OAI UE 5G NR FEATURE PLAN AND ROADMAP

Fabrice Nabet
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5G “Spirit”

5G

- Deep awareness
  - High capacity
  - High data rates
- eMBB
  - Low latency
  - High reliability
  - High mobility
  - Security
- Massive
  - High density
  - Long battery life
  - Low complexity
  - Low energy
- Critical

Seamless wireless-area coverage
- mMIMO, Novel multiple access, flexible duplex, AMC >100Mpbs

High capacity hot-spot
- UDN, mMIMO, Novel multiple access, flexible/full duplex > 1 Gbps peak rate

Low-power massive connection
- Novel multiple access, FBMC/F-OFDM, D2D, AMC >1000K/km2

Low-latency high reliability
- Short frame/TTI, Optimized signaling, Novel multiple access, D2D/V2X, AMC, Retransmissions <1ms

CTO Office, TCT
From OAI LTE to 5G NR

“LTE UE basic functionalities”

- 3GPP R9/R10 compliant new features
- FDD & TDD
- Good performances and stability
- Interoperability

TCL choice: 5G NR on UE

- Joint work on NR Physical Layer
- Support collaborative projects on 5G trials
- Give OAI-5G its name!
New OAI Project Proposal: “OAI 5G NR Physical layer”

- Implement and demonstrate 5G-NR Phase 1 eMBB/URLLC profile on OAI
  - DL Physical layer features compliant with 3GPP R15
  - GPP based with TP limitation, sub ms L1 latency
  - Tentative GPP + HW acceleration for higher TP

- Pre-requisites
  - Finalize LTE TDD mode uplift
  - Align with gNB development plan
  - Assume 3GPP standard options or adjust during R15 drafting

- Disseminate results
  - OSA 5G demonstration (MWC18)
  - Partners own exploitation, demonstrations & EU/CN projects
5G NR vs LTE : Physical Layer

- Support of scalable waveforms
- Up to 100 Mhz system bandwidth
- Scalable numerology allows from 15 kHz to 480 kHz

<table>
<thead>
<tr>
<th>SCS [KHz]</th>
<th>15</th>
<th>30</th>
<th>60</th>
<th>120</th>
<th>240</th>
<th>480</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW [MHz]</td>
<td>20</td>
<td>40</td>
<td>80</td>
<td>160</td>
<td>320</td>
<td>640</td>
</tr>
<tr>
<td>OFDM Symb duration [us]</td>
<td>71.3</td>
<td>35.7</td>
<td>17.8</td>
<td>8.9</td>
<td>4.5</td>
<td>2.2</td>
</tr>
</tbody>
</table>

- Slot : 7 (up to 60 Mhz) or 14 OFDM Symbols (above 60 Mhz)
- Mini Slot: 1 or 2 Symbols
- Channel coding : LDPC and Polar codes
- Beam Management
5G NR vs LTE: System Overview

- Interworking with LTE: Standalone (SA) or Non Standalone (NSA)

- L2/L3:
  - New RRC INACTIVE state
  - New L2 QoS layer: SDAP
  - Reordering in PDCP instead of RLC, no RLC SDU concatenation
  - MAC scheduling taking into account numerology
  - Asynchronous HARQ in UL and DL
NR 3GPP Timeline

“Complete Stage-3 specifications on eMBB including support of low latency for E-UTRA-NR DC via EPC where the E-UTRA is the master until December 2017”
OAI 5G NR Phy: TCL end 2017 objective

- Flexible BW (20-80 MHz) support

- eMBB Use Case e2e demonstration
  - 60 kHz SCS / 80 MHz
  - GPP based (TP restrictions)

- UrLLC Use Case e2e demonstration
  - < 2ms latency (RTD)
  - 15-60kHz SCS
  - Low throughput
  - Option 1: Relying on mini slot
  - Option 2 relying on self contained structure

- Reuse L2/L3 Protocols
  - Adaptation to NR Phy (MAC, RRC)

* GPP based, parallel plans for high throughput version via FPGA offloading
# OAI 5G NR Phy: UE roadmap and UE / gNB alignment

## Features list

<table>
<thead>
<tr>
<th>Features list</th>
<th>NR Delivery 1</th>
<th>NR delivery 2</th>
<th>2018</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth</td>
<td>80 MHz</td>
<td></td>
<td></td>
<td>80 MHz</td>
</tr>
<tr>
<td>Carrier frequency</td>
<td>&lt;= 6GHz</td>
<td>&lt;10 GHz, 28GHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waveforms</td>
<td>CP-OFDM / DFT-s-OFDM in UL</td>
<td></td>
<td></td>
<td>DL CP-OFDM / UL DFT-s-OFDM</td>
</tr>
<tr>
<td>Duplex mode</td>
<td>FDD</td>
<td>TDD &amp; FDD</td>
<td></td>
<td>FDD &amp; TDD</td>
</tr>
<tr>
<td>MIMO DL</td>
<td>1 spatial stream</td>
<td>4-8 spatial streams</td>
<td>4-8 spatial streams</td>
<td></td>
</tr>
<tr>
<td>MIMO UL</td>
<td></td>
<td>Tx diversity / beamforming</td>
<td>Tx diversity / beamforming</td>
<td></td>
</tr>
<tr>
<td>Flexible SCS</td>
<td>15 to 60 kHz</td>
<td></td>
<td>15 to 60 kHz</td>
<td></td>
</tr>
<tr>
<td>TTI</td>
<td>14 OFDM symbols</td>
<td>7 OFDM symbols</td>
<td>14 or 7 OFDM symbol</td>
<td></td>
</tr>
<tr>
<td>Mini-slots</td>
<td>2 OFDM symbols</td>
<td></td>
<td>2 symbols</td>
<td></td>
</tr>
<tr>
<td>Self contained structure</td>
<td></td>
<td>1ms Self cont.</td>
<td>1ms Self contained structure</td>
<td></td>
</tr>
<tr>
<td>Modulation</td>
<td>64 QAM</td>
<td></td>
<td>64 QAM</td>
<td></td>
</tr>
<tr>
<td>Sync &amp; Beam</td>
<td></td>
<td>Yes</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Error correction</td>
<td>LDPC (FPGA)</td>
<td>LDPC + Polar</td>
<td>LDPC + Polar</td>
<td></td>
</tr>
<tr>
<td>4G L2/L3 adapt</td>
<td>yes</td>
<td></td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>5G L2/L3 adapt</td>
<td>yes</td>
<td></td>
<td>yes</td>
<td></td>
</tr>
</tbody>
</table>

