

SPEED-5G will provide solutions answering the request for a thousand-fold increase in mobile traffic volume over a decade and for efficiently supporting very different classes of traffic and services. SPEED-5G will contribute to the ongoing effort of the European industry to drive the development of 5G standards. The project will also contribute to improving the innovation capacity in the wider ecosystem, leveraging on the European expertise network and increasing the appeal of European R&D centers.



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SUPERFLUIDITY

Superfluidity: a super-fluid, cloud-native, converged edge system

TECHNICAL AND RESEARCH CHALLENGES

SUPERFLUIDITY offers a converged solution to counter the complexity emerging from three forms of heterogeneity: Heterogeneous data traffic and end-points; Heterogeneity in services and processing needs; Heterogeneity in access technologies and their scale.

MAIN OBJECTIVES

Many shortcomings affect today's networks: overly long provisioning times; reliance on proprietary, hard-to-modify and cost-ineffective hardware devices; and the complexity arising from a wide range of heterogeneous access technologies.

The main goal of SUPERFLUIDITY is to run network processing virtualized, on-demand, on third-party infrastructure located throughout the network, and to develop technologies allowing such services to be "superfluid":

- Fast instantiation times (in milliseconds).
- Fast migration (in hundreds of milliseconds).
- High consolidation (running thousands on a single server).
- High throughput (10Gb/s and higher).

SUPERFLUIDITY tackles these challenges with a multi-pronged comprehensive strategy:

Flexibility, via an architectural decomposition of network components and network services into elementary, reusable primitives.

Simplicity, via a cloud-based architecture.

Agility, via virtualization of radio and network processing tasks.

Portability and viability, through platform-independent abstractions, permitting reuse of network functions across multiple heterogeneous hardware platforms.

High performance, via software acceleration, specialization and adaptation to hardware accelerators.

APPLICATIONS

Sample use cases include:

- Minimum-Delay Cloud storage.
- RAN As A Service.
- Localized services.
- Pooling.
- Edge offloading.
- Portable signal processing.
- On-the-fly Monitoring.
- Virtualized CDN operators.

Other examples are context-aware services that take advantage of location information, low-delay services such as augmented reality or SIRI, edge-based video analytics, and application-aware performance optimizations.

IMPACT

SUPERFLUIDITY will provide a converged cloud-based 5G concept with four key properties:

1. **location-independence**: services can be deployed (and relocated) at various networks.
2. **time-independence**: near instantaneous deployment and migration of services.
3. **scale-independence**: transparently scale services in a cloud-like manner.
4. **hardware-independence**: services with high performance irrespective of the underlying hardware.

Through these properties, SUPERFLUIDITY will exert impact as follows:

- at the **macro level**: consortium partners will become early adopters of SUPERFLUIDITY's system.
- at the **societal level**: enabling software and application providers to bring to the market innovative services and applications without worrying about the underlying hardware; the open application space will drive the quality of the service up and the costs down.
- at the **operational level**: i) deployment of services and applications close to users following their needs; ii) reduction of end-to-end latency; iii) development of 5G standards and production-quality open source code; iv) tools for system orchestration and management and for security, integrating the SUPERFLUIDITY system into a leading cloud management framework.

PROJECT COORDINATOR

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VIRTUWIND

Virtual and programmable industrial network prototype deployed in operational Wind park

TECHNICAL AND RESEARCH CHALLENGES

Translating VirtuWind's objectives and applying the concepts developed in the project to the domain of wind energy will address the following technical and research challenges:

1. Programmable industrial networks via SDN.
2. Multi-tenancy support via NFV as multiple stakeholders need different access profile.
3. Techno-economic analysis for foreseen OPEX and CAPEX reduction.
4. Increase in service provisioning velocity.

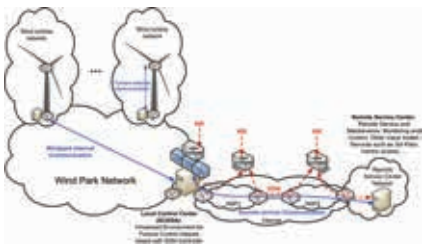
MAIN OBJECTIVES

The main aim of VirtuWind is to develop a SDN & NFV ecosystem for industrial domains, based on open, modular, and secure communication framework, leading to a prototype demonstration for intra-domain and inter-domain scenarios in real wind parks as a representative use case of industrial networks, and quantify the economic benefits of the solution. Following are the 5 key objectives of VirtuWind:

1. Realize industrial-grade QoS for intra-domain SDN solution.
2. Guarantee inter-domain QoS for SDN based multi-operator ecosystem.
3. Reduce time and cost for service provisioning and network maintenance.
4. Assure security-by-design for the SDN and NFV ecosystem.
5. Field trial of intra- and inter-domain SDN and NFV prototype.

