4G Core Network Training
BUPT – Beijing 2018-June
GOALS

- Show what Openairinterface offers in its 4G Core Network. What is actually the picture. How we run it.
Plan

- What is actually inside openair-cn
  • Core network entities released in github openair-cn repository.
  • HSS overview
  • MME Conformance
  • SPGW Conformance
  • Messages/interfaces

- Deployment used at Eurecom
  • Generic VM creation
  • Building NFs
3GPP Basic Picture of a 4G Core network.

Figure 4.2.1-1: Non-roaming architecture for 3GPP accesses
4G Core network entities released in openair-cn repo.
Perspective: 4G Core Network inter-working with 5G Core Network

From 3GPP TS23.501V2.0.1 (2017-12)
section 4.3.1Non-roaming architecture

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HSS

- Contributed back by Sprint (USA), started from OAI HSS rel 10.
  - Also contributed tiny/squeleton TDF (Traffic detection), CTF (Charging), PCEF, PCRF.
- Use Cassandra database (1 Node or fully distributed cluster of data centers)
- Interfaces
  - s6a(MME)/s6d(SGSN), s6c (GMSC), s6t (Service Capabilities Exposure Function SCEF) implemented.
- Fully written in C++11
HSS

• **External libraries**

  • **FreeDiameter** *(modified for overlapping AVPs between dictionaries).*
  
  • **c-ares** *(an asynchronous resolver library. It is intended for applications which need to perform DNS queries without blocking, or need to perform multiple DNS queries in parallel).*
  
  • **cpp-driver** *(Cassandra db driver).*
  
  • **pistache** *(HTTP and REST framework for C++ written in pure-C++11).*
  
  • **rapid json** *(A fast JSON parser/generator for C++ with both SAX/DOM style API).*
  
  • **spdlog** *(Very fast, header only, C++ logging library).*
MME

• Tech details:
  • Written in C.
  • Main Libraries
    • Asn1c.
    • Openssl.
    • NwGTPv2-c (BSD 2-clause) (GTPv2-c library written in C).
    • freeDiameter (not the same as HSS Rel14 actually).
    • bstring (better string library).
    • liblfds (lock free library: queues).
MME

- MME got a boost in its Mobility management features thanks to the contribution of Blackned (Dincer Beken).
  - Implementation of X2HO (also contributed by B-COM), S1HO, S10HO, Paging in MME.
  - Multiple PDN almost finished (will be released very soon).
  - Dedicated bearers should follow.
  - Tested with NG4T Ran emulator, Blackned HSS, third party S/P-GW.
## OAI MME Conformance interfaces

<table>
<thead>
<tr>
<th>Interfaces</th>
<th>S1-MME Interface</th>
<th>Supported</th>
<th>Still rel 10 should be upgraded to rel 14 soon</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>supported</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>S11 interface</td>
<td>supported</td>
<td>Rel 12 (Blackned)</td>
</tr>
<tr>
<td>3</td>
<td>S6a interface</td>
<td>supported</td>
<td>Still rel 10 should be upgraded to rel 14 soon (Sprint contribution on HSS)</td>
</tr>
<tr>
<td>4</td>
<td>S10 interface</td>
<td>supported</td>
<td>Rel 12 (Blackned)</td>
</tr>
<tr>
<td></td>
<td>OAI MME conformance functions 1/3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---------------------------------------------------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td><strong>NAS signalling</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>23.401 V10.13.0 4.4.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>supported</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td><strong>NAS signalling security</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>23.401 V10.13.0 4.4.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>supported</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><strong>Inter CN node signalling for mobility between 3GPP access networks (terminating S3)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>23.401 V10.13.0 4.4.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>not supported</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intra LTE HO only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td><strong>UE Reachability in ECM-IDLE state (including control, execution of paging retransmission and optionally Paging Policy Differentiation)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>23.401 V10.13.0 4.4.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>supported</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>We are working on this</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td><strong>Tracking Area list management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3GPP TS 23.401 V10.13.0 4.4.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>supported</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OAI MME conformance functions 2/3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>----------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Mapping from UE location (e.g. TAI) to time zone, and signalling a UE time zone change associated with mobility</td>
<td>23.401 V10.13.0 4.4.2</td>
<td>not supported</td>
</tr>
<tr>
<td>7</td>
<td>PDN GW and Serving GW selection</td>
<td>23.401 V10.13.0 4.4.2</td>
<td>supported</td>
</tr>
<tr>
<td>8</td>
<td>MME selection for handovers with MME change</td>
<td>23.401 V10.13.0 4.4.2</td>
<td>supported</td>
</tr>
<tr>
<td>9</td>
<td>SGSN selection for handovers to 2G or 3G 3GPP access networks</td>
<td>23.401 V10.13.0 4.4.2</td>
<td>not supported</td>
</tr>
<tr>
<td>10</td>
<td>Roaming (S6a towards home HSS)</td>
<td>23.401 V10.13.0 4.4.2</td>
<td>not supported</td>
</tr>
<tr>
<td>11</td>
<td>Authentication</td>
<td>23.401 V10.13.0 4.4.2</td>
<td>supported</td>
</tr>
<tr>
<td>12</td>
<td>Authorization</td>
<td>23.401 V10.13.0 4.4.2</td>
<td>supported</td>
</tr>
</tbody>
</table>
## OAI MME conformance functions 3/3

