OAI UE 5G
Project Status

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Agenda

Roadmap

Development Status

Feature List Status

Room for collaboration
OAI UE Roadmap

4G - Rel. 10 IOT
- Full Throughput (DL, UL)
- Commercial NW IOT
- MTBF > 120 min

4G - CA & MIMO
- RLC-UM
- 2x2 MIMO TM4
- 2 CA
- No TDD yet

5G
- 80MHz BW (1CC)
- < 6Ghz
- TDD & FDD
- LDPC
- 5G Wave & Num
- 300 Mbps (SISO)

5G M-MIMO
- 28 Ghz RF
- Beam detection
- M-MIMO Rx

5G ULR
- 8-10 Ghz RF
- Ultra long Range mode

2016
- PC / UED

2017
- PC / UEdnextGen

2018
- PC / UEnextGen

FPGA Accel
GPP (Core-i7)
GPP (Core-i7 / Xeon)
FPGA Accel
GPP (Core-i7 / Xeon)
FPGA Accel
GPP (Core-i7 / Xeon)
OAI UE Development Phases

**NR Dev Phase 1**
- **New developments**
  - 40 & 80 MHz numerologies
  - Shorter TTI (14 symbol slots, mini-slots 500 & 250us duration)
  - LDPC encoding + rate matching,
  - LDPC decoding + de-rate matching

- **Adaptations from LTE**
  - PDCCH, PUSCH, PSS/SSS/PBCH
  - PRACH : adapted from LTE (= NR PRACH Type A)
  - PDSCH : adapted from LTE to new numerology + LDPC support
  - PUCCH : adapted from LTE [option: less than 4 TTI FB time]

**NR Dev Phase 2**
- **New developments**
  - NR PSS/SSS/PBCH
  - NR pilot structures (impact all physical channels!)
  - Polar encoding
  - Polar decoding
  - NR PDCCH
  - NR PDSCH with single slot TTI (14 symbols or less)

**NR Dev Phase 3**
- **New developments**
  - M-MIMO Rx
  - Beam management
  - 28 GHz

**NR Demo 1 (Q1-2018)**

**NR Demo 2**
## OAI Development Status (2/3)
### SW Architecture Optimization results

<table>
<thead>
<tr>
<th>SW Optimization</th>
<th>Development Status</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front-End slots parallelization</td>
<td>100%</td>
<td>Process ‘at the same time’ on two different cores both slot0 and slot1</td>
</tr>
<tr>
<td>PDCCH Optimization</td>
<td>100%</td>
<td>Optimize PDCCH ofdm symbols decoding + DCI research</td>
</tr>
<tr>
<td>3 RX/TX parallel threads</td>
<td>100%</td>
<td>Process 3 consecutives subframes in parallel on different cores</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>20MHz without Optim @3,3GHz</th>
<th>Current 20MHz with Optim @4GHz</th>
<th>Optimization Gain</th>
<th>Targets for 5G NR compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front End Processing</td>
<td>120 us</td>
<td>50 us</td>
<td>~59%</td>
<td>50 us</td>
</tr>
<tr>
<td>Pdcch Decoding</td>
<td>90 us</td>
<td>25 us</td>
<td>~72%</td>
<td>25 us</td>
</tr>
<tr>
<td>LLRs Computation</td>
<td>100 us</td>
<td>80 us (no optim yet)</td>
<td>~20%</td>
<td>40 us ?</td>
</tr>
<tr>
<td>Sum</td>
<td>310 us</td>
<td>155 us &lt; 250 us</td>
<td>~50%</td>
<td>250 us (done)</td>
</tr>
<tr>
<td>Channel Deocoder</td>
<td>1250 us</td>
<td>1000 us (no optim yet)</td>
<td>~20%</td>
<td>250 us (req. FPGA)</td>
</tr>
<tr>
<td>Full Rx</td>
<td>1560 us</td>
<td>1155 us</td>
<td>~26%</td>
<td>500 us</td>
</tr>
</tbody>
</table>
OAI UE Development Status (3/3)

