The 5G Infrastructure Public-Private Partnership

5G research in Europe

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http://5g-ppp.eu/

Outline

- 5G PPP in Horizon 2020 of the European Union

- 5G Vision and Requirements

- 5G PPP research projects
  - Radio-related cluster
  - Fronthaul/backhaul
  - Hardware implementation
  - Network automation
  - SDN, NFV, Cloud and Virtualisation
  - Security

- Conclusions

Major milestones towards the 5G PPP implementation

- Commissioner Kroes asked Industry in Europe to cooperate on 5G PPP at Mobile World Congress 2013 in Barcelona

- First Call for Proposals published on December 11, 2013

- 5G PPP Contractual Arrangement signed between EU Commission and private side on December 17, 2013

- Budget for 2014 – 2020 time frame
  - Up to 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

- Submission deadline of proposals on November 25, 2014

- Project start on July 1, 2015

- 5G Vision EU – CTO Press Event at Mobile World Congress on March 3, 2015

- 5G Infrastructure Association vision paper published

  http://5g-ppp.eu/wp-content/uploads/2015/02/5G-Vision-Brochure-v1.pdf

19/06/2015

Source: 5G Infrastructure Association.

From left to right:
- Marcus Weldon, Chief Technology Officer and President Bell Labs, Alcatel-Lucent
- Li Yingtao, President of 2012 Laboratories, Huawei
- Kyunghoon Cheun, Executive Vice President, Samsung Electronics
- Hermann Eul, Corporate Vice President General Manager, Mobile and Communications Group, Intel
- Mari-Noëlle Jego-Laveissière , Senior Executive Vice President of Innovation, Marketing and Technologies, Orange
- Günther H. Oettinger, Commissioner for Digital Economy and Society
- Hossein Moiin, Executive Vice President, Chief Technology Officer, Nokia Networks
- Didier le Boulc'h, Chief Technology Officer, Thales Alenia Space
- Mr Seizo Onoe, Executive Vice President, Chief Technical Officer, and Member of the Board of Directors, Docomo
- Ulf Ewaldsson, Chief Technology Officer, Ericsson

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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.

5G PPP Vision and Requirements
5G new service capabilities

USER EXPERIENCE CONTINUITY — INTERNET OF THINGS — MISSION CRITICAL SERVICES

- 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

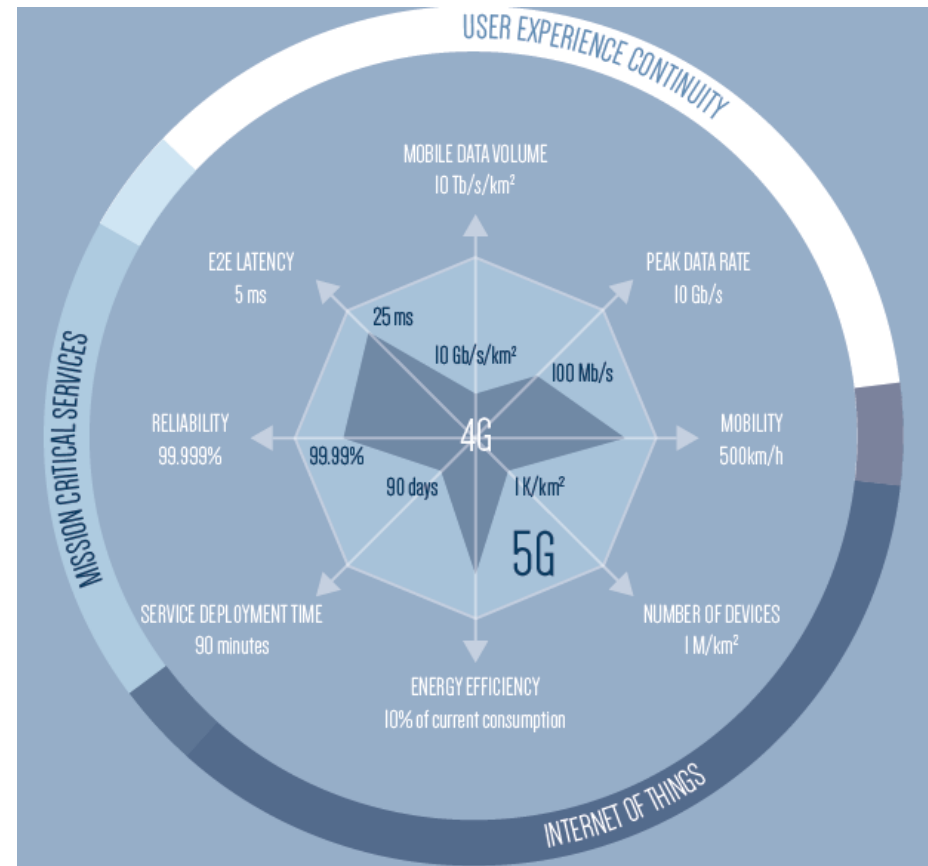Source: 5G Infrastructure Association: Vision White Paper, February 2015.

