The 5G Infrastructure
Public-Private Partnership

5G Vision and Requirements in 5G PPP

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Chair of the board of 5G Infrastructure Association

http://5g-ppp.eu/
Outline

- 5G research projects in Framework Program 7
- International activities
- 5G PPP in Horizon 2020 of the European Union
- Indicative time plan
- Implementation of 5G PPP and Call 1
- 5G Vision and Requirements
- Conclusions
EU Framework Program 7
System and radio projects

- **METIS**  Mobile and wireless communications Enablers for Twenty-twenty (2020) Information Society
  - **Overall objective**
  Lay the foundation & Ensure a global forum & Build an early global consensus for beyond 2020 “5G” mobile & wireless communications.

- **5GNOW**  5th Generation Non-Orthogonal Waveforms for Asynchronous Signalling
  - **Overall objective**
  5GNOW will develop new PHY and MAC layer concepts being better suited to meet the upcoming needs with respect to service variety and heterogeneous transmission setups.

- **iJOIN**  Interworking and JOINt Design of an Open Access and Backhaul Network Architecture for Small Cells based on Cloud Networks
  - **Overall objective**
  iJOIN introduces concept RAN-as-a-Service (RANaaS), where RAN functionality is centralised through an open IT platform based on cloud infrastructure. Joint design and optimisation of access and backhaul, operation and management algorithms and architectural elements, integrating small-cells, heterogeneous backhaul and centralised processing.
EU Framework Program 7
Radio and security projects

- **Tropic**
  DisTributed computing, storage and radio resource allocation over cooperative femtocells
  - **Overall objective**
  The project aims at exploiting the convergence of pervasive femto-network infrastructure and cloud computing paradigms for virtualisation/distribution of applications and services.
  
- **MiWaveS**
  Beyond 2020 Heterogeneous Wireless Networks with Millimeter-Wave Small Cell Access and Backhauling
  - **Overall objective**
  Demonstrate how low-cost or advanced millimetre-wave (mmW) technologies can provide multi-Gigabits per second access to mobile users and contribute to sustain the traffic growth. Hence, spectrum flexibility and the exploitation of the available mmW spectrum will be key strategies to build high-throughput and low-latency infrastructures for next generation heterogeneous mobile networks.

- **PHYLAWS**
  PHYsical LA yer W ireless S ecurity
  - **Overall objective**
EU Framework Program 7
Network and Internet projects

- **combo**
  - **Convergence of fixed and Mobile Broadband access/aggregation networks**
  - **Overall objective**
    Propose and investigate new integrated approaches for Fixed / Mobile Converged (FMC) broadband access / aggregation networks for different scenarios (dense urban, urban, rural)

- **MOTO**
  - **Evolving Mobile internet with innovative terminal-To-terminal Offloading technologies**
  - **Overall objective**
    Design an integrated operator-managed offloading system and combined offloading algorithms.

- **MCN**
  - **Mobile Cloud Networking**
  - **Overall objective**
International activities on 5G getting momentum

- ITU-R Visions Group
- EU
  - Framework Program 7, e.g. METIS and 5GNow projects
  - 5G PPP in Horizon 2020
- Germany – 5G Lab Germany at TU Dresden
- UK – 5G Innovation Centre (5GIC) at University of Surrey
- US
  - Intel Strategic Research Alliance (ISRA)
  - NYU Wireless Research Center
  - 4G Americas
- China
  - 863 Research Program
  - Future Forum
  - IMT-2020 (5G) Promotion Association
- Japan – 2020 and Beyond Ad-Hoc Group under ARIB’s Advanced Wireless Communications Study Committee, now transformed to 5G Promotion Forum
- Korea – 5G Forum
- Taiwan – TAICS, Ministry of Science and Technology, Ministry of Economic Affairs
- Russia – 5GRUS by Russia’s Icom-Invest
- CJK White Paper
- NGMN – White paper on future requirements
  - Company internal research

Source: 5G Infrastructure Association.
International cooperation
General status of MoUs

• Korea 5GForum
  – MoU signed with 5G Forum on June 17, 2014 after signature of Joint Declaration between EU Commission and Korean government

• China IMT-2020
  – MoU text agreed with IMT-2020 Promotion Association
  – Intended date for signatures early May 2015 at visit of Commissioner Öttinger in China

• Japan 5GIMF
  – MoU text agreed with 5G Promotion Forum
  – Intended signature date around regular EU-Japan dialogue end of March 2015

• USA 4G Americas
  – MoU text agreed with 4G Americas
  – MoU signed on March 2, 2015 at Mobile World Congress 2015 in Barcelona

• Multilateral MoU intended on global annual 5G conference
  – Intention to organise an annual global 5G event
  – Rotation between continents

Source: 5G Infrastructure Association.
Why Collaborative research?