<table>
<thead>
<tr>
<th></th>
<th>Function Description</th>
<th>Standard</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Bearer management functions including dedicated bearer establishment</td>
<td>3GPP TS 23.401 V10.13.0 4.4.2</td>
<td>not supported</td>
</tr>
<tr>
<td>14</td>
<td>Lawful Interception of signalling traffic</td>
<td>3GPP TS 23.401 V10.13.0 4.4.2</td>
<td>not supported</td>
</tr>
<tr>
<td>15</td>
<td>Warning message transfer function (including selection of appropriate eNodeB)</td>
<td>3GPP TS 23.401 V10.13.0 4.4.2</td>
<td>not supported</td>
</tr>
<tr>
<td>16</td>
<td>UE Reachability procedures</td>
<td>3GPP TS 23.401 V10.13.0 4.4.2</td>
<td>not supported</td>
</tr>
<tr>
<td>17</td>
<td>Support Relaying function (RN Attach/Detach)</td>
<td>3GPP TS 23.401 V10.13.0 4.4.2</td>
<td>not supported</td>
</tr>
</tbody>
</table>
SPGW

• Tech details:
  • Written in C.
  • Main Libraries
    • NwGTPv2-c.
    • Libfluid or libgtpnl.
    • libevent.
    • bstring (better string library).
    • liblfds (lock free library: queues).
  • Use OVS or GTP in kernel only.
  • Strong dependency on kernel 4.9 actually
# OAI SGW conformance interfaces

