The OAI-based Academic Research Project of Open5G Platforms in Taiwan

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Speaker: Yuan-Te Liao
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The Open 5G Project in Taiwan

- 4 universities have been invited to join this project
  - Prof. Terng-Yin Hsu of NCTU (the coordinator)
  - Prof. Ray-Guang Cheng of NTUST
  - Prof. Jerry Chou of NTHU
  - Prof. Whei-En Chen of NIU
- Project administration: WIT CLUB
- Project sponsor: Institute for Information Industry (III)
Targets for 2017 (1/2)

- **Subproject I**: Soft PHY and its virtualization for Open 5G platform
  - PHY splitting and virtualization
  - Parallel architecture of Soft PHY
  - Giga-bit soft PHY

- **Subproject II**: Study of protocol technologies on Open 5G Platform
  - Trace and analyze OAI MAC source codes
  - Cooperate with OSA to develop OAI NB-IoT eNodeB MAC codes and define the interfaces to RRC, RLC & PHY
Targets for 2017 (2/2)

- **Subproject III**: Study of cloud computing and dynamic resource allocation for Open 5G platform
  - Develop an experimental cloud computing platform for the 5G mobile network
  - Analyze what factors to effect the 5G NFV computing performance
  - Mechanism of dynamic resource allocation

- **Subproject IV**: Study of IoT integrated services on the Open 5G platform
  - Focuses on the core network, IMS and application-layer protocols on Open 5G platform
  - Identifies the issues on the Open 5G platform and proposes the mechanisms to improve the performance for the IoT integrated service
Subproject I: Soft PHY and its virtualization for Open 5G platform

Will not spend too much time on this subproject
Scope

- Based on OAI, create keys of a soft PHY with multi-user and virtualization for TW Open 5G platform
  - HW Platform
    - Fiber Fronthaul
    - RRH with Multiple Antennas
    - RRH Synchronization
  - Soft-PHY APPization
    - Adaptive Parallelism
    - Algorithmic Improvement
    - Gbps Supporting
Proposed – Soft-PHY APPization

- Create and Manage multiple soft PHY as APPs in BBU pool with VM dynamically
- Distribute radio signals via 4-to-1 fiber fronthaul
Major Deliveries

- **Algorithm**
  - Giga-bit Soft PHY
  - Machine Learning for RX Beamforming

- **Software Architecture**
  - Adaptive Parallelism for Multi-user
  - APPization for Slicing Services

- **Hardware**
  - RRH Control
  - Fronthaul Management
Subproject II：Study of Protocol Technologies on Open 5G Platform

Will spend more time on this subproject (because Prof. Cheng has been invited but can not attend)
Problems

- Lack of design documents for OAI source codes
- Not so easy to maintain and extend for new comers
Goals

- Join the OSA NB-IoT project to be one of the key contributors
- Provide **design documents** of OAI NB-IoT eNodeB codes and contribute to the community, for
  - Maintaining/developing the code
  - Training new members
  - Improving collaboration and cooperation
Design Documents

- **Target deliverables**
  - Check list: supported features in OAI
  - Service access point (SAP)
    - SAP primitive for interface spec.
    - Message sequence chart for inter-layer operation
  - Detail design (DD) document:
    - Specification description language (SDL)
## Design Documents for NB-IoT eNB

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Our Solution</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>NB-IoT specification is spread in several LTE specifications.</td>
<td>A excel file listing the difference between LTE and NB-IoT</td>
<td>Check List</td>
</tr>
<tr>
<td>Lack of high-level design document</td>
<td>Identify major functional blocks and primitives used in OAI Use <strong>MSC</strong> to describe the interactions among blocks</td>
<td>SAP Document</td>
</tr>
<tr>
<td>Lack of detail design document</td>
<td>Use <strong>SDL</strong> to describe the design concept based on OAI</td>
<td>Design Document</td>
</tr>
</tbody>
</table>

**NB-IoT** specification is spread in several LTE specifications.

Check List

**SAP Document**

**Design Document**

http://www.witclub.org.tw/
Where to Find

- https://gitlab.eurecom.fr/oai/openairinterface5g/tree/develop-nb-iot-mac/targets/DOCS/NB-IoT_Docs
<table>
<thead>
<tr>
<th>OAI MAC Procedure</th>
<th>Check by</th>
<th>Rel 13.2 Spec Numbering</th>
<th>Chapter</th>
<th>Page</th>
<th>Modification Item</th>
<th>Note</th>
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<tbody>
<tr>
<td>DLSCH_Process</td>
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</table>

(Other Blocks in MAC System defined in different sheet)
2.2 Overview

Figure 1.1 shows the primitives implemented in the MAC layer and the SAPs to RRC, RLC, PHY layers.

