5G in Research Activities: TIM Commitment

Umberto Ferrero
The Myth - the fifth element

I Tetrahedron Fire

II Octahedron - Air

III Icosahedron Water

IV Esahevron (Cube) Earth

V Dodecaedro Aether

... start thinking about 5G in 2012 ...
... while deploying 4G ...
Looking back ... looking ahead

2012

2004 - Early talks on 4G

2007 - Early 4G technical demonstration

2008 – LTE early field trial

2006 – 2009: WINNER 1 & 2 European Project

January 2010 - June 2012- ARTIST4G European Project

2020

December 2012: commercial Launch in Italy
Funded European Projects on 5G – First Phase

**FP7 - € 200 million financed from the EU (2012-2015)**

- Telecom Italia: METIS, iJoin, MiWaves

**Foundations of 5G system.** The Project involved 29 major partners, completed in April 2015.

- **METIS pillars:** Extreme Mobile Broadband, Massive Machine-Type Communication, Ultra-reliable Machine Type Communication

- **Centralization** of some Radio Access Network (RAN) functionalities through a platform based on cloud infrastructure

- Introducing the concept of RAN-as-a-service (iJOIN Project, completed April 2015)

- **Miwaves Project** (from Jan.2014 until Dec.2016)
  - Use of millimetre-waves (e.g. 60 GHz and higher) both for radio access and backhauling in small cells scenarios
METIS Scenarios

More information in METIS deliverable D1.1

Amazingly fast
Data-rate, delay

Great service in a crowd
Accessibility, crowds

Best experience follows you
Accessibility, mobility

Super real-time and reliable connections
Delay, reliability

Ubiquitous things communicating
Devices, coverage, energy & cost

Dense urban information society
Shopping mall
Open air festival
Stadium
Traffic jam

Traffic efficiency and safety

Mobile cloud processing

Emergency communications

Teleprotection in smart grid networks

Massive deployment of sensors and actuators

Data-access
100 Mbps
1 Gbps
5 Gbps

Virtual reality office

5G: what’s Myth and Reality?
Wireless Innovation – Umberto Ferrero
METIS Technical objectives

1000x higher mobile data volumes
10x – 100x typical end-user data rates
10x – 100x higher number of connected devices
10x longer battery life (low-power devices)
5x lower latency

Data rate

- xMBB
- 5G services
- mMTC

Latency/Reliability

Number of devices

- Dynamic RAN
- Lean System Control Plane
- Localized Contents and Traffic Flows
- Spectrum Toolbox

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**METIS I-II Overview**

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

- First coordinated 5G research project
- METIS laid the foundation of 5G in FP7 call phase, paving the way to 5GPPP
- METIS II is the continuation of METIS, P1 in 5G PPP terminology, with a slightly changed consortium

The final METIS meeting was held in Torino, on 10-12 March 2015. METIS 2 is planned in the framework H2020-5GPPP (2H15).

- [http://5g-ppp.eu/metis-ii/](http://5g-ppp.eu/metis-ii/)
Interworking and JOINt Design of an Open Access and Backhaul Network Architecture for Small Cells based on Cloud Networks

**Objectives**
- **iJOIN aims for a joint design and optimisation of access and backhaul, integrating small-cells, heterogeneous backhaul, and centralised processing**
- **iJOIN introduces the novel concept RAN-as-a-Service (RANaaS), where RAN functionality is flexibly centralised through an open IT platform based on a cloud infrastructure**
The effective introduction of V-RAN requires the definition of a proper level of centralization and virtualization of RAN functionalities.

Different options for functional split between Baseband and Radio Equipment are possible (RAN as a Service – RANaaS concept).

RANaaS: alternatives of Functional Split

- Distributed vs Centralized and Dedicated vs GPP Hardware

- Least Perf. Improvement: Loose delay and bandwidth req.
- Best Perf. Improvement: Strict delay and bandwidth req.

- Which trade-off?
MiWaveS project

Beyond 2020 Heterogeneous Wireless Network with Millimetre-Wave Small-Cell Access and Backhauling

- **Objective 1**: Mobile access with up to 5 Gbps data rate through mmW radios and above 10 Gbps aggregate capacity for backhaul.

- **Objective 2**: Reduction of the overall EMF exposure (reduction of 3G/4G traffic, higher free-space attenuation at mmW, high directivity antennas)

- **Objective 3**: Reduction of the power consumption per bit transmitted (access and backhaul) (green radio) (mmW radios, directive antennas, short distance links).

- **Objective 4**: Improvement of flexibility, QoS, robustness, security for operator networks (split of data and signaling traffic, priority traffic on the 3G/4G network, mmW directive and short-range access links, self-organizing network).

http://www.miwaves.eu/
The EU Commission signed a landmark agreement with the ‘5G Infrastructure Association’ on 17 December 2013, representing major industry players, to establish a Public Private Partnership on 5G (5G-PPP). This is the EU flagship initiative to accelerate research developments in 5G technology.

The European Commission has earmarked a public funding of €700 million through the Horizon 2020 Programme to support this activity.
The new H2020 5G-PPP projects (starting July 1\textsuperscript{st}, 2015)

Radio network architecture and technologies strand

Note: The size of the Projects boxes does not indicate the potential size or manpower of Projects

http://5g-ppp.eu/
Funded European Projects on 5G – Second Phase

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**METIS II – P1**
Overall architecture definition of 5G system.