<table>
<thead>
<tr>
<th></th>
<th>GTP-based S5/S8 interface</th>
<th>not supported</th>
<th>missing split between SGW and PGW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>S1-U interface</td>
<td>supported</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>S11 interface</td>
<td>supported</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Standard</td>
<td>Supported</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------------------------------------------------</td>
<td>---------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>1</td>
<td>the local Mobility Anchor point for inter-eNodeB handover (except when user data is transported using the Control Plane CIoT EPS Optimisation)</td>
<td>3GPP TS 23.401 V10.13.0 4.4.3.2</td>
<td>supported</td>
</tr>
<tr>
<td>2</td>
<td>sending of one or more &quot;end marker&quot; to the source eNodeB, source SGSN or source RNC immediately after the Serving GW switches the path during inter-eNodeB and inter-RAT handover, especially to assist the reordering function in eNodeB</td>
<td>3GPP TS 23.401 V10.13.0 4.4.3.2</td>
<td>not supported</td>
</tr>
<tr>
<td>3</td>
<td>Mobility anchoring for inter-3GPP mobility (terminating S4 and relaying the traffic between 2G/3G system and PDN GW)</td>
<td>3GPP TS 23.401 V10.13.0 4.4.3.2</td>
<td>not supported</td>
</tr>
<tr>
<td>4</td>
<td>ECM-IDLE mode downlink packet buffering and initiation of network triggered service request procedure and optionally Paging Policy Differentiation</td>
<td>3GPP TS 23.401 V10.13.0 4.4.3.2</td>
<td>not supported</td>
</tr>
<tr>
<td>5</td>
<td>Lawful Interception</td>
<td>3GPP TS 23.401 V10.13.0 4.4.3.2</td>
<td>not supported</td>
</tr>
<tr>
<td></td>
<td>Packet routing and forwarding</td>
<td>3GPP TS 23.401 V10.13.0 4.4.3.2</td>
<td>supported</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------</td>
<td>---------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>7</td>
<td>Transport level packet marking in the uplink and the downlink, e.g. setting the DiffServ Code Point, based on the QCI, and optionally the ARP priority level, of the associated EPS bearer</td>
<td>3GPP TS 23.401 V10.13.0 4.4.3.2</td>
<td>not supported</td>
</tr>
<tr>
<td>8</td>
<td>Accounting for inter-operator charging. For GTP-based S5/S8, the Serving GW generates accounting data per UE and bearer</td>
<td>3GPP TS 23.401 V10.13.0 4.4.3.2</td>
<td>not supported</td>
</tr>
<tr>
<td>9</td>
<td>Interfacing OFCS according to charging principles and through reference points specified in TS 32.240</td>
<td>3GPP TS 23.401 V10.13.0 4.4.3.2</td>
<td>not supported</td>
</tr>
</tbody>
</table>
GTPv2 Messages implemented

PATH MANAGEMENT MESSAGES

<table>
<thead>
<tr>
<th>Messages</th>
<th>Status (S10/S11)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Echo Request/Response</td>
<td>Not implemented</td>
<td>Required (not with OAI eNB)</td>
</tr>
<tr>
<td>Version not supported Indication</td>
<td>Not implemented</td>
<td></td>
</tr>
</tbody>
</table>
## GTPv2 Messages implemented 1/4

### TUNNEL MANAGEMENT MESSAGES

<table>
<thead>
<tr>
<th>Messages</th>
<th>Interface</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create Session Request/Response</td>
<td>S11</td>
<td></td>
</tr>
<tr>
<td>Create Bearer Request/Response</td>
<td>S11</td>
<td>Not used now (dedicated bearers)</td>
</tr>
<tr>
<td>Modify Bearer Request/Response</td>
<td>S11</td>
<td></td>
</tr>
<tr>
<td>Delete Session Request/Response</td>
<td>S11</td>
<td></td>
</tr>
<tr>
<td>Delete Bearer Request/Response</td>
<td>S11</td>
<td>TODO</td>
</tr>
<tr>
<td>Downlink Data Notification/Acknowledge</td>
<td>S11</td>
<td>network triggered service request procedure</td>
</tr>
</tbody>
</table>
## GTPv2 Messages implemented 2/4

### TUNNEL MANAGEMENT MESSAGES

<table>
<thead>
<tr>
<th>Messages</th>
<th>Interface</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delete Indirect Data Forwarding Tunnel Request/Response</td>
<td>S11</td>
<td>S1-based handover</td>
</tr>
<tr>
<td>Modify Bearer Command and Failure Indication</td>
<td>S11</td>
<td>HSS Initiated Subscribed QoS Modification procedure</td>
</tr>
<tr>
<td>Update Bearer Request/Response</td>
<td>S11</td>
<td>Many procedures</td>
</tr>
<tr>
<td>Delete Bearer Command and Failure Indication</td>
<td>S11</td>
<td>eNodeB requested bearer release or MME-Initiated Dedicated Bearer Deactivation procedure.</td>
</tr>
<tr>
<td>Create Indirect Data Forwarding Tunnel Request/Response</td>
<td>S11</td>
<td>Handover procedures or TAU/RAU procedure with Serving GW change and data forwarding</td>
</tr>
</tbody>
</table>
TUNNEL MANAGEMENT MESSAGES

