Overview of TCL OAI Activity

Zhenhong Li, Fabrice Nabet
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TCL Communication

A world-leading mobile terminal producer and service provider

Overview

- 13,000 employees
- 9 product innovation centers world-wide
- Annual manufacturing output of 120 million sets
- Products sold in 160 countries and regions
- 835.5 million sets sold in 2015
- Ranked 5th globally

Products

- TCL950 smart phone
- IDOL4 4G smart phone
- 2 in 1 tablet PC
- TCL Lewan 4G smart phone
- Smart wearable devices
- Blackberry smart phone
5G “Spirit”

- eMBB
  - Deep awareness
  - High capacity
  - High data rates
  - 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
Vision OAI Eco-system

Synergies between contributors

Reduce innovation cycles

Requires a e2e implementation (CN, RAN, UE) at standards’ state of the art

CTO Office, TCT
From OAI LTE UE to 5G NR UE

**LTE UE Basic Functions**
- 3GPP R9/10 compliant features: TDD/FDD, 5/10/20M, CQI, SRS, MIMO, TM3, AM....
- **Interoperability:** CMW500, COST eNB, Ericsson EPC+ENB live test NW
- **Good performances:** 70Mbps Downlink
- **Stability:** up to 10hrs

**5G NR UE**
- Joint work on 5G NR PHY
- Supporting collaborative projects on 5G trial
- Starting 5G NR UE project
OAI 5G NR UE PHY

Scalable Waveforms
- DL CP-OFDM
- UL DFT-s-OFDM

System BW & SCS
- Up to 100 MHz
- 15 kHz to 480 kHz

Slot & Mini Slot
- 7 or 14 Symbols
- 1 or 2 Symbols

Beam Management Channel Coding
- LDPC and Polar
OAI 5G NR UE PHY 2017 Objective

Flexible BW
- 20-80 MHz & 15-60kHz SCS

eMBB
- 60 kHz SCS / 80 MHz
- GPP based (TP restrictions)

UrLLC
- < 2ms latency & Low throughput
- mini slot or self contained structure

L2/L3 Protocol
- Adaptation LTE L2/L3 to NR (MAC, RRC)

Timeline:
- LTE TDD Delivery 1
  - 2017Q1
- LTE TDD Final
  - 2017Q4
- NR UE Delivery 1
  - 2017Q3
- NR UE Delivery 2
  - 2018Q1
Towards 5G NR UE

- Creating: 5G NR UE GIT OAI branch
- Inputing: 5G NR UE functions
- Tracking: 5G NR UE project status
- Initiating: 5G NR UE SW/HW architecture study
- Sharing: 5G NR UE develop exp.

Open & Collaborating

Join and contribute to OAI 5G NR UE project!
TCL OAI Contacts

- Pierre BONNARD  pierre.bonnard@tcl.com
- Zhenhong LI      zhenhong.li@tcl.com
- Fabrice NABET    fabrice.nabet@tcl.com
- Yanbo TANG       yanbo.tang@tcl.com
谢谢
### 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 TTI in 80 MHz BW (4 TTI FB)</td>
<td></td>
</tr>
<tr>
<td><strong>Mini-slots</strong></td>
<td>6 down to 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>
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<td><strong>UL control channels</strong></td>
<td>tbd</td>
<td>Adapt 4G prot. to 5G PHY feat.</td>
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<td><strong>HARQ modification</strong></td>
<td>tbd</td>
<td>Adapt 4G prot. to 5G PHY feat.</td>
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<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>
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<td><strong>RLC/PDCP modifications</strong></td>
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</tbody>
</table>

* TCL developing only 5G UE, agreement with gNB developer is required*
# OAI 5G NR PHY: UE roadmap and UE / gNB alignment

<table>
<thead>
<tr>
<th>Features list</th>
<th>NR Delivery 1</th>
<th>NR delivery 2</th>
<th>2018</th>
<th>2019</th>
<th>gNB requirements (Eurecom + community)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth</td>
<td>80 MHz</td>
<td></td>
<td></td>
<td>80 MHz</td>
<td></td>
</tr>
<tr>
<td>Carrier frequency</td>
<td>&lt;= 6GHz</td>
<td>&lt;10 GHz, 28GHz</td>
<td></td>
<td></td>
<td>DL CP-OFDM / UL DFT-s-OFDM</td>
</tr>
<tr>
<td>Waveforms</td>
<td>CP-OFDM / DFT-s-OFDM in UL</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Duplex mode</td>
<td>FDD</td>
<td>TDD &amp; FDD</td>
<td></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>
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<td></td>
<td></td>
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<tr>
<td>MIMO UL</td>
<td></td>
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<td>14 or 7 OFDM symbol</td>
<td></td>
<td></td>
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<tr>
<td>Mini-slots</td>
<td>2 OFDM symbols</td>
<td></td>
<td>2 symbols</td>
<td></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>
<td></td>
</tr>
<tr>
<td>Modulation</td>
<td>64 QAM</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Sync &amp; Beam</td>
<td></td>
<td>Yes</td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Error correction</td>
<td>LDPC (FPGA)</td>
<td>LDPC + Polar</td>
<td></td>
<td>LDPC + Polar</td>
<td></td>
</tr>
<tr>
<td>4G L2/L3 adapt</td>
<td>yes</td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>5G L2/L3</td>
<td></td>
<td>yes</td>
<td></td>
<td>yes</td>
<td></td>
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