Resource and spectrum management - an European research projects survey

Valerio Frascolla
Intel

2017.04.25, COCORA 2017, Venice

Outline

- Setting the scene:
  - Need for a new spectrum and resource management in 5G?

- The view of
  - **ADEL**
  - **SPEED-5G**
  - **FUTEBOL**
  - **5G-MiEdge**
  - **mmMAGIC**

- Q&A

Setting the scene

- **5G networks need new spectrum and resource management techniques**
  - Stringent new requirements to fulfil new services
  - Ubiquitous seamless wireless experience (VR/AR, 1Gbps, …)

- **EU research projects propose innovative solutions:**
  - ***ADEL:***
    - New use of existing spectrum: LSA/LSA+
  - ***mmMAGIC:***
    - Advanced Cooperative Multi Point techniques
  - ***SPEED-5G:***
    - New concepts for new spectrum usage: eDSA
  - ***FUTEBOL:***
    - LSA to the masses: open research access
  - ***5G-MiEdge:***
    - MEC & mmWaves spectrum, liquid control plane

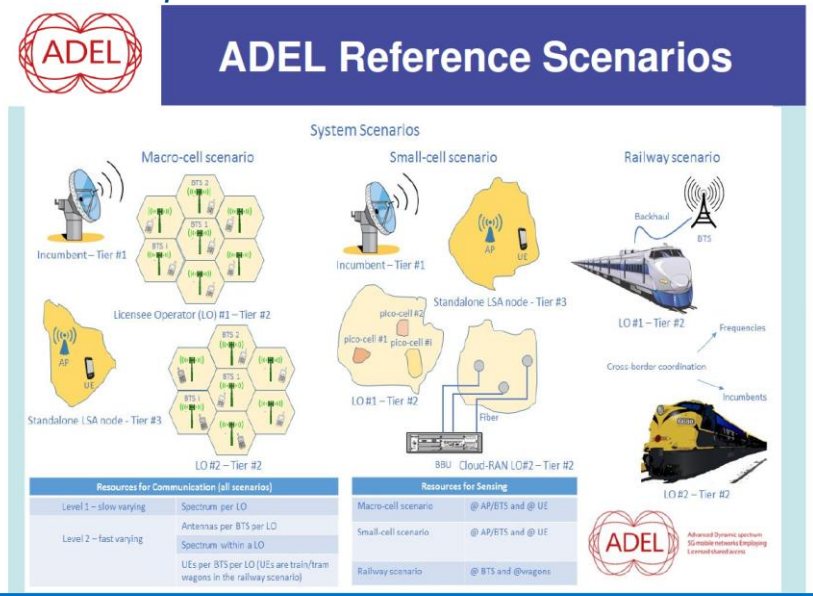
Use case category	User Experienced Data Rate	E2E Latency	Mobility
Broadband access in dense areas	DL: 300 Mbps UL: 50 Mbps	10 ms	On demand, 0-100 km/h
Indoor ultra-high broadband access	DL: 1 Gbps, UL: 500 Mbps	10 ms	Pedestrian
Broadband access in a crowd	DL: 25 Mbps UL: 50 Mbps	10 ms	Pedestrian
50+ Mbps everywhere	DL: 50 Mbps UL: 25 Mbps	10 ms	0-120 km/h
Ultra-low cost broadband access for low ARPU areas	DL: 10 Mbps UL: 10 Mbps	50 ms	on demand: 0-50 km/h
Mobile broadband in vehicles (cars, trains)	DL: 50 Mbps UL: 25 Mbps	10 ms	On demand, up to 500 km/h
Airplanes connectivity	DL: 15 Mbps per user UL: 7.5 Mbps per user	10 ms	Up to 1000 km/h
Massive low-cost/long-range/low-power MTC	Low (typically 1-100 kbps)	Seconds to hours	on demand: 0-500 km/h
Broadband MTC	See the requirements for the Broadband access in dense areas and 50+Mbps everywhere categories		
Ultra-low latency	DL: 50 Mbps UL: 25 Mbps	<1 ms	Pedestrian
Resilience and traffic surge	DL: 0.1-1 Mbps UL: 0.1-1 Mbps	Regular communication: not critical	0-120 km/h
Ultra-high reliability & Ultra-low latency	DL: From 50 kbps to 10 Mbps; UL: From a few bps to 10 Mbps	1 ms	on demand: 0-500 km/h
Ultra-high availability & reliability	DL: 10 Mbps UL: 10 Mbps	10 ms	On demand, 0-500 km/h
Broadcast like services	DL: Up to 200 Mbps UL: Modest (e.g. 500 kbps)	<100 ms	on demand: 0-500 km/h