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

USER EXPERIENCE CONTINUITY

MOBILE DATA VOLUME
10 Tb/s/km²

PEAK DATA RATE
10 Gb/s

E2E LATENCY
5 ms

25 ms

10 Gb/s/km²   100 Mb/s

MOBILITY
500km/h

RELIABILITY
99.999%

99.99%

90 days   1 K/km²

4G

5G

MISSION CRITICAL SERVICES

SERVICE DEPLOYMENT TIME
90 minutes

NUMBER OF DEVICES
1 M/km²

ENERGY EFFICIENCY
10% of current consumption

INTERNET OF THINGS

Source: 5G Infrastructure Association: Vision White Paper, February 2015.

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5G PPP Vision and Requirements
Key requirements

1000 TIMES

20 BILLION HUMAN-ORIENTED TERMINAL

1 TRILLION

90%

<5MS LATENCY

99.999%

- 1,000 X in mobile data volume per geographical area reaching a target ≥ 10 Tb/s/km^2
- 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

19/06/2015

Source: 5G Infrastructure Association: Vision White Paper, February 2015.

5G PPP Vision and Requirements
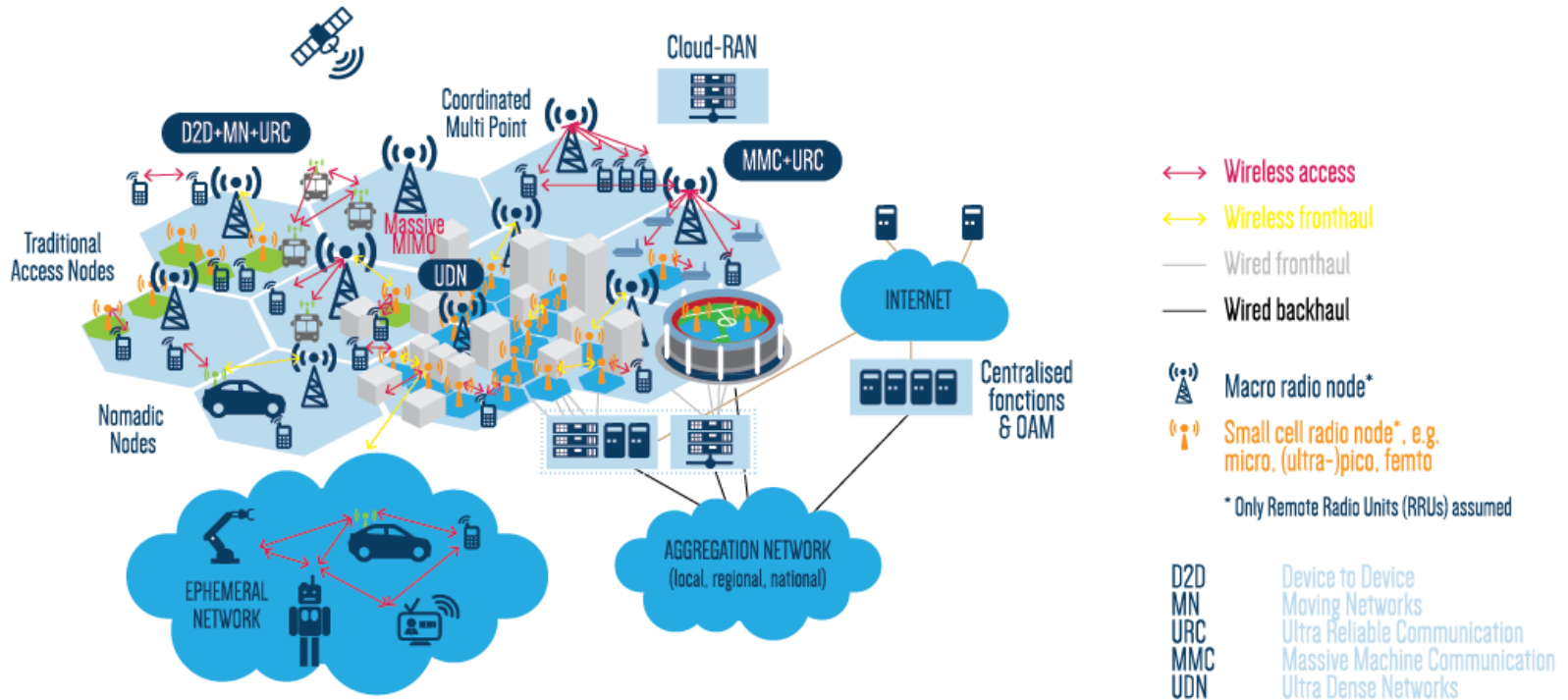## Key technological components

