EMERGING 5G TECHNOLOGIES AND INSIGHTS FROM EXPERIMENTS WITH SELECTED VERTICAL DOMAINS

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Fundamentals: Requirements on 5G

- 1000x more capacity and data rates
- Towards 0-5ms E2E latency
- 1M/km² devices
- 500km/h high mobility
- 99.999% reliability
- <90mins service deployment time
- 90% energy efficiency

Source: 5G-PPP (https://5g-ppp.eu/)
Fundamentals: 5G Technology Trends

1. RAT evolution
2. Spectrum
3-4. Cell
5. Software Nets
6. Cloudification

Potential for sharing between operators (e.g., spectrum, network elements, network segments)

6. 5G, WMB infrastructures:
   Cloud platforms offering services through abstractions, on demand, with elasticity, scalability, fairness

- Activation of functional components
- Functional components deployment to physical elements
- Physical element interconnection

Repository of virtualized functions

Applications connecting everyone and everything, anywhere, anytime, involving all types of media

Communication, computing, storage resources

Macro

Micro

Pico

Femto

Core

2020+

4GHz 2GHz 4GHz 6GHz 30GHz 60GHz 300GHz

Previous generations
2G, 2.5G, 3G, 3.5G

B1

B2

B3

B4

Emerging RATs (5G)

LTE-A (4G)

5G-PPP Phase 1: Selected achievements

35+ projects funded by EC for 5G research

**Requirements/Technology Trends**

- Phase I (2015-17)
- Phase II (2017-18)
- Phase III (2018-20)

- QoS provision and capacity expansion - Advanced **spectrum** management

- **New Radio** below 6GHz

- **Hardware/Software** implementation aspects
FANTASTIC-5G: New Air Interface below 6GHz

Features
- New waveforms
- Frame design
- Advanced coding
- Advanced modulation
- Massive MIMO
- Enhanced RRM

Evaluation
Flexible frame: ~50% reduced latency compared to LTE-A

New waveforms: QoS achievement with 30-50% less cost (e.g. retransmissions) compared to OFDM

Sample achievements: Over 20 patents filed, standardization etc.
SPEED-5G: Spectrum optimization

Features

- Novel spectrum management
- Extended Dynamic Spectrum Assignment (eDSA)
- Lightly-licensed spectrum and licensed/unlicensed
- New MAC/RRM

Evaluation

Achievement of 5G performance with up to 70% less cost (signalling due to hierarchical RAT/spectrum management)

Hardware evaluation—Hardware in the loop

Results/Visualization

Traffic generator

USRPs
Flex5Gware - Flexible and efficient HW/SW

Features

- HW versatility and reconfigurability
- HW-agnostic, flexible and cost-effective SW platforms
- More capacity of 5G communication platforms
- Less energy consumed by 5G communication platforms

Evaluation

20 ms, up to 300 ms less reconfiguration time, in terms of optimization execution, compared to current optimization solutions

10% less power consumption, when moving more functions to SW implementation
5G-PPP Phase 2

Verticals and technology

**One5G**
- Megacities and Under-served areas
- E2E-aware optimizations
- Advanced link technologies and enhancements beyond Rel.15
- Multi-service operation
- Advanced massive MIMO and RRM

**Clear5G**
- Factories of the Future (FoF)
- Towards “zero” latency
- Ultra-reliable services
- Configure and optimize radio network architectures
- Energy and spectral efficiency
- Protocol enhancements

**MATILDA**
- Operational framework where software for 5G-ready applications
- Supporting virtual and physical network functions
- Development of micro-services & VNFs
- Automotive, Smart cities, Industry 4.0, Media

**5G-PHOS**
- Integrated optical technologies
- Enhancing Fiber-Wireless (FiWi) convergence
- Joint optical/wireless network optimization
- Cost-effective & energy-efficient 5G network solutions
- Media delivery in smart venues
5G-PPP Phase 3
Evolution-Experiments-Pilots-Trials

- **Verticals**
  - Advanced automation
  - Energy management
  - Water management

- **Trials**

- **Beyond Phase 3**
  - Exploitation
  - Innovation Management
  - Funding instruments in conjunction with market forces
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Thank You!