Keynote speech: The Path to 5G - New Spectrum Access Paradigms and Mobile Device Reconfigurability

Dr. Markus Mueck
Markus.Dominik.Mueck@intel.com
Intel Mobile Communications Group
I. Wireless Broadband Capacity

II. mmWave for 5G

III. Licensed Shared Access

IV. Mobile Device Reconfigurability

V. Conclusions
I. Wireless Broadband Capacity
Issue: Massive amounts of capacity required for exploiting Mobile Traffic!

- Mobile Data Traffic expected by 2017
  - Cisco Visual Networking Indexing

How to address Capacity requirements?

➢ A 5G System Vision for addressing Capacity requirements

- Cloud RAN & Enhanced Backbone Network
- Several (heterogeneous) RATs/BS (types) serving a Mobile Device (including, e.g., U/C plane splitting)
- Small Cell, typically using mmWave spectrum
- Macro Cell, typically using spectrum < 6GHz
- Wireless Backhaul link, e.g. by mmWave connection through Macro BS or directly to Backbone
- Dynamic Cell structuring (set-up of small cells upon need, etc.)
- Device-to-Device / Multi-Hop communication

Source: Global Standards enabling a 5th Generation Communications System Architecture Vision, Mueck, Haustein et al., to appear in Globecom’14
In the context of 5G activities, a 1000x increase of capacity is targeted.

- New dedicated licensed bands (e.g., spectrum under discussion towards WRC-15)
  - Issue: limited opportunities
- Spectrum Sharing (e.g. Licensed Shared Access in 2.3-2.4 GHz in Europe)
- New mmWave spectrum (10/28-90 GHz, licensed/unlicensed)
- New rules for unlicensed Spectrum for WiFi (5 GHz) or TVWS

<table>
<thead>
<tr>
<th>Company</th>
<th>Spectrum</th>
<th>Spectral Efficiency</th>
<th>Base Station Densification</th>
<th>Total capacity increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nokia</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>1000</td>
</tr>
<tr>
<td>Huawei</td>
<td>4</td>
<td>16-30</td>
<td>10</td>
<td>640-1200</td>
</tr>
<tr>
<td>NTT DoCoMo</td>
<td>2.8</td>
<td>24</td>
<td>15</td>
<td>1000</td>
</tr>
<tr>
<td>Ericsson</td>
<td>4</td>
<td>2.5</td>
<td>100</td>
<td>1000</td>
</tr>
<tr>
<td>RWTH Aachen</td>
<td>3</td>
<td>5</td>
<td>66</td>
<td>1000</td>
</tr>
</tbody>
</table>

Source: 5G Summit Munich, 10-Feb-2014
II. mmWave for 5G
**mmWave spectrum is a key ingredient in a heterogeneous 5G Context**

- Utilizing mmWaves, the cell densification can be driven much further than with frequencies below 6 GHz due to reduced coverage range.

The inherent relationship between cell sizes and transmit power is illustrated on the left side. The advantages of Small Cells in terms of overall power efficiency are obvious.

Source: Global Standards enabling a 5th Generation Communications System Architecture Vision, Mueck, Haustein et al., submitted to Globecom’14
mmWave spectrum is a key ingredient in a heterogeneous 5G Context

Current studies reveal that matching the expected growth rate of wireless traffic with mmWave small cells will outperform small cells operated at below 6 GHz already in 5 years’ time.