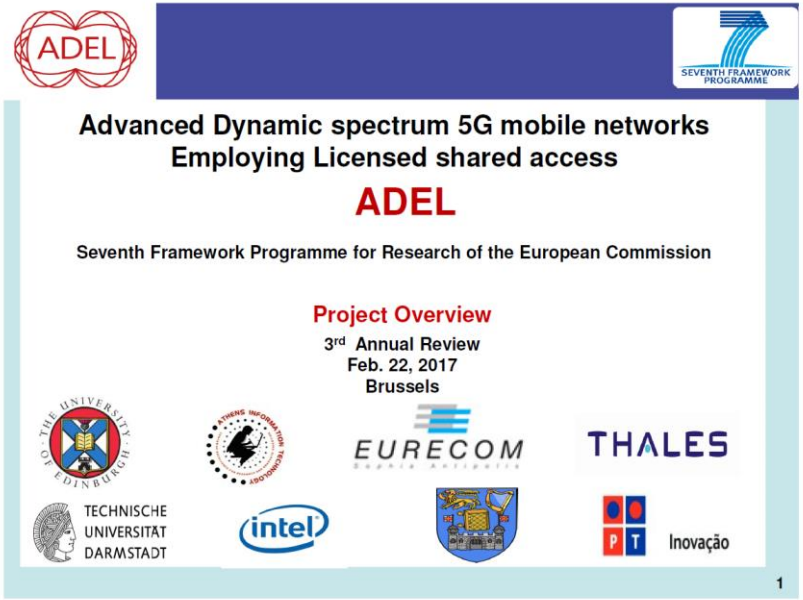
Source: NGMN 5G White Paper, 2015

Duration / Project	2014		2015		2016		2017		2018		2019	
	H1	H2	H1	H2	H1	H2	H1	H2	H1	H2	H1	H2
ADEL												
mmMAGIC												
SPEED-5G												
FUTEBOL												
5G-MiEdge												

ADEL (www.fp7-adel.eu)

- Advanced Dynamic Spectrum 5G mobile networks Employing Licensed Shared Access
- FP7, 2013.12 – 2016.11
- Explore the potential of LSA as a key enabler of 5G mobile broadband networks, via:
  - *Collaborative sensing techniques,*
  - *Dynamic, radio-aware resource allocation,*
  - *Cooperative communication.*

