Implementation and evaluation for the commercial uses of OAI

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Our team

- Developing for commercial use of OAI-eNB since August 2017
  - Features added (re-establishment, Handover etc.)
  - Quality improvement (load test, CI, code clean up)

High performance NW realized by 5G!
Limited vendors can provide
NW vendor will increase?

Our 1st target area of OAI software!
Flexible NW realized by software!

Performance, NW Coverage

LTE Technology for Public Networks
Extend to Private Network

Telecom Operators
Various Industries and Companies
Number of Operators

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# FUJITSU activity (feature based)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Tested</th>
<th>Implemented</th>
<th>Implementing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Multiple Access</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>OFDMA (DL) / SC-FDMA (UL)</td>
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<tr>
<td><strong>Duplex</strong></td>
<td></td>
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<tr>
<td>FDD / TDD (Config1/Config2)</td>
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<tr>
<td><strong>Modulation</strong></td>
<td></td>
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<tr>
<td>QPSK / 16QAM / 64QAM</td>
<td></td>
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</tr>
<tr>
<td><strong>Bandwidth</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5MHz / 10MHz / 20MHz</td>
<td></td>
<td></td>
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<tr>
<td><strong>Transmission Mode</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>DL Channel</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>PSS / SSS / PBCH / PCFICH / PHICH / PDCCH</td>
<td></td>
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<tr>
<td><strong>UL Channel</strong></td>
<td></td>
<td></td>
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<tr>
<td>PRACH / PUSCH / PUCCH (format 1/1a/1b) / SRS / DRS</td>
<td></td>
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<tr>
<td><strong>Call</strong></td>
<td></td>
<td></td>
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<tr>
<td>Origination/Termination/Release/Reestablishment/Hand Over</td>
<td></td>
<td></td>
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<tr>
<td><strong>Performance</strong></td>
<td></td>
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<tr>
<td>Number of UEs ↑ (256UEs w/ Bw5MHz)</td>
<td></td>
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</tr>
<tr>
<td><strong>Others</strong></td>
<td></td>
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<tr>
<td>sXGP / O&amp;M (Network Data Collection)</td>
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</table>
Load test for OAI-eNB (Environment)

- Verifying stability of OAI-eNB operation

**OAI-eNB (Test Target)**
- eNB Software
- VM (4Core)
- FJT Virtualization Platform
- Linux

**Artiza Networks: LTE-A Tester DuoSIM-A**
- EPC Load Simulator
- UE Load Simulator

Test categories

- Test for Robustness / Capacity
  - Burst RACH per millisecond
  - Stress test with maximum number of UEs

- Test for Long-term Stability
  - Long time (i.e. over 12 hours) C-plane and U-plane combined Test

**Test conditions**

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Duplex</td>
<td>FDD, TDD Configuration 1</td>
</tr>
<tr>
<td>Transmission Mode</td>
<td>SISO(TM1)</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>5.0 MHz</td>
</tr>
<tr>
<td>Scheduler Mode</td>
<td>fairRR</td>
</tr>
</tbody>
</table>

http://www.artizanetworks.com/
Load test for OAI-eNB (Results)

Overall evaluation was good

Artiza Networks : LTE-A Tester DuoSIM (EPC / UE)

RF-unit of UE simulator

RF of eNB (USRP X310)

OAI-eNB (Fujitsu’s IA Server)
Load test for OAI-eNB (Results)

- **RACH per ms (Burst RACH)**

  ![Diagram](image)

  **UE Simulator**  
  **eNB Software**

  - **RACH Preamble**
  - **1ms**
  - **Continue for 2 minutes**

  **Attach completion rate**

  - **6 call/ms**
  - **100.0%**
  - **100.0%**
  - **99.3%**

  **Time transition of Attach completion rate**

  - **6 RACH per ms**
  - **100%**

  - **10 RACH per ms**
  - **99.3%**

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Load test for OAI-eNB (Results)

- 8640 BHCA (busy-hour call attempts) for 12 hours

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Completion Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seq.1 Paging</td>
<td>100%</td>
</tr>
<tr>
<td>Seq.2 Attach</td>
<td>84.5%</td>
</tr>
<tr>
<td>Seq.3 Re-establishment</td>
<td>85.1%</td>
</tr>
<tr>
<td>Seq.4 Re-establishment Complete ~ Detach</td>
<td>93.8%</td>
</tr>
</tbody>
</table>

Anomaly!!  Assertion!!

Now debugging for stabilization
30 bug fixes to be contributed
Enhancement of X2 Handover

- Support FDD & TDD (Configuration 1)
- Expansion of Neighbor Cells: 2 or more cells

**Diagram:**

- EPC
- HUB
- OAI-eNB#1
- USRP X310
- OAI-eNB#2
- USRP B210
- USRP B210

**Network Connections:**

- Cell ID: 3584
- Cell ID: 3585
- Cell ID: 3586

**FDD Band 3:** BW 5MHz

**Transmit Power:** -15dbm

**Distances:**

- 10m
- 5m

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MIMO with nFAPI I/F

- Now verifying MIMO(TM3) with our original PHY function

Test Conditions
- Duplex: FDD
- Bandwidth: 20 MHz

DL throughput over 100Mbps
nFAPI expands the possibilities of OAI

- Allows the connection of many device types
- There are still challenges
  - Synchronization is not stable
  - not real-time
  - Tune the parameters of the nFAPI Interface
- What we should do for OAI and its users
  - Documentation
    - Parameters (OAI original interpretation)
    - Sequence and timing chart of synchronization and sub-frame processing
  - Interoperability test
CI running time at Fujitsu side

215,292 min = 150 days
Always running!!

48 bugs found & fixed
In search of new RRH interfaces

- Supporting more types broadens the usefulness of OAI
- Now trying to connect OAI-eNB with FUJITSU’s products

- Development to expand interface variation
  - eCPRI
  - ORAN
Number of commits 52% up compared to last 12mon.

and Congratulations on the release Master Branch v1.0.0
It is good for everyone to see the status of the community in real time.
Progress of the past proposal from Fujitsu

1. Provide working “master branch”
   - Increase OAI stability
     → Achieved

2. Merge new features easily
   - Reduce time to merge new features
     → CI is working

3. Keep source code in an easy-to-understand state
   - Make the latest source code easy-to-understand
     → Code Clean Up is ongoing
Why Do We Need Quality Improvement?

- Improving the quality leads to the development of the community.

Improve quality

More users and developers

Community development

Let’s increase OAI fans!!
FUJITSU

shaping tomorrow with you