- **Done**
  - Extension of multi-threading, memory separation
  - Slot //, SF //,
  - Optimization for 8-cores CPU (core i7-6900K)
  - PHY code clean-up for flexible numerology support
  - L2 / L3 adaptation
  - New NR repository
  - LTE 20MHz operation achieved with flat model ZC706 + ADRV9371

- **On going**
  - 40 / 80 MHz RF integration

- **Latest news (this week)**
  - First 40 MHz BW PHY test reaching 90Mbps DL (no FPGA offloading)
  - First UE attach @ 40 MHz BW(full stack)
  - First Cell detection @ 80 MHz BW
# OAI UE Feature List

<table>
<thead>
<tr>
<th>5G-NR Features</th>
<th>TCL plan for 2017 &amp; 2018</th>
<th>Non covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth</td>
<td>20-80 MHz</td>
<td></td>
</tr>
<tr>
<td>Carrier frequency</td>
<td>&lt;= 6GHz</td>
<td></td>
</tr>
<tr>
<td>Throughput target</td>
<td>300 Mbps per 1 spatial stream</td>
<td></td>
</tr>
<tr>
<td>Latency target</td>
<td>&lt; 2 ms RTD (L1/L2)</td>
<td></td>
</tr>
<tr>
<td>Waveforms</td>
<td>CP-OFDM in DL, DFT-s-OFDM in UL</td>
<td></td>
</tr>
<tr>
<td>Duplex mode</td>
<td>FDD &amp; TDD, incl. flexible TDD</td>
<td></td>
</tr>
<tr>
<td>MIMO Rx</td>
<td>2 antennas / 4 antennas</td>
<td></td>
</tr>
<tr>
<td>MIMO Tx</td>
<td>Tx diversity / beam forming</td>
<td></td>
</tr>
<tr>
<td>Flexible SCS</td>
<td>15 to 60 kHz</td>
<td></td>
</tr>
<tr>
<td>TTI</td>
<td>Slot based scheduling (14 OFDM symbols)</td>
<td></td>
</tr>
<tr>
<td>Slot / Mini-slots</td>
<td>Slot @ 80 MHz BW</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 symbols mini slot in 20 MHz BW, perhaps in 80 MHz BW with restrictions</td>
<td></td>
</tr>
<tr>
<td>Modulation</td>
<td>Up to 64 QAM</td>
<td>256QAM</td>
</tr>
<tr>
<td>Error correction - LDPC</td>
<td>LDPC decoder (SW &amp; FPGA)</td>
<td>LDPC encoder</td>
</tr>
<tr>
<td>Error correction - Polar Codes</td>
<td>None</td>
<td>Polar codes</td>
</tr>
<tr>
<td>Synchronization channel &amp; beam management</td>
<td>NR PSS/SSS wo beam sweeping</td>
<td>Beam management</td>
</tr>
<tr>
<td>DL control channels</td>
<td>Adapt 4G prot. to 5G PHY feat.</td>
<td>NR Pilot structure</td>
</tr>
<tr>
<td>UL control channels</td>
<td>Reuse of LTE RACH (adopted also in 5G NR as type A RACH)</td>
<td>NR PRACH (with beam sweeping)</td>
</tr>
<tr>
<td>HARQ modification</td>
<td>Adapt 4G prot. to 5G PHY feat.</td>
<td>Asynchronous flexible HARQ</td>
</tr>
<tr>
<td>MAC modification</td>
<td>Adapt 4G prot. to 5G PHY feat.</td>
<td>NR MAC</td>
</tr>
<tr>
<td>RLC/PDCP modifications</td>
<td>Adapt 4G prot. to 5G PHY feat.</td>
<td>NR RLC / PDCP</td>
</tr>
</tbody>
</table>
Room for Collaboration

• Still quite some opens

• TCL & Eurecom focus yet mainly on PHY

• Main rooms for 3\textsuperscript{rd} party contribution
  • NR L1 Procedures
  • NR MAC
  • NR RLC / PDCP
  • Some PHY (256 QAM, polar
谢谢

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