## TCL Planning Overview

- **TDD final**
- **NR Delivery 1**
- **NR Delivery 2**

**Timeline:**

- **17Q1**
- **Q2**
- **Q3**
- **Q4**
- **18Q1**
JOIN and CONTRIBUTE to OAI UE Community Towards 5G NR!

- Start 5G NR PHY project NOW
  - SW/HW architecture study
  - New GIT OAI project or branch
  - Project tracking

- Invite OAI community to join and contribute to 5G NR project!
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谢谢

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## Backup: OAI 5G NR Phy: 2017 feature list & opens

<table>
<thead>
<tr>
<th>5G-NR features</th>
<th>Delta vs 4G</th>
<th>TCL plan for 2017</th>
<th>Opens</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bandwidth</strong></td>
<td>20 to 640 MHz</td>
<td>20-80 MHz</td>
<td>160 MHz and above</td>
</tr>
<tr>
<td><strong>Carrier frequency</strong></td>
<td>up to 100 GHz</td>
<td>&lt;= 6GHz</td>
<td>other frequency bands</td>
</tr>
<tr>
<td><strong>Throughput target</strong></td>
<td></td>
<td>300 Mbps per 1 spatial stream</td>
<td></td>
</tr>
<tr>
<td><strong>Latency target</strong></td>
<td></td>
<td>&lt; 2 ms RTD (L1/L2)</td>
<td></td>
</tr>
<tr>
<td><strong>Waveforms</strong></td>
<td>DL CP-OFDM / UL CP-OFDM or DFT-s-OFDM</td>
<td>CP-OFDM in DL, DFT-s-OFDM in UL</td>
<td>CP-OFDM in UL</td>
</tr>
<tr>
<td><strong>Duplex mode</strong></td>
<td>FDD &amp; TDD</td>
<td>FDD &amp; TDD</td>
<td></td>
</tr>
<tr>
<td><strong>MIMO Rx</strong></td>
<td>up to 8 antenna</td>
<td>1 antenna (ready for 2)</td>
<td>more than 2 antennas</td>
</tr>
<tr>
<td><strong>MIMO Tx</strong></td>
<td>CP-OFDM required if MIMO</td>
<td>Tx diversity / beam forming</td>
<td>Multi-layer UL MIMO (imply support of CP-OFDM)</td>
</tr>
<tr>
<td><strong>Flexible SCS</strong></td>
<td>15, 30, 60, 120, 240, 480 kHz</td>
<td>15 to 60 kHz</td>
<td>&gt; 60 kHz</td>
</tr>
<tr>
<td><strong>TTI</strong></td>
<td>14 or 7 OFDM symbols</td>
<td>14 and 7 OFDM symbols TTl in 80 MHz (4 TTI FB)</td>
<td></td>
</tr>
<tr>
<td><strong>Mini-slots</strong></td>
<td>6 down to 1 OFDM symbol</td>
<td>2 symbols mini slot in 20 MHz BW, perhaps in 80 MHz BW with restrictions</td>
<td>1 symbol mini slot</td>
</tr>
<tr>
<td><strong>Self contained structure</strong></td>
<td>TDD, Rx and UL feedback in the same SF (1ms)</td>
<td>Self contained structure, low latency TDD</td>
<td>256QAM</td>
</tr>
<tr>
<td><strong>256 QAM</strong></td>
<td>in LTE std but not supported in OAI</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Synchronization channel &amp; beam management</strong></td>
<td>Beam management</td>
<td>Beam management</td>
<td></td>
</tr>
<tr>
<td><strong>Error correction - LDPC</strong></td>
<td></td>
<td>LDPC offloaded onto FPGA</td>
<td>LDPC SW</td>
</tr>
<tr>
<td><strong>Error correction - Polar Codes</strong></td>
<td></td>
<td>None</td>
<td>Polar</td>
</tr>
<tr>
<td><strong>DL control channels</strong></td>
<td>tbd</td>
<td>Adapt 4G prot. to 5G PHY feat.</td>
<td>5G NR protocol dev</td>
</tr>
<tr>
<td><strong>UL control channels</strong></td>
<td>tbd</td>
<td>Adapt 4G prot. to 5G PHY feat.</td>
<td>5G NR protocol dev</td>
</tr>
<tr>
<td><strong>HARQ modification</strong></td>
<td>tbd</td>
<td>Adapt 4G prot. to 5G PHY feat.</td>
<td>5G NR protocol dev</td>
</tr>
<tr>
<td><strong>MAC modification</strong></td>
<td>tbd</td>
<td>Adapt 4G prot. to 5G PHY feat.</td>
<td>5G NR protocol dev</td>
</tr>
<tr>
<td><strong>RLC/PDCP modifications</strong></td>
<td>tbd</td>
<td>Adapt 4G prot. to 5G PHY feat.</td>
<td>5G NR protocol dev</td>
</tr>
</tbody>
</table>

* TCL developing only 5G UE, agreement with gNB developer is required