International consensus building at an early stage

- Horizon 2020 is open for organizations from outside of Europe

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Common interest vs. Competition over time

- Increasing investment in solutions
- Increasing IPR portfolios

Chance for consensus building decreasing

Pre-competitive early collaborative research

Standardization in early competitive environment

Grade of concept maturity

IPRs

Products and markets in competitive environment

- Increasing IPRs portfolios make consensus building difficult

EU Commissioner Kroes called industry to join EU Commission in a PPP on 5G

- Commissioner Kroes called industry at Mobile World Congress 2013 in Barcelona, Spain

“… And today I call on EU industry and other partners to join us in a Public-Private partnership in this area. An open platform that helps us reach our common goal more coherently, directly, and quickly. European 5G is an unmissable opportunity to recapture the global technological lead. And I hope you will be able to support and join us. …”

Major milestones towards the 5G PPP implementation

• 5G PPP is a new instrument in Horizon 2020
• First Call for Proposals published on December 11, 2013
• Contractual Arrangement on 5G PPP signed between EU Commission and private side on December 17, 2013

From left to right:
• Marcus Weldon, Chief Technology Officer and President Bell Labs, Alcatel-Lucent
• Hossein Moin, Executive Vice President, Chief Technology Officer, Nokia Networks
• Neelie Kroes, Vice-President of the EU Commission, Digital Agenda
Major milestones towards the 5G PPP implementation

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- First Call for Proposals published on December 11, 2013
- Contractual Arrangement on 5G PPP signed between EU Commission and private side on December 17, 2013
- Budget for 2014 – 2020 time frame
  - 700 million € public funding
  - Matched by private side including leveraging factor 5 of additional private investment results in private value of about 3.5 billion €
- 5G PPP industry launch at Mobile World Congress on February 24, 2014
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• 5G PPP industry launch at Mobile World Congress on February 24, 2014
• Submission deadline of proposals on November 25, 2014
• Project start first half of 2015
• 5G Vision EU – CTO Press Event at Mobile World Congress on March 3, 2015
• 5G Infrastructure Association vision paper published


Source: 5G Infrastructure Association.
Key challenges

• PPP Program that will deliver solutions, architectures, technologies and standards for the ubiquitous 5G communication infrastructures of the next decade

• Program Ambitions: Key Challenges / High level KPIs
  • Providing 1000 times higher wireless area capacity and more varied service capabilities compared to 2010
  • Saving up to 90% of energy per service provided. The main focus will be in mobile communication networks where the dominating energy consumption comes from the radio access network
  • Reducing the average service creation time cycle from 90 hours to 90 minutes
  • Creating a secure, reliable and dependable Internet with a “zero perceived” downtime for services provision
  • Facilitating very dense deployments of wireless communication links to connect over 7 trillion wireless devices serving over 7 billion people
  • Enabling advanced User controlled privacy

Source: 5G Infrastructure Association.
Faster, More Powerful and More Energy Efficient Solutions for integrated High Capacity Access and Core Networks for a Wider Range of Services

- Wireless Networks
- Optical Networks
- Automated Network Organisation - Network Management and Automation
- Implementing Convergence Beyond the Access Last Mile

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

Ensuring availability, robustness and security

Ensuring efficient hardware implementations
5G PPP Contractual Arrangement
KPIs for Monitoring

• Business-related KPIs:
  – Leverage effect of EU research and innovation funding in terms of private investment in R&D for 5G systems in the order of 5 to 10 times;
  – Target SME participation under this initiative commensurate with an allocation of 20% of the total public funding;
  – Reach a global market share for 5G equipment & services delivered by European headquartered ICT companies at, or above, the reported 2011 level of 43 % global market share in communication infrastructure.

• Performance KPIs:
  – Providing 1000 times higher wireless area capacity and more varied service capabilities compared to 2010;
  – Reducing the average service creation time cycle from 90 hours to 90 minutes (as compared to the equivalent time cycle in 2010);
  – Very dense deployments to connect over 7 trillion wireless devices serving over 7 billion people;
  – Secure, reliable and dependable Internet with a “zero perceived” downtime for services provision.