**FANTASTIC 5G – P2**
Design of flexible/adaptable 5G air interface

**FLEXGWARE – P5**
Efficient hardware/software platforms for 5G

**XHAUL – P7**
Backhaul and fronthaul technologies for 5G

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5G Research in Horizon 2020 (€ 700 million in next 7 years)
- € 125 million in the first call (Nov ‘14)
- Start July 2015

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5G: what’s Myth and Reality?
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The reality - today

Around a world in a day – 5G reality check in an hour
Candidate radio access technologies for 5G

New radio Access components
- New Radio interface (e.g. FBMC for example, addressing also low cost M2M)
- New duplexing modes (i.e. full duplex)
- Ultra-lean signalling

Innovative deployments
- Mesh networks
- Massive use of direct communication

Technologies for flexible use of spectrum
- Frequencies above 6 GHz (up to 100 GHz)
- Opportunistic access to spectrum, including use of unlicensed bands

Virtualized access network with base band pooling (towards Virtual – RAN)

Reinforce LTE-A techniques
- Network densification and HetNet
- Massive MIMO (> than 8x8 antennas)
- Advanced receivers and interference coordination
- Enhanced multi-RAT coordination
- Wireless back/fronthaul; enhanced fronthaul

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Developing 5G know how and enablers – what we are doing

Cloud RAN towards Virtual RAN  
Study, prototypes and trials

Candidate 5G radio technology components analysis:  
Physical and system level modelling and evaluation

Analyze how mobile systems could efficiently support M2M/IoT services

Evaluate new fronthauling techniques (wired and wireless)

Scouting of innovative technologies (e.g. startups)

mmWave and massive MIMO: analysis and measurement

Set up of innovative lab for advanced antennas testing up to 90 GHz (end of 2015)
5G sneak preview ... in 9 demo corner
5G demo introduction: waveform and system concept

- The current cellular OFDM waveform is optimized for high-data rate traffic such as video and web access, but is sub-optimal for short-packet and low latency-transmissions for machine type traffic.
- The demonstration shows how a carrier using the UF-OFDM waveform can support both types of traffic very efficiently.

**UF-OFDM: efficient waveform for mobile broadband and machine type traffic**

**ERICSSON 5G Radio Test Bed**

- Terminal and NX basestation prototypes
- Technology for large bandwidth, high frequency systems
- Explore propagation @ 10+ GHz
- Demonstrate wireless transmission at up to 5 Gbit/s
5G demo introduction: air interface and ultra high capacity small cell

- F-ODMA: a new waveform for Self-adaptive Air Interface
- SCMA: Sparse Code Multiple Access, massive Connectivity & Low Latency, with polar channel coding.

- 5G Small cell, over 100Gbit/s, @ E-band
- Exploits massive MIMO (128x128) and 3D beamforming antennas
- High flexibility & scalability as a complement to macro site @ Low Frequency
5G demo introduction: full duplex and massive MIMO

- Same Channel for Access and Backhaul – Self-Backhaul
- Self-Interference cancellation technology enables Full-Duplex wireless operation: transmits and receives on the same frequency at the same time, doubles spectral efficiency and eliminates TDD/FDD duplexing
- The demo features In-Band Full-Duplex Relay Node that was previously considered impossible to implement

Massive MIMO antenna system, as well as small cells are the key enablers to evolve to 5G
- Prototype supports 64x2 antenna elements with dual cross polarizations supporting 100 MHz bandwidth
5G demo introduction: use cases and mobility

Interactive 3D visualization of key 5G use cases and Nokia’s 5G E2E solution

The 5G E2E demo is a virtual and interactive journey into 5G, depicted along the lines of the key requirement extremes in 5G and displaying both the uses cases likely to be relevant in 5G and Nokia’s comprehensive 5G solution portfolio in form of a 3D model of Manhattan.

- 1.2 Gbit/s at 110km/h using 28 GHz band
- Mobile station at 112 km/h, data rate: 1244Mpbs
- Record-breaking 5G demo: 7.5 Gbps 5G peak rate (static)
5G demo introduction: Virtual RAN and RAN as a service (functional split)

- Cloud implementation of decoder and computational Aware Scheduler, running in standard IT platform
- RANaaS is a cloud computing platform delivering general purpose computational resource: computational load is shared among a multitude of radio access points where part of RAN protocols are centralized in such hardware. A centralized scheduler and Link Adaptation algorithm have been designed.

Virtual RAN: a key enabler for 5G systems

- Virtual RAN prototype based on open source project.
- The prototype features a base station and a terminal. All radio access functionalities are completely implemented in software, running on commercial desktop or laptops.
- The platform allows the development of functionalities and algorithms, as well as performance evaluation.
... next steps towards 5G ...

- **International cooperation**: develop a common vision and strong competences through the participation to European projects

- **Partnership**: start testing technologies together with vendors

- **University**: prepare new skills

- **Experience hands on**: prepare lab and proof of concept, starting from basic building blocks
Thank you!