Resource and spectrum management - an European research projects survey

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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 & mmRays spectrum, liquid control plane

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<table>
<thead>
<tr>
<th>Use case category</th>
<th>User Experienced Data Rate</th>
<th>E2E Latency</th>
<th>Mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor ultra-high broadband access</td>
<td>DL: 1 Gbps, UL: 1 Gbps</td>
<td>10 ms</td>
<td>Pedestrian</td>
</tr>
<tr>
<td>Broadband access in a crowd</td>
<td>DL: 25 Mbps, UL: 50 Mbps</td>
<td>10 ms</td>
<td>Pedestrian</td>
</tr>
<tr>
<td>50+ Mbps everywhere</td>
<td>DL: 50 Mbps, UL: 25 Mbps</td>
<td>10 ms</td>
<td>0-120 km/h</td>
</tr>
<tr>
<td>Ultra-low cost broadband access for low ARPU areas</td>
<td>DL: 10 Mbps, UL: 50 Mbps</td>
<td>50 ms</td>
<td>On demand, 0-500 km/h</td>
</tr>
<tr>
<td>Mobile broadband in vehicles (cars, trains)</td>
<td>DL: 50 Mbps, UL: 25 Mbps</td>
<td>10 ms</td>
<td>On demand, up to 500 km/h</td>
</tr>
<tr>
<td>Airplanes connectivity</td>
<td>DL: 15 Mbps per user, UL: 7.5 Mbps per user</td>
<td>10 ms</td>
<td>Up to 1000 km/h</td>
</tr>
<tr>
<td>Massive low-cost long-range low-power MTC</td>
<td>Low (typically 1-1000 kbps)</td>
<td>Seconds to hours</td>
<td>On demand: 0-500 km/h</td>
</tr>
</tbody>
</table>

Broadband MTC: See the requirements for the broadband access in dense areas and 50+ Mbps everywhere categories

Ultra-low latency:
- DL: 50 Mbps, UL: 15 Mbps
- <1 ms | Pedestrian

Resilience and traffic surge:
- UL: 0.1-1 Mbps
- Regular communication: not critical

Ultra-high reliability & Ultra-low latency:
- From 50 kbps to 10 Mbps
- 1 ms | On demand: 0-500 km/h

Ultra-high availability & reliability:
- DL: 10 Mbps, UL: 10 Mbps
- On demand: 0-500 km/h

Broadcast like services:
- DL: Up to 200 Mbps
- UL: Modem (e.g. 500 kbps)
- <100 ms | On demand: 0-500 km/h

Duration / Project

- **ADEL**
- **mmMAGIC**
- **SPEED-5G**
- **FUTEBOL**
- **5G-MiEdge**

Source: NGMN 5G White Paper, 2015

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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.
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 conventional 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.
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.
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
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.
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 experimentation 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
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
Questions?

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