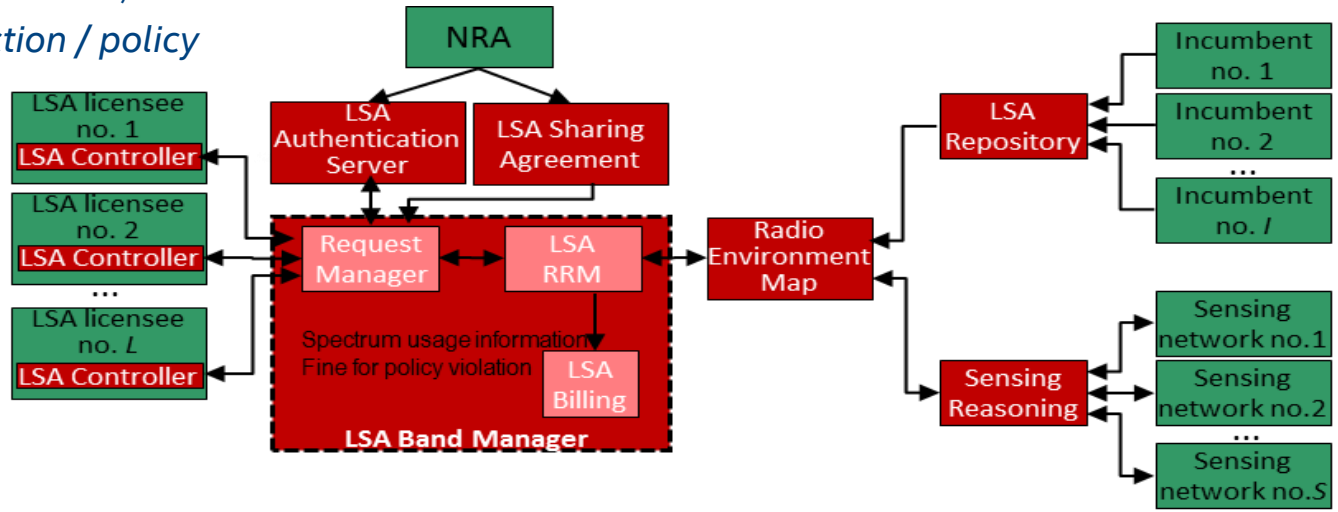




ADEL

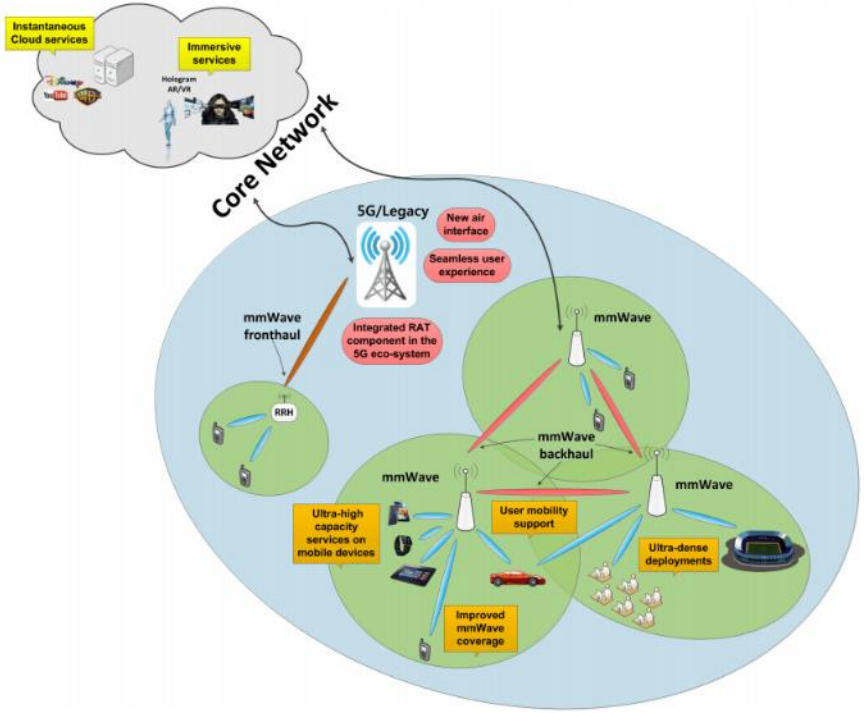
- ***Several research directions:***
  - *Collaborative spectrum sensing,*
  - *Signal processing techniques for sensing,*
  - *Interference channel estimation and interferer localization,*
  - *Cooperative communication,*
  - *Dynamic resource allocation,*
  - *Policy violation detection / policy reinforcement.*

- *A new network architecture is proposed:*
  - *Supporting conventinal LSA schemes,*
  - *Proposing new or enhanced functionalities (red blocks)*
- *The dynamic ADEL architecture was proposed to ETSI in 2015:*



mmMAGIC (mmmagic.eu)