Source: Global Standards enabling a 5th Generation Communications System Architecture Vision, Mueck, Haustein et al., to appear in Globecom’14
Currently, mmWave Spectrum Occupancy is as follows:

<table>
<thead>
<tr>
<th>Band (GHz)</th>
<th>Frequency Range (GHz)</th>
<th>Primary Services</th>
<th>Primary Allocation to MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>27.5-29.5</td>
<td>27.5-28.5</td>
<td>FS, MS, FSS</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>28.5-29.1</td>
<td>FS, MS, FSS</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>29.1-29.5</td>
<td>FS, MS, FSS</td>
<td>Yes</td>
</tr>
<tr>
<td>LMDS</td>
<td>31.075-31.225</td>
<td>MS, FS</td>
<td>Yes</td>
</tr>
<tr>
<td>39 GHz</td>
<td>38.6-39.5</td>
<td>MS, FS, FSS</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>39.5-40.0</td>
<td>MS, FS, FSS, MSS</td>
<td>Yes</td>
</tr>
<tr>
<td>40 GHz</td>
<td>40.50-42.50</td>
<td>FS, FSS, BS, BSS</td>
<td>No (MS is secondary)</td>
</tr>
<tr>
<td>46 GHz</td>
<td>45.5-46.9</td>
<td>MS, MSS, RNS, RNSS</td>
<td>Yes</td>
</tr>
<tr>
<td>47 GHz</td>
<td>47.2-48.2</td>
<td>MS, FS, FSS</td>
<td>Yes</td>
</tr>
<tr>
<td>49 GHz</td>
<td>48.2-50.2</td>
<td>MS, FS, FSS</td>
<td>Yes</td>
</tr>
<tr>
<td>60 GHz</td>
<td>57-64</td>
<td>MS, FS, EESS (up to 59.3), SRS (up to 59.3), ISL (except for 58.2-59)</td>
<td>Yes</td>
</tr>
<tr>
<td>E-band</td>
<td>71-76, 81-86, 92-95</td>
<td>MS, FS, FSS, MSS, BS (74-76), BSS (74-76), RAS (81-81), RAS (92-95), SRS (94-94.1), RLS</td>
<td>Yes</td>
</tr>
</tbody>
</table>

- A variety of services exist, including Fixed Service (FS), Mobile Service (MS), Fixed Satellite Service (FSS), etc.
- **MS**: Mobile Service;
- **SRS**: Space Research Service; **ISL**: Inter-Satellite Links;
- **FS**: Fixed Service;
- **ARNS**: Aeronautical radio Navigation;
- **RLSS**: Radiolocation Satellite Service;
- **FSS**: Fixed Satellite Service;
- **RLS**: Radiolocation Service;
- **RAS**: Radio Astronomy Service;
- **EESS**: Earth Exploration Satellite Service;
- **RNS**: Radionavigation Service;
- **MSS**: Mobile Satellite Service
III. Licensed Shared Access
Based on EC Mandate M/512, ETSI ERM/RRS have developed a Shared Spectrum related System Reference Document (SRdoc): TR 103 113

Scope: Mobile broadband services in the 2 300 MHz – 2 400 MHz frequency band under Licensed Shared Access regime, the basic architecture approach is as follows:
• Key Challenge:
  • In Europe, main FDD LTE networks are deployed
  • However, LTE Band 40 (LSA candidate) is an LTE TDD band

• An TDD/FDD Carrier Aggregation solution is required
  • LTE Band 40 can serve as „full“ band or supplemental DL

Carrier Aggregation: TDD & FDD !
European Commission issued standardization mandate (M/512), ETSI develops corresponding Licensed Shared Access (LSA) Standards in response to the mandate.

European Regulators collaborate closely with ETSI in order to resolve Regulation hurdles, defining for example spectrum access conditions For Licensed Shared Access in 2.3-2.4 GHz (CEPT WG FM PT52/53)

Integrated approach to dynamically authorizing access to the Priority Access and General Authorized Access (GAA) tiers of the 3.5 GHz Band: approach towards implementing the next generation of spectrum management systems

ETSI develops standards for Licensed Shared Access, in particular A System Architecture Design standard is in preparation. INTEL is in A Lead Role (ETSI RRS Chairman is INTEL’s Markus Mueck)
• ETSI TR 103 113 was issued: System Reference Document (SRdoc); Mobile broadband services in the 2 300 MHz – 2 400 MHz frequency band under Licensed Shared Access regime