In this chapter, need to point out:
1. Other layers that is connected with MAC layer
2. The upper or lower relationship between layers

<table>
<thead>
<tr>
<th>Primitive</th>
<th>Direction</th>
<th>Document</th>
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</thead>
<tbody>
<tr>
<td>MAC_RRC_SAP</td>
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<tr>
<td>mac_rlc.data_req()</td>
<td>RRC → MAC</td>
<td>openair_rlc.L2_interface.c</td>
</tr>
<tr>
<td>rlc_mac_config_req()</td>
<td>RRC → MAC</td>
<td>openair2/layer2/mac/config.c</td>
</tr>
<tr>
<td>mac_rlc.data.ind()</td>
<td>MAC → RRC</td>
<td>openair_rlc.L2_interface.c</td>
</tr>
<tr>
<td>mac_eNB.get_rpc_status()</td>
<td>MAC → RRC</td>
<td>openair_rlc.L2_interface.c</td>
</tr>
<tr>
<td>MAC_RLC_SAP</td>
<td></td>
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<tr>
<td>mac_rlc.data_req()</td>
<td>RLC → MAC</td>
<td>Rlc/Rlc.mac.c</td>
</tr>
<tr>
<td>mac_rlc.data.ind()</td>
<td>MAC → RLC</td>
<td>Rlc/Rlc.mac.c</td>
</tr>
<tr>
<td>mac_rlc.status_ind()</td>
<td>MAC → RLC</td>
<td>Rlc/Rlc.mac.c</td>
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<tr>
<td>MAC_PHY_SAP</td>
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<tr>
<td>eNB_dlsch.ulsch_scheduler()</td>
<td>PHY → MAC</td>
<td>openair2/Phy_interface/defs.h</td>
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<td>initiate_ra_proc()</td>
<td>PHY → MAC</td>
<td>openair2/Phy_interface/defs.h</td>
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<td>fill_rar()</td>
<td>PHY → MAC</td>
<td>openair2/Phy_interface/defs.h</td>
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<tr>
<td>cancel_ra_proc()</td>
<td>PHY → MAC</td>
<td>openair2/Phy_interface/defs.h</td>
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<td>phy_config_sib2_eNB()</td>
<td>MAC → PHY</td>
<td>openair1/phy/init.h</td>
</tr>
<tr>
<td>rx_sdu()</td>
<td>PHY → MAC</td>
<td>openair2/Phy_interface/defs.h</td>
</tr>
<tr>
<td>get_dlsch_sdu()</td>
<td>MAC → PHY</td>
<td>openair2/Phy_interface/defs.h</td>
</tr>
<tr>
<td>get_dci_smu()</td>
<td>MAC → PHY</td>
<td>openair2/Phy_interface/defs.h</td>
</tr>
</tbody>
</table>

Table 3.1 MAC SAP Primitives
FAPI-Style Interface

- 5 steps API (general)

Diagram:

- MAC
  - Schedule Response
    - DLSCH SDU
    - DCI SDU (rnti + data)
  - UL Indication
    - Preamble(List)
    - ULSCH SDU
    - ACK/NACK
  - UL Response
    - Handle of the retransmission
    - DCI N0
  - Config Request
    - Configuration

- PHY
  - Schedule Indication
    - Time tick: 1ms
Subproject III: Study of cloud computing and dynamic resource allocation for Open 5G platform
Proposed Cloud Computing Platform

Streaming Server

Core Networks

P-GW/S-GW

Virtual MME

Virtual HSS

Containerized BBU

SSCloud RAN

RRU

5G

4G LTE

WiFi

Bluetooth
Dynamic Resource Allocation

- Decompose the functionality of OAI eNodeB, and elastically scale its resource capacity to meet workload demands.
Cyclic test Benchmark with 500,000 cycles

- **Without** system load [cpu-16, RAM-24]

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**Tuning**

![Graph](graph.png)
- **Cyclic test Benchmark with 500,000 cycles**

  - **With system load [cpu-16, RAM-24]**

  ![Graph showing latency in μSec for VM, Docker, and PM with different system loads.](image)
Subproject IV: Study of IoT integrated Services on the Open 5G platform
Scope and Goal

- This subproject focuses on the core network, IMS and application-layer protocols on Open 5G platform.
- This subproject identifies the issues on the Open 5G platform and proposes the mechanisms to improve the performance for the IoT integrated service.
- The subproject considers to transmit IoT messages through both IP and non-IP paths.
Difference between LTE & NB-IoT

- Traditional IMS service: (a) → (c) → (e) → (f)
- IoT: (b) → (d) → (e) → (g)
IoT-Integrated Service Platform

(a) iClothes (IoT UE)
(b) IoT eNB
(c) Edge Gateway
(d) SCEF
(e) Core Network
(f) IMS
(g) IoT Talk Server

UE ID Mapping
Internal ID ↔ External ID

User

UE

(i) Internet

(h) Firewall

S1-lite

m_{cn}
Major Deliveries

- **Mechanisms**
  - Mobile Edge Computing Mechanism (e.g., Offloading)
  - UE Internal ID and External ID Mapping
  - Effective UL/DL Scheduling
  - Performance Improvement between SCEF and application server

- **Software**
  - Application Server (e.g., IoT Talk server)
  - iClothes Applications
m_{cn} Interface

- We will analyze the performance of the following protocols for m_{cn} Interface.
  - MQTT (MQ Telemetry Transport)
  - HTTP (Hypertext Transfer Protocol)
  - SIP (Session Initiation Protocol)
  - CoAP (Constrained Application Protocol)