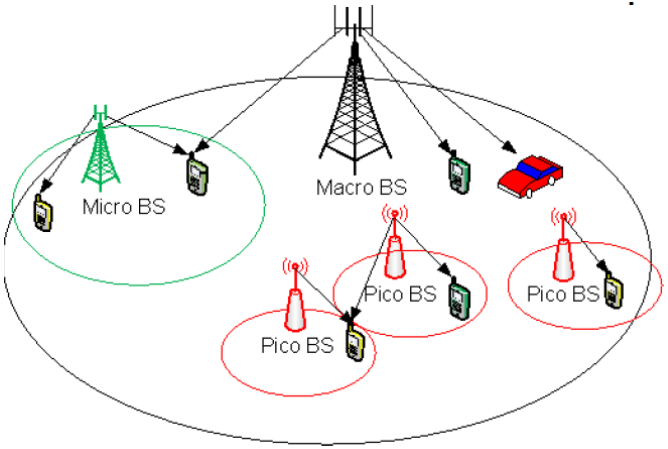
- Millimetre-Wave Based Mobile Radio Access Network for Fifth Generation Integrated Communications
- FP8, 5GPPP family project, 2015.07 – 2017.06
- *Key target:*
  - Develop and design new concepts for mobile radio access technology, for deployment in the 6-100 GHz range.



Sinopsys of mmMAGIC use cases

mmMAGIC

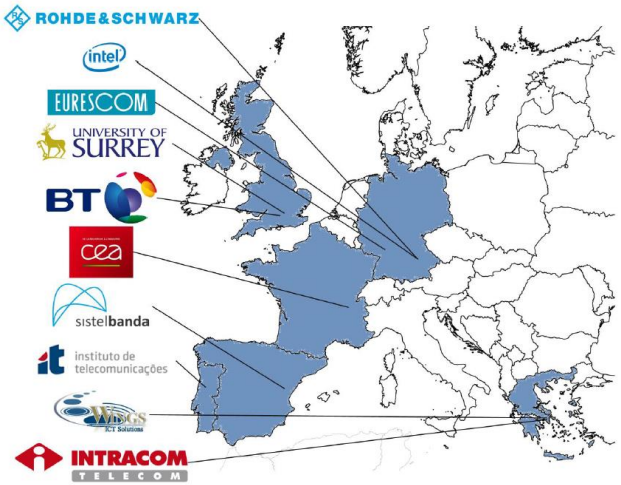
- Key 5G enabling streams of activities:
  - Realistic channel measurements and modeling via extensive campaigns in relevant 5G scenarios,
  - Front-haul and back-haul mmwave technologies for fast and easy deployments,
  - Conduct measurements and develop accurate channel models for mmwave frequency bands,
  - Design and develop channel waveforms and coding-decoding schemes, numerology, and frame structure for 5G RATs,
  - Design TX technologies for front-runner 5G deployment,
  - Advanced CoMP techniques,
  - Heavy standards impact of the novel proposed technologies.

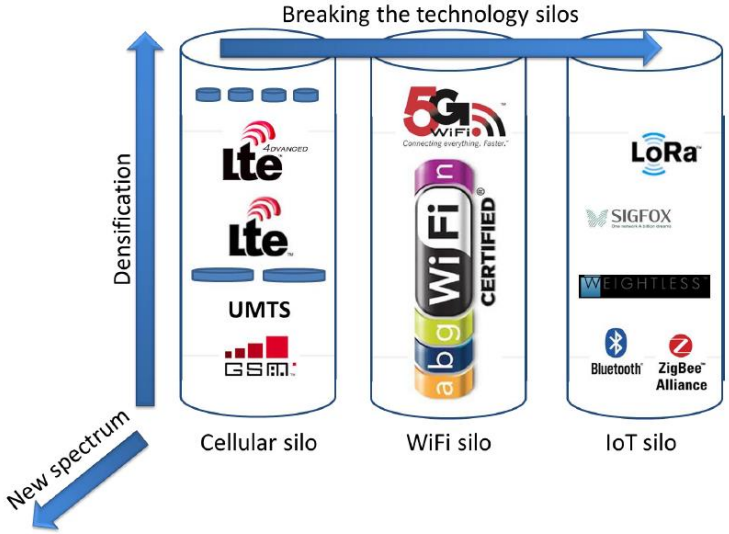


Joint optimization of precoding, load balancing and BS operation modes

SPEED-5G (speed-5g.eu)