• ETSI TS 103 154 is in final draft stage: System requirements for LSA in 2300-2400 MHz

• ETSI TS 103 235 is in early draft stage: System Architecture and High Level Procedures for operation of Licensed Shared Access (LSA) in the 2300 MHz-2400 MHz band

• Related: TS 103 143 is in draft stage: System Architecture for WSD GLDBs
• “France Telecom Orange, Telecom Italia, Telefonica and TeliaSonera consider that the LSA could offer a complementary and streamlined approach to increase the amount of overall spectrum resources available to mobile services. Provided that compatibility among services/systems are proven feasible, LSA may be applied to share frequency bands that otherwise cannot be exploited for commercial purposes in the short term.

• Consequently, France Telecom Orange, Telecom Italia, Telefonica and TeliaSonera consider the LSA could be an alternative and effective solution to access the 2300-2400MHz band in the countries where clearing and/or refarming of the spectrum from legacy non-mobile services and users are not achievable in the short term, and therefore where subsequent spectrum allocation to mobile services/systems is not feasible in a timely way.”
INTEL Activities: Lead ETSI RRS Technical Body

- The committee has focused on the RRS encompassing both SDR and CR.
- The committee's activities include studies on the feasibility of RRS standardization, collecting and defining RRS requirements, identifying gaps where existing standards do not fulfill those requirements and proposing solutions to fill those gaps.
- On average, 35 ETSI members attend the RRS meeting (Plenaries and/or WG meetings).
IV. Mobile Device Reconfigurability
The new Radio Equipment Directive (RED)

Article 3(3)(i):

3. Radio equipment within certain categories or classes shall be so constructed that it complies with the following essential requirements:

   (i) radio equipment supports certain features in order to ensure that software can only be loaded into the radio equipment where the compliance of the combination of the radio equipment and software has been demonstrated.

Article 4: Provision of information on the compliance of combinations of radio equipment and software

1. Manufacturers of radio equipment and of software allowing radio equipment to be used as intended shall provide the Member States and the Commission with information on the compliance of intended combinations of radio equipment and software with the essential requirements set out in Article 3. Such information shall result from a conformity assessment carried out in accordance with Article 17, and shall be given in the form of a statement of compliance which includes the elements set out in Annex VI. Depending on the specific combinations of radio equipment and software, the information shall precisely identify the radio equipment and the software which have been assessed, and it shall be continuously updated.

2. The Commission shall be empowered to adopt delegated acts in accordance with Article 44 specifying which categories or classes of radio equipment are concerned by the requirement set out in paragraph 1 of this Article.
What’s being standardized?

- Standard Software Architecture for Radio Computer (ETSI TS 103 095)
- Standard Interfaces for Radio Computer (ETSI TS 103 146)
V. Conclusion
• EC Mandate on RRS - available draft documents introduce requirements related to
  • Objective A: In the area of commercial applications, to enable the deployment and operation of cognitive radio systems (CRS) ... under Licenced Shared Access regime, dependent ... from geo-location databases (GLDB).
  • Objective B: In the area of civil security and military applications, the standardization of suitable SDR architecture(s) (SCA-based for the military domain).
  • Objective C: To explore potential areas of synergy among commercial, civil security and military applications.

• Please join us for the ETSI Workshop
  • 3-4-Dec-2014, Sophia Antipolis, France
  • http://www.etsi.org/news-events/events/807-etsi-rrs-workshop-2014
New Wireless Mobile Broadband Capacity is the key focus for Next Generation Wireless (Cellular) Systems

- While “traditional” Dedicated Licensed Spectrum is still a key ingredient, new spectrum management approaches are upcoming, including Shared Access ("Licensed Shared Access (LSA)"),
- And new spectrum opportunities will be exploited in particular in mmWave bands.

FDD / TDD Carrier Aggregation is a topic of key relevance to future Licensed Shared Access Systems.
References
- ETSI
- ITU, WRC
- UMTS Forum
- ERC Report 038