Outdoor Field Tests for the OAI Network (eNodeB and EPC)

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Motivation

• Most of the developments and tests for OAI in the community are done in the indoor environment.

• It is clear the use cases of the cellular networks cannot exclude outdoor applications.
  – The air channel conditions for outdoor are different from that for indoor.

• To verify OAI networks (eNodeB & EPC) work for outdoor as well, NCTU and III team up to develop the SDR platform to enable the OAI community to extend their researches for OAI networks in outdoor environments.
The OAI team leads by NCTU Prof. Terng-Yin Hsu has modified the OAI PHY codes to enable outdoor access between COTS 4G UE and OAI networks in NCTU campus in Q4 2016.

Video for this field test:
https://www.youtube.com/watch?v=M5mnosKCuFc
Stable YouTube video access for 110 meters NLOS condition
OAI Outdoor Field Test in NCSIST in Jan 2017

- III with the helps of Prof. Hsu’s team has also done the field test in the incubation center of NCSIST in Jan, by using the eNB & EPC codes from OAI develop branch.
  - UE is located apart from the OAI eNodeB for 50, 120, 200 meters respectively, and play YouTube video stably.
  - Field test video: https://youtu.be/y8zMxOOGhaU

<table>
<thead>
<tr>
<th>Entity</th>
<th>Device spec.</th>
<th>OS version &amp; OAI commit</th>
</tr>
</thead>
<tbody>
<tr>
<td>OAI eNB</td>
<td>CPU: intel i7-6700; RAM: 32 GB</td>
<td>Ubuntu 14.04; 3.19.74 lowlatency kernel develop branch 10/26: 9927838e8cc57be557b130e904bf8caf35cb423</td>
</tr>
<tr>
<td>OAI EPC</td>
<td>CPU: intel i7-4760; RAM: 8 GB</td>
<td>Ubuntu 14.04; 4.7.1 kernel develop branch 11/07: 0c63e3822f9d1fa904d3d848d13b9107f55c524c</td>
</tr>
<tr>
<td>COTS UE (NEXUS 5)</td>
<td>Qualcomm MSM8974 Snapdragon 800 (CPU: Quad-core 2.3 GHz); RAM: 2 GB</td>
<td>Android 6.0.1</td>
</tr>
</tbody>
</table>
**III Outdoor SDR platform**

- **Omni Antenna**
  - Frequency Range: 2.3-2.7 GHz
  - Gain: 8dBi
  - Vertical Beam-width: 15 Deg
  - Horizontal Beam-width: 360 Deg

- **USRP B210**
  - Frequency Range: 70MHz – 6GHz
  - Power Output: > 10dBm
  - IIP3: -20dBm
  - Receive Noise Figure: < 8dBm

- **Power Amplifier**
  - Frequency Range: 20MHz – 3GHz
  - Gain, Typical: 27dB
  - IIP3: 39dBm
  - Voltage, DC Typical: 12Volts
  - Current, DC Typical: 380 mA

- **Power Supply for Power Amplifier**
  - Input Voltage: 88V AC – 264V AC
  - Output Voltage: 15V DC
  - Output Current: 1.7A

- **Power Regulator**
  - Input Voltage: 2.7V DC – 20V DC
  - Adjustable Output Voltage: 1.21V DC – 20V DC
  - Output Current: 3A (Maximum)

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About NT$ 60,000 excluding USRP B210 & engineering cost
Improvement of Outdoor SDR Platform

• Using panel directional antenna instead of omni one used in the field test of January.
• Including Band 7 duplexer

| Panel Antenna | Frequency Range : 2200-2690 MHz  
|              | Gain : 8.6 dBi  
|              | Vertical Beam-width : 60 Deg  
|              | Horizontal Beam-width : 63 Deg  
|              | Isolation : > 25 dB  |

| Duplexer | Center Frequency (fo): 2535MHz (TX), 2655MHz (RX)  
|          | Bandwidth: fo ± 35MHz  
|          | Insertion Loss in BW: 2.5 dB (max)  
|          | Ripple in BW: 1.0 dB (max)  
|          | Return Loss in BW: 1.7 dB (min)  
|          | Isolations:  
|          | @ 2500.0 ~ 2570.0 MHZ: 45MHz  
|          | @ 2570.0 ~ 2620.0 MHZ: 20MHz  
|          | @ 2620.0 ~ 2690.0 MHZ: 45MHz  |
Outdoor field test in NCSIST in March

Cases of LOS, near LOS and non-LOS have been tested and up to 3 COTS UEs (Samsung, LG, Huawei) are used simultaneously for YouTube video access.
Test for 120m LOS

- 3 COTS UEs are located apart from the antenna for 120m LOS, and stably access YouTube video content simultaneously for several minutes
- Video for the test: https://youtu.be/6Mh0Pgu8Rml
Test for 200m LOS

We found the UL throughput is double by using panel directional antenna.
Test for 190m Near LOS
Test for 180m NLOS

• We held the smartphone, play YouTube video and walk from the location of 200m LOS to the location of 180m non-LOS, which is in the forest behind a cement building.

• The video keep plays for minutes.
Major Parameters to Be Fine Tuned

• tx_gain:
  - ~ 50

• rx_gain:
  - ~ 105

• pdsch_referenceSignalPower
  - ~ 8

• pusch_p0_Nominal
  - ~ -85

• rach_preambleInitialReceivedTargetPower
  - ~ -104

• tx_sample_advance
  - ~ 95
Conclusion

• Our field tests in Taiwan show the current OAI codes for eNodeB and EPC work for the use cases of outdoor environment as well.
  – We believe the coverage of the OAI eNodeB can extend to > 200 meters
  – The issue of `RRCConnectionReestablishment` gets even worse for the outdoor environment
  – The next tests by NCTU & III will be the case of low mobility as well as OAI NB-IoT field test in Q4 2017

• Our finding can encourage the OAI community to include their researches (such as advanced communications algorithm) and embed them into the codes of OAI networks, verified through the air in both indoor and outdoor environments.