- Quality of Service Provision and Capacity Extension through Extended – DSA for 5G
- FP8, 5GPPP family project, 2015.07 – 2018.04
- *extended Dynamic Spectrum Access* new paradigm, via
  - Ultra-densification through small cells,
  - Using additional spectrum,
  - Exploitation of available resources across different technologies



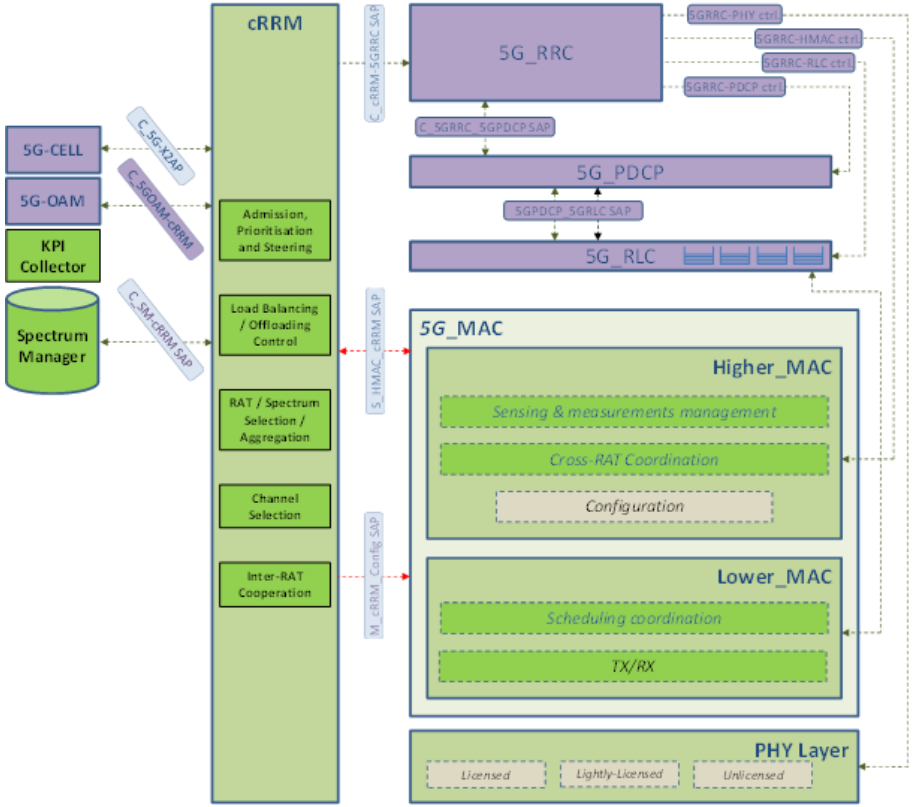


SPEED-5G

- Main focus on RRM and MAC functionalities (green blocks in the picture)

- *Small-cell RRM research directions:*
  - *Channel selection,*
  - *Traffic steering,*
  - *Load balancing,*
  - *RAT/Spectrum selection and aggregation,*
  - *Multi-RAT cooperation,*
  - *Spectrum Sensing.*

- *Next steps:*
  - Focus on UE-based decision mechanisms,
  - Autonomic inter-RAT switching.