- 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

- Easer and optimised network management by means of exploitation of Data Analytics and Big Data techniques
  - to monitor users Quality of Experience
  - while guaranteeing privacy

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Source: 5G Infrastructure Association: Vision White Paper, February 2015.

Source: 5G Infrastructure Association: Vision White Paper, February 2015.

Radio-related cluster
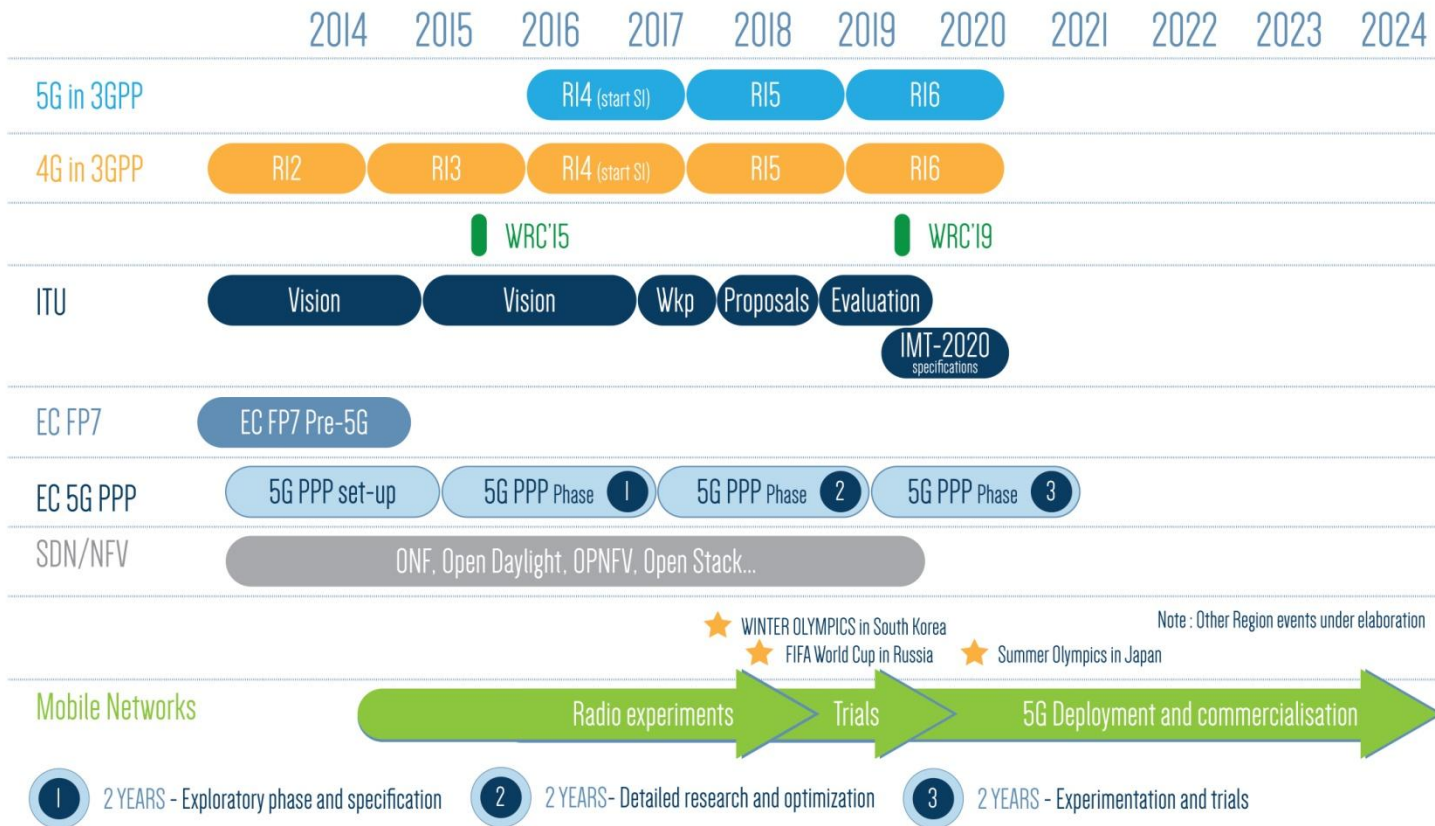
Objectives

- Radio interface below 6 GHz

- Radio interface above 6 GHz

- Overall RAN design

- Heterogeneous radio access networks (RAN)

- Novel adaptive 5G mobile network architecture

- Spectrum access

Source: COHERENT, FANTASTC-5G, Metis-II, mmMAGIC, 5G-NORMA, SPEED-5G.

Fronthaul/backhaul

Objectives

- **5G integrated backhaul and fronthaul transport network**
- Fronthaul and backhaul solutions between RAN and packet core
- Demonstration and validation of xHaul technology components will be integrated into a software-defined flexible and reconfigurable 5G Test-bed
- **Flexible backhaul/fronthaul network** for serving current and future RAN deployments in a dynamic, service oriented, and cost-effective way
- **Seamless integration of future-proof technologies** in the optical and wireless (Sub-6 GHz, mm-Wave) metro/access domains, through a converged software-based control plane

Source: xHaul, 5G-xHaul.

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Hardware implementation

Objectives

- Increasing the HW versatility and reconfigurability
- Providing HW-agnostic, flexible and cost-effective SW platforms
- Increasing the overall capacity of 5G communication platforms
- Decreasing the energy consumed by 5G communication platforms
- Identifying and prototyping key building blocks

Areas to be addressed

- RF front-ends and antennas (versatility, TRX > 6 GHz, antennas, …)
- Mixed-signal technology (broadband DAC/ADC, full duplex, …)
- Digital front-end + HW/SW split (HW for new waveforms, MIMO …)
- SW modules and functions (SW re-configurability, energy savings)

Source: Flex5Gware.

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Network automation

Objectives