• Societal KPIs:
  – Enabling advanced User controlled privacy;
  – Reduction of energy consumption per service up to 90 % (as compared to 2010);
  – European availability of a competitive industrial offer for 5G systems and technologies;
  – New economically-viable services of high societal value like U-HDTV and M2M applications;
  – Establishment and availability of 5G skills development curricula in partnership with the EIT.

Source: 5G PPP Contractual Arrangement.
Indicative time plan

- 2013
  - Exploratory phase:
    - Detailed requirements
    - Identify most promising functional architectures and technologies
    - Build on previous research work

- 2014
  - Submission deadline: November 25, 2014

- 2015
  - Start of first projects mid 2015
  - Detailed system research and development
  - Basis for Pan European experimental infrastructure

- 2016
  - Detailed system optimization
  - Consensus building on globally to be identified frequency bands (consider result of WRC15)
  - Validation of concepts and early trials
  - Contributions to initial global standardization activities
  - Preparation of WRC18/19

- 2017
  - New frequency bands available for trial network deployment and initial commercial deployment
  - Close to commercial systems deployment

- 2018
  - Extension of trials to non ICT stakeholders
  - Detailed standardization process

- 2019
  - Large scale demonstrations and trials, scalability testing, etc.

- 2020
  - Support of initial international standardization
    - Support of regulatory bodies for allocation of newly identified frequency bands
    - Implementation of large trials for validation under close to real world conditions

Source: 5G Infrastructure Association.
Indicative time plan

- **2013**
  - Start of first projects mid 2015
  - Exploratory phase:
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    - Build on previous research work
    - Detailed system optimization
    - Consensus building on globally to be identified frequency bands (consider result of WRC15)
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    - Preparation of WRC18/19
  - Detailed system research and development
    - Basis for Pan European experimental infrastructure

- **2014**
  - Release 12
  - Release 13

- **2015**
  - Winter Olympics, Korea
  - FIFA World Cup, Russia 2018

- **2016**
  - Summer Olympics, Japan
  - FIFA World Cup, Qatar 2022

- **2017**
  - Release 14

- **2018**
  - Release 15

- **2019**

- **2020**

Source: 5G Infrastructure Association.
Governance model – Basic approach
Relation of new ETP to 5G PPP


Source: NetWorld2020 ETP and Annex to 5G PPP Contractual Arrangement.
5G Infrastructure Association
Working Groups and Activities

5G Infrastructure Association Board

WG 5G Vision and Societal Challenges
• Facilitator: Orange

WG 5G Pre-standards
• Facilitator: Ericsson

WG SME support
• Facilitator: Interinnov (SME)

WG 5G Spectrum
• Facilitator: Telenor

Activity Community building and PR (Public Relations)
• Facilitator: Interinnov (SME)

Activity 5G International cooperation
• Facilitator: Nokia

Activity Activities based on the 5G PPP Contractual Arrangement, KPIs
• Facilitator: Alcatel-Lucent

Source: 5G Infrastructure Association.

05/03/2015
Members of 5G Infrastructure Association including international dimension

Industry
- ADVA Optical Networking SE
- Alcatel-Lucent
- Airbus
- Atos
- Deutsche Telekom
- DOCOMO Communications Laboratories Europe GmbH
- Ericsson
- Huawei Technologies Düsseldorf GmbH
- IBM Research
- Intel Mobile Communications
- NEC Europe Ltd., NEC Laboratories Europe
- Nokia
- Orange Labs
- Samsung Electronics Research Institute Ltd.
- SES
- Telecom Italia
- Telefónica I+D
- Telenor ASA
- Telespazio
- Thales Alenia Space
- Turk Telekomünikasyon A.Ş.

Research
- CEA-LETI
- Centre Tecnologic de Telecomunicacions de Catalunya (CTTC)
- Consorzio Nazionale Interuniversitario per le Telecomunicazioni (CNIT)
- Fundacion IMDEA Networks
- Instituto de Telecomunicacoes
- IST – University of Lisbon
- TNO
- University of Bologna – DEI

SMEs
- Integrasys SA
- INTERINNOV
- M.B.I. S.R.L.
- Nextworks s.r.l.
- Quobis
- Sequans Communications

Source: 5G Infrastructure Association.
Governance model – Basic approach
Project Implementation