FUTEBOL (www.ict-futebol.org.br)

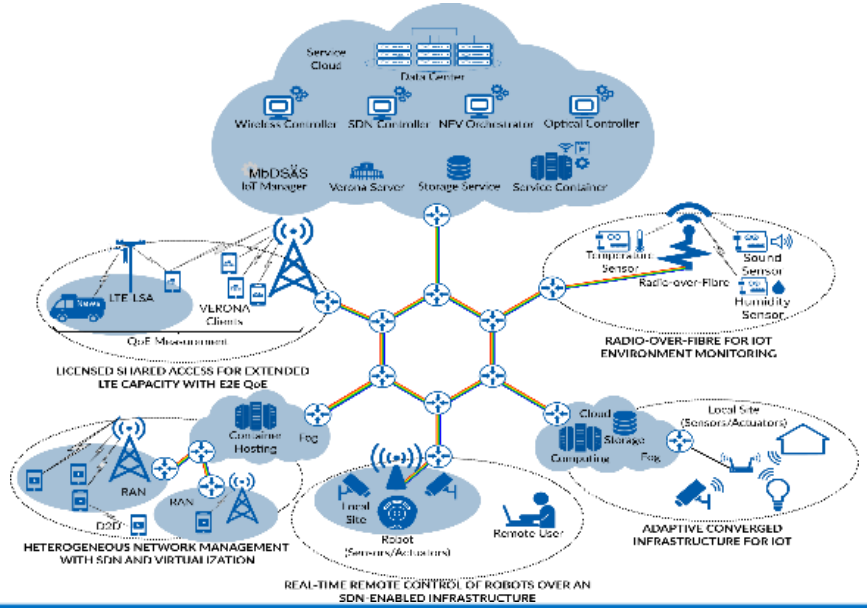
- Federated Union of Telecommunications Research Facilities for an EU-Brazil Open Laboratory

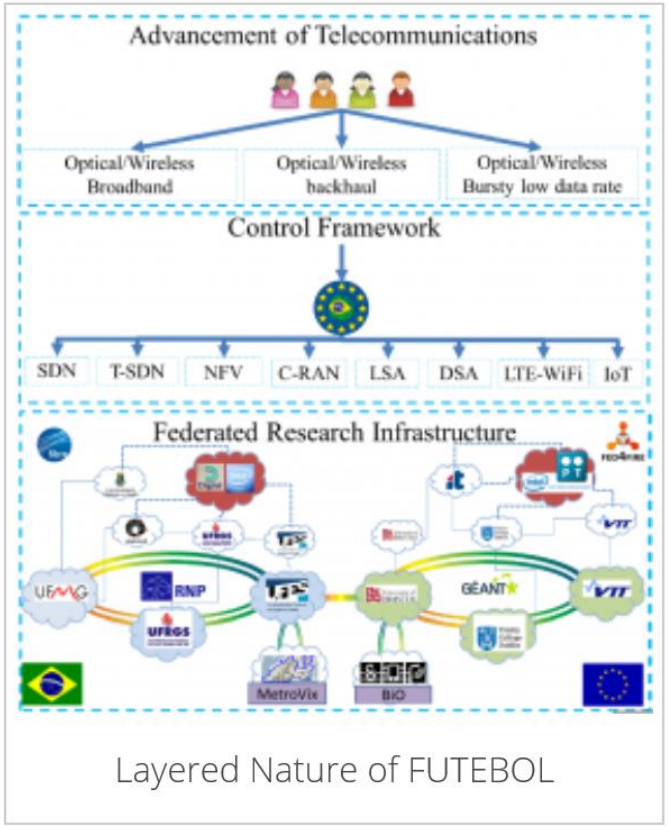
- FP8, Europe-Brazil co-funding, 2016.03 – 2019.02

- FUTEBOL targets:
  - *Compose a federation of research infrastructure,*
  - *Develop a supporting control framework,*
  - *Conduct experimentation-based research in order to advance the state of telecommunications,*
  - *Stress on the investigation of the optical/wireless networks boundary.*

FUTEBOL

- Main objectives of the project:
  - *Deploy facilities in Europe & Brazil that can be openly accessed by external experimenters,*
  - *Design & develop a converged control framework for experimentations at the optical/wireless boundary, currently missing in FIRE and FIBRE research infrastructures,*
  - *5 Experiments are planned, among which:*
    - LSA to the masses - Experiment 1: Licensed Shared Access for extended LTE capacity with E2E QoE