APPLICATIONS

VirtuWind will adapt SDN as per requirements in industrial networks by developing novel SDN-based mechanisms to implement industrial-grade QoS and to reduce CAPEX and OPEX in Wind park control network. The envisioned solution is depicted in the following diagram:



The new concept for industrial networks will immensely benefit by transferring existing SDN concepts from other disciplines into the industrial networking domain.

IMPACT

VirtuWind will create industrial capability in Europe with major push towards the centre of competence for "QoS-enabled SDN/NFV". Due to such enhanced capabilities, it is possible to deploy different network services and applications very quickly as compared to the state of the art.

By addressing wind park use case for SDN/NFV in Energy domain and through decisive technical advances in the area of QoS, VirtuWind will boost the take-up of SDN and NFV approaches in the area of Critical Infrastructure and other disciplines with large scale deployments.

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XHAUL

The 5G Integrated fronthaul/backhaul

TECHNICAL AND RESEARCH CHALLENGES

Xhaul will design the new 5G backhauling/fronthauling network for 5G and will solve the fundamental cost, network efficiency and scalability issues of 5G transport network in the following aspects:

- It will design converged networking devices (XFE) running a unified data plane capable of transporting all kinds of Xhaul traffic. This will significantly reduce the network cost leveraging the integrated network design and will improve network utilization.
- It will facilitate network densification. In Xhaul, new physical layer technologies and solutions (leveraging optical fiber, mmWave, free-space optics and low-cost copper infrastructure, etc.) will be explored to significantly reduce the deployment and installation cost.
- It will design a centralized control plane following the SDN paradigm providing high flexibility and scalability (XCI).

Fig. 1 shows the Xhaul functional structure and the new Xhaul services. The lowest layer corresponds to the overlay of all the different physical technologies used by Xhaul. The middle layer represents one of the key concepts associated to Xhaul: the integration of the different technologies (including fronthaul and backhaul) in a common packet network based on technology abstraction, unified framing and common data, control and management planes. Finally, the upper layer presents a selection of the features envisioned for the Xhaul infrastructure.

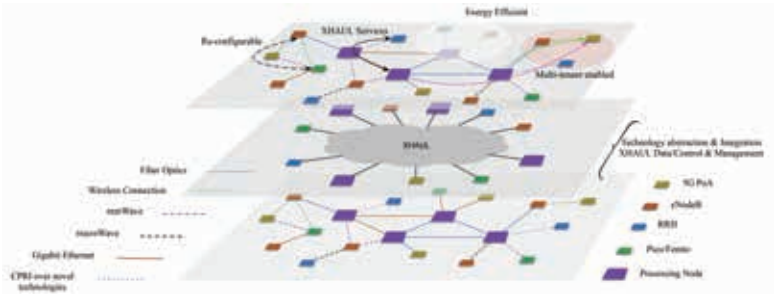

Fig.1 : Functional Structure of Xhaul

MAIN OBJECTIVES

Xhaul aims at developing an adaptive, sharable, cost-efficient 5G transport network solution integrating the fronthaul and backhaul segments of the network. This transport network will flexibly interconnect distributed 5G radio access and core network functions, hosted on in-network cloud nodes, through the implementation of two novel building blocks: i) a control infrastructure using a unified, abstract network model for control plane integration (Xhaul Control Infrastructure, XCI); ii) a unified data plane encompassing innovative high-capacity transmission technologies and novel deterministic-latency switch architectures (Xhaul Packet Forwarding Element, XFE). Xhaul will greatly simplify network operations despite growing technological diversity. It will hence enable system-wide optimisation of Quality of Service (QoS) and energy usage as well as network-aware application development.

APPLICATIONS

Xhaul will provide flexible and scalable capacity to wireless access points in the field fulfilling 5G relevant KPIs towards throughput, latency and energy efficiency for static and dynamic infrastructure.

Xhaul will be an integrated multi-technology network including its underlying advanced functional feature sets in a real-world urban deployment. Xhaul mobility support will be evaluated and showcased in a PoC, using mobile backhaul for moving Small Cells for high-speed trains along a 400 km track based.

IMPACT

At macro level, the target impact is to keep and reinforce a strong EU industrial base in the domain of network technologies, which is seen as strategic industry worldwide. Retaining at least 35% of the global market share in Europe regarding future network equipment would be a strategic goal.

At societal level, the impact is to support an ubiquitous access to a wider spectrum of applications and services offered at lower cost, with increased resilience and continuity, with higher efficiency of resources usage, and to reduce network energy consumption.

PROJECT COORDINATOR

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