Phase I
- Project N
- Project 3
- Project 2
- Project 1

Phase II
- Project N
- Project 3
- Project 2
- Project 1

Phase III
- Project N
- Project 3
- Project 2
- Project 1

Phase IV
- Project N
- Project 3
- Project 2
- Project 1

Cross Issues
- Topic area 1
- Topic area 2
- Topic area 3
- Topic area 4
- Topic area 5
- Topic area 6
- Topic area 7
- Topic area m

Active PPP Projects
- Project N
- Project 3
- Project 2
- Project 1

Steering Board
- Industry Advisory Group

Project Implementation
05/03/2015

Source: 5G PPP Annex to contractual arrangement.
Convergence beyond last mile
Support integration of a ubiquitous access continuum composed of cooperative, cognitive fixed and heterogeneous wireless resources, with fixed optical access reaching at least the 10 Gb/s range
- Solving the management heterogeneity of different fixed and heterogeneous wireless networks
- Architectures to optimize reuse and sharing of functionality across heterogeneous access technologies and networks

Network management
Challenge to radically decrease network management Opex through automation whilst increasing user perceived quality of service, of experience and security
- Novel simplified (low Opex) approaches to overall management of the network (e.g. Self-organizing networks –SON) and service level management
- Combination of software defined network implementations with autonomic management of resources
- Network security across multiple virtualized or SDN domains

Network virtualization and Software Networks
Highly flexible, manufacturer-independent model of controlling reconfigurable resources supporting changing/emerging application requirements
- Virtualization of network functionalities at infrastructure level and implementation of network services
- Orchestration logic (SDN), enabling network programmability, automation of cross domain network configuration, simplification and programmability of devices
- Tighter integration between application/service layers and networking layers
- Support of open network functionalities for dynamic integration with third party and OTT cloud environments

Radio network architecture and technologies
Support anticipated 1000 fold mobile traffic increase and very different classes of traffic/services
- Network architecture, protocols and radio technologies capable of at least a ten times increase in frequency reuse and new frequency ranges above 3.6 GHz
- Versatile low cost ubiquitous radio access infrastructure equally supporting low rate IoT and very high rate (> 1 Gbit/s) access
- Flexible and efficient radio, optical or copper based backhaul/fronthaul with low latency
- Innovative architectures for 5G transceivers and micro-servers
- Experiment based research preparing for large scale demonstrator and test-beds

How to start a project?
Major steps

Openness and transparency

1. EU Commission publishes open Call for Proposals

2. Proposal preparation
   - Consortium Building
     - In minimum 3 partners from
     - In minimum 3 EU countries
     - Open for international cooperation

3. Proposal submission at fixed deadline

4. Proposal evaluation by independent evaluators

Implementation

Grant agreement to successful consortia

Source: 5G Infrastructure Association.
5% of European GDP, corresponding to an annual value of about €660 billion, is generated today by the ICT sector itself.

Impact of communication sector extends beyond the industrial domain.

Additional investment in ICT in Europe could contribute to rebirth of GDP growth in Europe up to (Source: World Bank)
- about 1.2% points in high-income economies and
- about 1.4% points in low and middle-income economies.

Overall employment level of ICT sector in Europe has been rather stable between 7.2 to 7.5 million employees since 2002 (Source: Digital Agenda Scoreboard).

Strong industrial base in Europe in research, development, integration and manufacturing of complex systems like communication networks.

Wide spread well-established research community in universities and R&D centres cooperating with industry and SMEs for knowledge and IPR generation.

Novel 5G network requirements, technologies and architectures opens wide range of opportunities for both established and new actors including SMEs.
The start of commercial deployment of 5G systems is expected in years 2020+

5G is an **opportunity for the European ICT sector** which is already well positioned in the global R&D race

5G will bring **new unique network and service capabilities**
- user experience continuity
- Internet of Things
- mission critical services (low latency, high reliability)

5G targets a **unified and programmable infrastructure**

5G will support **multi tenancy models**

5G will be designed to be a **sustainable and scalable technology**

5G will create an **ecosystem for technical and business innovation**

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5G PPP Vision and Requirements
5G new service capabilities

- 5G needs to support efficiently three different types of traffic profiles
  - high throughput for e.g. video services
  - low energy for e.g. long–living sensors
  - low latency for mission critical services

- 5G covers network needs and contributes to digitalization of vertical markets
  - automotive, transportation, manufacturing, banking, finance, insurance, food and agriculture
  - education, media
  - city management, energy, utilities, real estate, retail
  - government
  - healthcare