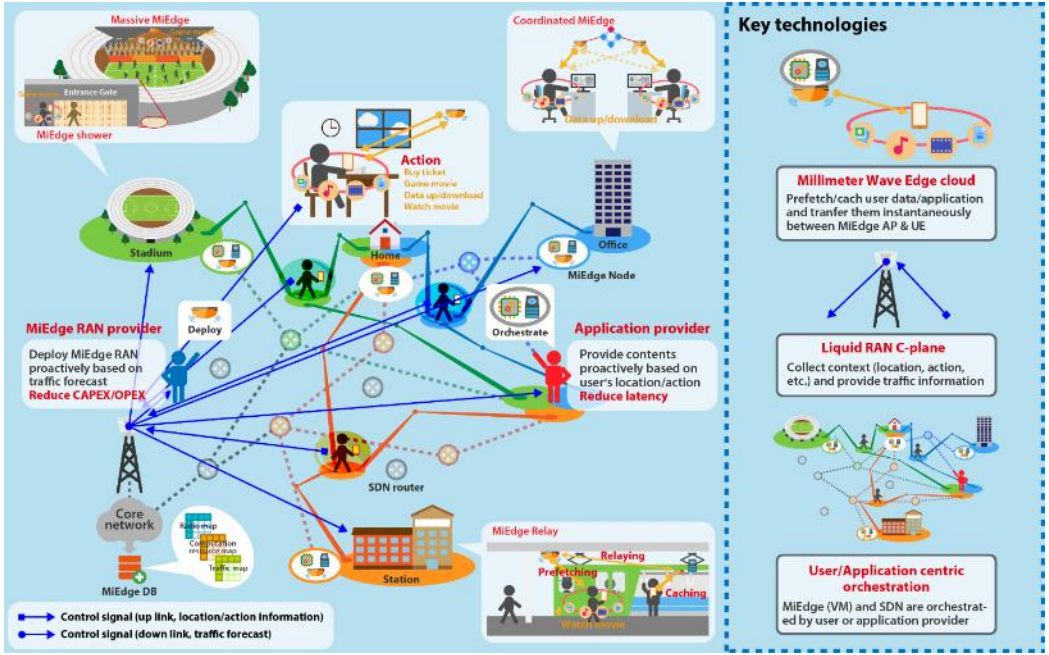


Layered Nature of FUTEBOL

5G-MiEdge (5g-miedge.eu)

- Millimeter-wave Edge Cloud as an Enabler for 5G Ecosystem

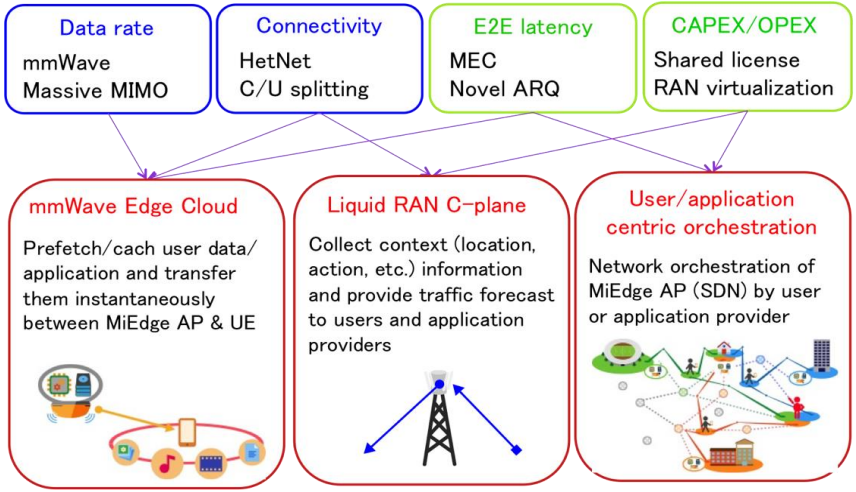
- FP8, Europe-Japan co-funding, 2016.06 – 2019.05