<table>
<thead>
<tr>
<th>Messages</th>
<th>Interface</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Release Access Bearers Request/Response</strong></td>
<td>S11</td>
<td><strong>S1 release procedure</strong> and eNodeB initiated Connection Suspend procedure</td>
</tr>
<tr>
<td><strong>Stop Paging Indication</strong></td>
<td>S11</td>
<td>network triggered service request procedure. TODO.</td>
</tr>
<tr>
<td><strong>Modify Access Bearers Request/Response</strong></td>
<td>S11</td>
<td>If both the SGW and the MME support the MABR feature</td>
</tr>
<tr>
<td><strong>Remote UE Report Notification/Acknowledge</strong></td>
<td></td>
<td>Proximity Services</td>
</tr>
</tbody>
</table>
## MOBILITY MANAGEMENT MESSAGES

<table>
<thead>
<tr>
<th>Messages</th>
<th>Interface</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward Relocation Request/Response/Complete Notification/Complete Acknowledge</td>
<td>S10</td>
<td>S1-based handover relocation procedure</td>
</tr>
<tr>
<td>Context Request/Response/Acknowledge</td>
<td>S10</td>
<td>TAU/RAU procedure</td>
</tr>
<tr>
<td>Forward Access Context Notification/Acknowledge</td>
<td>S10</td>
<td>sent from the Old MME to the New MME over the S10 interface to forward the RNC/eNodeB contexts to the target system.</td>
</tr>
<tr>
<td>Relocation Cancel Request/Response</td>
<td>S10</td>
<td>S1 Based handover Cancel procedure</td>
</tr>
<tr>
<td>Configuration Transfer Tunnel</td>
<td>S10</td>
<td>transfer information from an eNodeB to another eNodeB in unacknowledged mode</td>
</tr>
</tbody>
</table>
# GTPv2 Messages implemented 3/4

## Tunnel Management Messages

<table>
<thead>
<tr>
<th>Messages</th>
<th>Interface</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Release Access Bearers Request/Response</td>
<td>S11</td>
<td><strong>S1 release procedure</strong> and eNodeB initiated Connection Suspend procedure</td>
</tr>
<tr>
<td>Stop Paging Indication</td>
<td>S11</td>
<td>network triggered service request procedure. TODO.</td>
</tr>
<tr>
<td>Modify Access Bearers Request/Response</td>
<td>S11</td>
<td>If both the SGW and the MME support the MABR feature</td>
</tr>
<tr>
<td>Remote UE Report Notification/Acknowledge</td>
<td></td>
<td>Proximity Services</td>
</tr>
</tbody>
</table>
END OF FEATURES
CN generic deployment - libvirt

- default switch (NAT mode)
- ws2018 switch (Isolated mode)

Ubuntu cloud image xenial (16.04) or ubuntu image built from ISO
- 32 GB disk
- 2 cores
- 4 GB RAM
- Customized kernel 4.9.x (1..108) (SPGW/GTP constraints)
- 8 physical network interfaces

Note on required disk size:
- Kernel 4.9 compilation and install (15GB) needs at least 21GB disk.
- Installation of HSS, MME, SPGW need 1GB disk space.
## CN deployment - Networking plan