- **Automated and fast provisioning** of infrastructure services in a multi-domain/multi-operator 5G environment
- Innovative framework for the **automated management** and rapid deployment **of self-configuring next-generation networks and services**
- Extending the state-of-the-art network management within the Software-Defined Networking and Network Function Virtualization (SDN/NFV) arena
- Network Management at the **5G/IOT** scale

Source: CogNet, SELFNET, 5GEx.

SDN, NFV, Cloud and Virtualisation

Objectives

- **Network Functions Virtualisation (NFV)** and **Edge Cloud Computing**;
- Substantial evolution of the Small Cell concept
- 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.
- **Reduce time to market for networked services** by shortening service development (Programming model and SDK)
- Optimizing resource utilization and reduce cost of service deployment and operation
- Converged cloud-based 5G concept that will enable innovative use cases in the mobile edge, empower new business models, and reduce investment and operational costs
- 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

Source: SESAME, SONATA, SUPERFLUIDITY, VirtuWind.

Security

Objectives
- End-to-end security across all layers of the converged and virtualised open access network
- Physical layer low-latency security for both wireless and optical, in open, dynamic, multi-user, highly connected and decentralized 5G networks
- Build two secure end-to-end pilot demonstrators

Source: CHARISMA, 5G-ENSURE.

Conclusions

- 5G research started already in EU Framework Program 7

- 5G research is getting momentum globally

- In Europe 5G PPP launched in December 2013 as part of new research program Horizon 2020

- 5G PPP is addressing the complete future communication network including support of vertical sectors

- 5G PPP published its Vision and Requirements White Paper in Barcelona at MWC 2015

- Horizon 2020 Call 1 projects will start on July 1, 2015 and will address major components of future communication network

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

Source: 5G Infrastructure Association.

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Thank you for your attention!