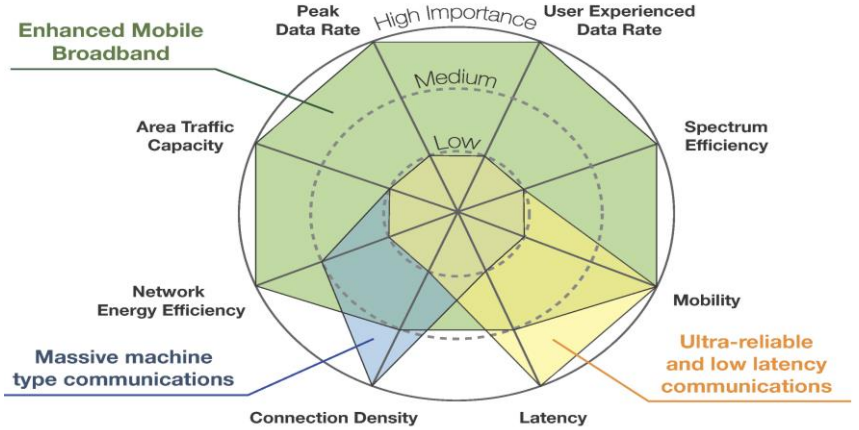
- *Key technology enablers:*
  - mmWave Access & Backhaul,
  - User/Application Centric Orchestration,
  - Liquid RAN Control-plane:
    - novel ultra-lean and inter-operable control signaling over 3GPP LTE to provide liquid ubiquitous coverage in 5G networks, based on acquisition of context information and forecasting of traffic requirements.

5G-MiEdge

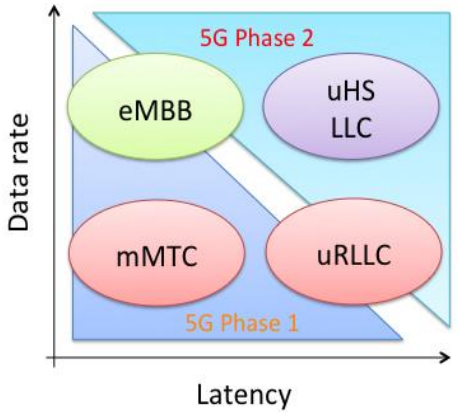
- Research directions:
  - 5G Phase II features
  - Focus on the uHSLLC cluster of use cases - ultra High-Speed and Low Latency Communications
  - Advanced management techniques targeting 5G access stratum layers
  - Intelligent mmwave spectrum usage



Technology components for uHSLLC and related KPIs



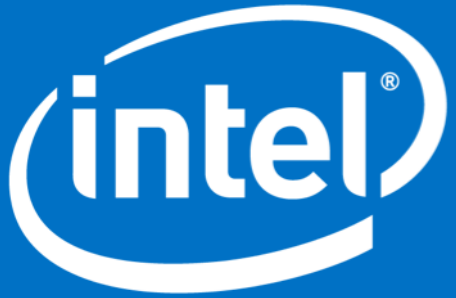
5G KPI defied in IMT-2020



Q&A

➢Questions?

Disclaimers:
5G-MiEdge: The research leading to these results are jointly funded by the European Commission (EC) H2020 and the Ministry of Internal affairs and Communications (MIC) in Japan under grant agreements N° 723171 5G MiEdge in EC and 0159-{0149, 0150, 0151} in MIC.
SPEED-5G: The research leading to these results received funding from the European Commission H2020 programme under grant agreement n°671705 (SPEED-5G project).
FUTEBOL: The research leading to these results received funding from the European Union's Horizon 2020 for research, technological development, and demonstration under grant agreement no. 688941 (FUTEBOL), as well from the Brazilian Ministry of Science, Technology and Innovation (MCTI) through RNP and CTIC.
mmMAGIC: The research leading to these results partially received funding from the European Commission H2020 programme under grant agreement no671650 (5G-PPP mmMAGIC project).



Intel Communication and Devices Group