<table>
<thead>
<tr>
<th>NW ref</th>
<th>VM Device</th>
<th>Subnet</th>
<th>Connection to host</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management</td>
<td>ens3</td>
<td>DHCP, NAT192.168.122.0/24</td>
<td>“default” switch in NAT mode</td>
</tr>
<tr>
<td>S11</td>
<td>ens4</td>
<td>192.168.17.0/24</td>
<td>“ws2018” switch in isolated mode</td>
</tr>
<tr>
<td>spare</td>
<td>ens5</td>
<td>192.168.27.0/24 (unused)</td>
<td>“ws2018” switch in isolated mode</td>
</tr>
<tr>
<td>S1-MME</td>
<td>ens6</td>
<td>192.168.37.0/24</td>
<td>“ws2018” switch in isolated mode</td>
</tr>
<tr>
<td>S1-U</td>
<td>ens7</td>
<td>192.168.47.0/24</td>
<td>“ws2018” switch in isolated mode</td>
</tr>
<tr>
<td>S5</td>
<td>ens8</td>
<td>192.168.57.0/24 (unused)</td>
<td>“ws2018” switch in isolated mode</td>
</tr>
<tr>
<td>S6a</td>
<td>ens9</td>
<td>192.168.67.0/24</td>
<td>“ws2018” switch in isolated mode</td>
</tr>
<tr>
<td>SGi</td>
<td>ens10</td>
<td>192.168.77.0/24</td>
<td>“ws2018” switch in isolated mode</td>
</tr>
</tbody>
</table>
VM networking - default network

file default.xml content:

```xml
<network>
  <name>default</name>
  <uuid>c605dfba-fe70-497f-87f3-f1b90e58e752</uuid>
  <forward mode='nat'>
    <nat>
      <port start='1024' end='65535'/>
    </nat>
  </forward>
  <bridge name='virbr0' stp='on' delay='0'/>
  <mac address='52:54:00:5b:cc:7b'/>
  <dns>
    <forwarder addr='192.168.106.12'/>
    <forwarder addr='192.168.106.10'/>
  </dns>
  <ip address='192.168.122.1' netmask='255.255.255.0'>
    <dhcp>
      <range start='192.168.122.2' end='192.168.122.254'/>
    </dhcp>
  </ip>
</network>
```

`ubuntu@ubuntu# sudo virsh net-create default.xml`
`ubuntu@ubuntu# sudo virsh net-autostart default`
`ubuntu@ubuntu# sudo virsh net-define ws2018.xml # make it persistent`
VM networking - 4G network

file ws2018.xml content:

```xml
<network>
  <name>ws2018</name>
  <uuid>94a99b8d-5737-4357-8e79-b1b21e9e56f2</uuid>
  <bridge name='virbr2' stp='on' delay='0'/>
  <mac address='52:54:00:bd:e0:83'/>
  <domain name='ws2018'/>
  <ip address='192.168.100.1' netmask='255.255.255.0'/>
</network>
```

```
ubuntu@ubuntu# sudo virsh net-create ws2018.xml
ubuntu@ubuntu# sudo virsh net-autostart ws2018
ubuntu@ubuntu# sudo virsh net-define ws2018.xml # make it persistent
```
VM networking

```bash
ubuntu@ubuntu# virsh net-list --all
Name    State   Autostart   Persistent
----------------------------------------------------------
default  active   yes        yes
ws2018  active   yes        yes
```

```bash
ubuntu@ubuntu# ifconfig
...
virbr0   Link encap:Ethernet  HWaddr 00:00:00:00:00:00
        inet addr:192.168.122.1  Bcast:192.168.122.255  Mask:255.255.255.0
        UP BROADCAST MULTICAST  MTU:1500  Metric:1
        ...
virbr2   Link encap:Ethernet  HWaddr 00:00:00:00:00:00
        inet addr:192.168.100.1  Bcast:192.168.100.255  Mask:255.255.255.0
        UP BROADCAST MULTICAST  MTU:1500  Metric:1
        ...
```
VM Creation

```bash
```

```xml
<domain type='kvm'>
  <memory unit='KiB'>25165824</memory>
  <currentMemory unit='KiB'>25165824</currentMemory>
  <vcpu placement='static'>2</vcpu>
  <os>
    <type arch='x86_64' machine='pc-i440fx-xenial'>hvm</type>
    <boot dev='hd'/>
  </os>
  <features>
    <acpi/>
    <apic/>
    <pae/>
  </features>
  <cpu mode='host-model'>
    <model fallback='allow'/>
    <topology sockets='1' cores='2' threads='1'/>
  </cpu>
  <devices>
    <interface type='bridge'>
      <source network='default' bridge='virbr0'/>
    </interface>
    <interface type='network'>
      <source network='ws2018' bridge='virbr2'/>
    </interface>
  </devices>
</domain>
```

network-interfaces: |
  auto ens3
  iface ens3 inet dhcp
  auto ens4
  iface ens4 inet static
    address 192.168.17.221
    netmask 255.255.255.0
  ...
  auto ens10
  iface ens10 inet static
    address 192.168.77.221
    netmask 255.255.255.0

apt:
  preserve_sources_list: true

primary:
  - arches: [amd64, default]

security:
  uri: http://security.ubuntu.com/ubuntu
VM Creation - other steps (not detailed)