- Sustainable and scalable technology to handle
  - anticipated dramatic growth in number of terminal devices
  - continuous growth of traffic (at a 50-60% CAGR)
  - heterogeneous network layouts
  - without causing dramatic increase of power consumption and management complexity within networks

- Larger ecosystem, more open to new players, start-ups and other sectors

5G PPP Vision and Requirements

Disruptive capabilities

- Order of magnitude of improvement in performance in terms of
  - more capacity
  - lower latency
  - more mobility
  - more accuracy of terminal location
  - increased reliability and availability

- Connection of many more devices simultaneously

- Improved terminal battery capacity lifetime

- 5G will help European citizens to manage their personal data, tune their exposure over the Internet and protect their privacy

- More efficient 5G infrastructures in terms of
  - enhanced spectral efficiency
  - energy consumption for same amount of transmitted data
  - reduced service creation time
  - built on more efficient hardware

5G PPP Vision and Requirements

5G will have disruptive capabilities

• 5G will provide an order of magnitude improvement in performance in the areas of more capacity, lower latency, more mobility, increased reliability and availability

• 5G infrastructures will be also much more efficient in terms of
  – energy consumption
  – service creation time
  – hardware flexibility
5G PPP Vision and Requirements

Key requirements

- 1,000 X in mobile data volume per geographical area reaching a target ≥ 10 Tb/s/km²
- 1,000 X in number of connected devices reaching a density ≥ 1M terminals/km²
- 100 X in user data rate reaching a peak terminal data rate ≥ 10Gb/s
- Guaranteed user data rate >50Mb/s
- 1/10 X in energy consumption compared to 2010
- 1/5 X in end-to-end latency reaching 5 ms for e.g. tactile Internet and radio link latency reaching a target ≤ 1 ms for e.g. Vehicle to Vehicle communication
- 1/5 X in network management OPEX
- 1/1,000 X in service deployment time reaching a complete deployment in ≤ 90 minutes
- Mobility support at speed ≥ 500km/h for ground transportation
- Accuracy of outdoor terminal location ≤ 1m

5G PPP Vision and Requirements

Key technological components

- 5G wireless will support a heterogeneous set of integrated air interfaces
  - from evolutions of current access schemes
  - to brand new technologies
- 5G networks will encompass cellular and satellite solutions
- Seamless handover between heterogeneous wireless access technologies
- Simultaneous radio access technologies to increase reliability and availability
- Deployment of ultra-dense networks with numerous small cells requires new interference mitigation, backhauling and installation techniques
- 5G will be driven by software and will heavily rely on emerging technologies
  - Software Defined Networking (SDN)
  - Network Functions Virtualization (NFV)
  - Mobile Edge Computing (MEC)
  - Fog Computing (FC)
  to achieve required performance, scalability and agility
- Easier and optimised network management by means of exploitation of Data Analytics and Big Data techniques
  - to monitor users Quality of Experience
  - while guaranteeing privacy

5G PPP Vision and Requirements
Key design principles and technologies

• Key design principles
  – Small cells will be pushed further leading to Ultra Dense Networks.
  – New Radio Area Network paradigms such as Device to Device (D2D) and Moving Networks (MN) will emerge.
  – Operators of ICT infrastructures need more network and services flexibility, scalability and business sustainability.
  – 5G design need to be inspired by modern operating system architectures
  – New business models will be created thanks to open interfaces (APIs for resources, connectivity and services enablers)

• Key technologies
  – Wireless technologies will be the starting point
  – 5G will leverage on the strengths of both optical and wireless technologies
  – 5G will be driven by software
  – Efficiency and security will be of paramount importance

5G PPP Vision and Requirements
5G networks and services vision

5G PPP Vision and Requirements
5G roadmap

Conclusions

- 5G research started in EU Framework Program 7
- 5G research is getting momentum globally
- Collaborative research as means for consensus building even between competitors to prepare future standards
- In Europe 5G PPP launched in December 2013 as part of new research program Horizon 2020
- 5G PPP is addressing the future communication network including support of vertical sectors
- In addition to system and technology development support of policy objectives
- Call 1 for Proposals are currently under evaluation
- Big bunch or research projects will start mid of 2015
- 5G PPP published a Vision and Requirements White Paper at MWC 2015
- Horizon 2020 is open for international participation

Acknowledgement: The author would like to thank his colleagues for their contributions.

Source: 5G Infrastructure Association.
Thank you for your attention!

http://5g-ppp.eu