- Retrieve its IP address on management interface (ens3)
- Create a user
- Set encrypted password to user (login ‘eurecom’, passwd ‘eurecom’)
- Set user as sudoer
- Copy authorized keys to user .ssh dir
Get openair-cn code

- Login as the sudoer
  ```
  ubuntu@ubuntu# ssh eurecom@192.168.122.170
  # Install kernel for SPGW
  sudo apt install libncurses5-dev libncursesw5-dev bc binutils gcc libssl-dev make autoconf
  ```

  ```
eurecom@ws2018:~$ cd /usr/src; sudo wget https://cdn.kernel.org/pub/linux/kernel/v4.x/linux-4.9.108.tar.xz
  eurecom@ws2018:/usr/src$ sudo tar xf linux-4.9.108.tar.xz && cd linux-4.9.108/
  eurecom@ws2018:/usr/src/linux-4.9.108$ sudo make olddefconfig && sudo make -j`nproc`
  eurecom@ws2018:/usr/src/linux-4.9.108$ sudo make modules_install && sudo make install
  ```

  ```
eurecom@ws2018:~$ git clone https://github.com/OPENAIRINTERFACE/openair-cn.git
  eurecom@ws2018:~$ cd openair-cn; git checkout develop
  eurecom@ws2018:~/openair-cn$ cd scripts
  ```
Build OAI HSS, MME, SPGW

eurecom@ws2018:~/openair-cn/scripts$ ./build_hss_rel14 -i && ./build_hss_rel14 --clean

eurecom@ws2018:~/openair-cn/scripts$ ./build_mme -i && ./build_mme --clean

eurecom@ws2018:~/openair-cn/scripts$ ./build_spgw -i && ./build_spgw --clean
Configure HSS - verify cassandra

Verify that Cassandra is installed and running

# nodetool status

The output should look something like:

eurecom@ws2018:~/openair-cn/scripts$ nodetool status
Datacenter: datacenter1
================================================================
Status=Up/Down
|/ State=Normal/Leaving/Joining/Moving
-- Address  Load  Tokens  Owns (effective)  Host ID       Rack
UN  127.0.0.1  51.64 KB  256   100.0%  41399cd4-c832-4d9a-9fbc-895a8301638e  rack1
Configure HSS - configure cassandra

Stop Cassandra and cleanup the log files before modifying the configuration

```
sudo service cassandra stop
sudo rm -rf /var/lib/cassandra/data/system/*
sudo rm -rf /var/lib/cassandra/commitlog/*
sudo rm -rf /var/lib/cassandra/data/system_traces/*
sudo rm -rf /var/lib/cassandra/saved_caches/*
```
Configure HSS - Update cassandra configuration

(c) Update the Cassandra configuration if needed (default configuration set 1 cassandra node listening on localhost)

Update /etc/cassandra/cassandra.yaml as indicated below. The \(<\text{Cassandra Server IP}>\) address should be the IP address of the Cassandra server that the HSS will use to connect to Cassandra. The "..." below indicate configuration lines between values that need to be modified.

```
...  
cluster_name: "HSS Cluster"
...  
seed_provider:
- class_name: org.apache.cassandra.locator.SimpleSeedProvider
- seeds: "<\text{Cassandra Server IP}>"
...
listen_address: <\text{Cassandra Server IP}>
...
rpc_address: <\text{Cassandra Server IP}>
...
endpoint_snitch: GossipingPropertyFileSnitch

or
endpoint_snitch: SimpleSnitch
```