5G OpenSrc(2)

양종석

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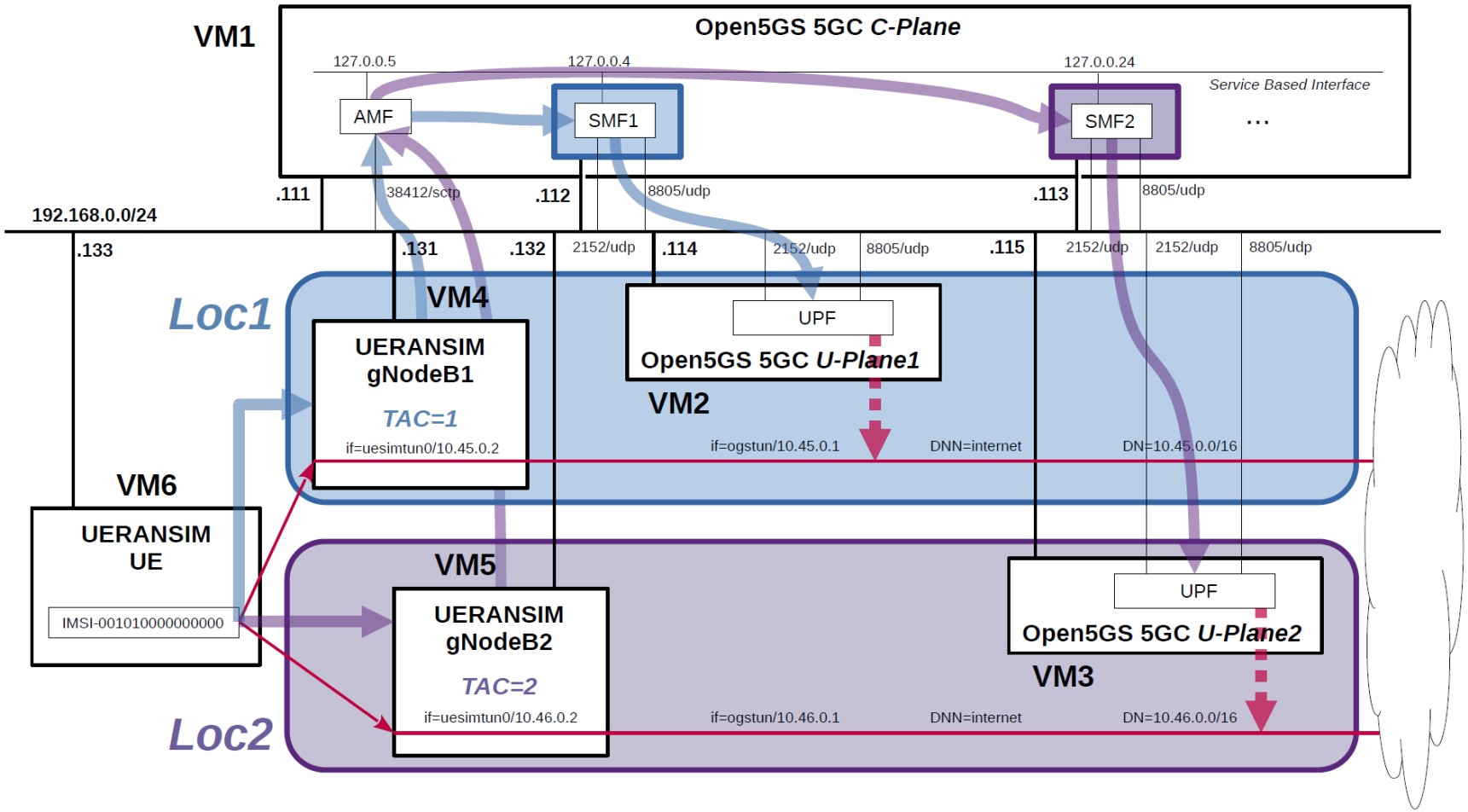
Architecture

>>

https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config



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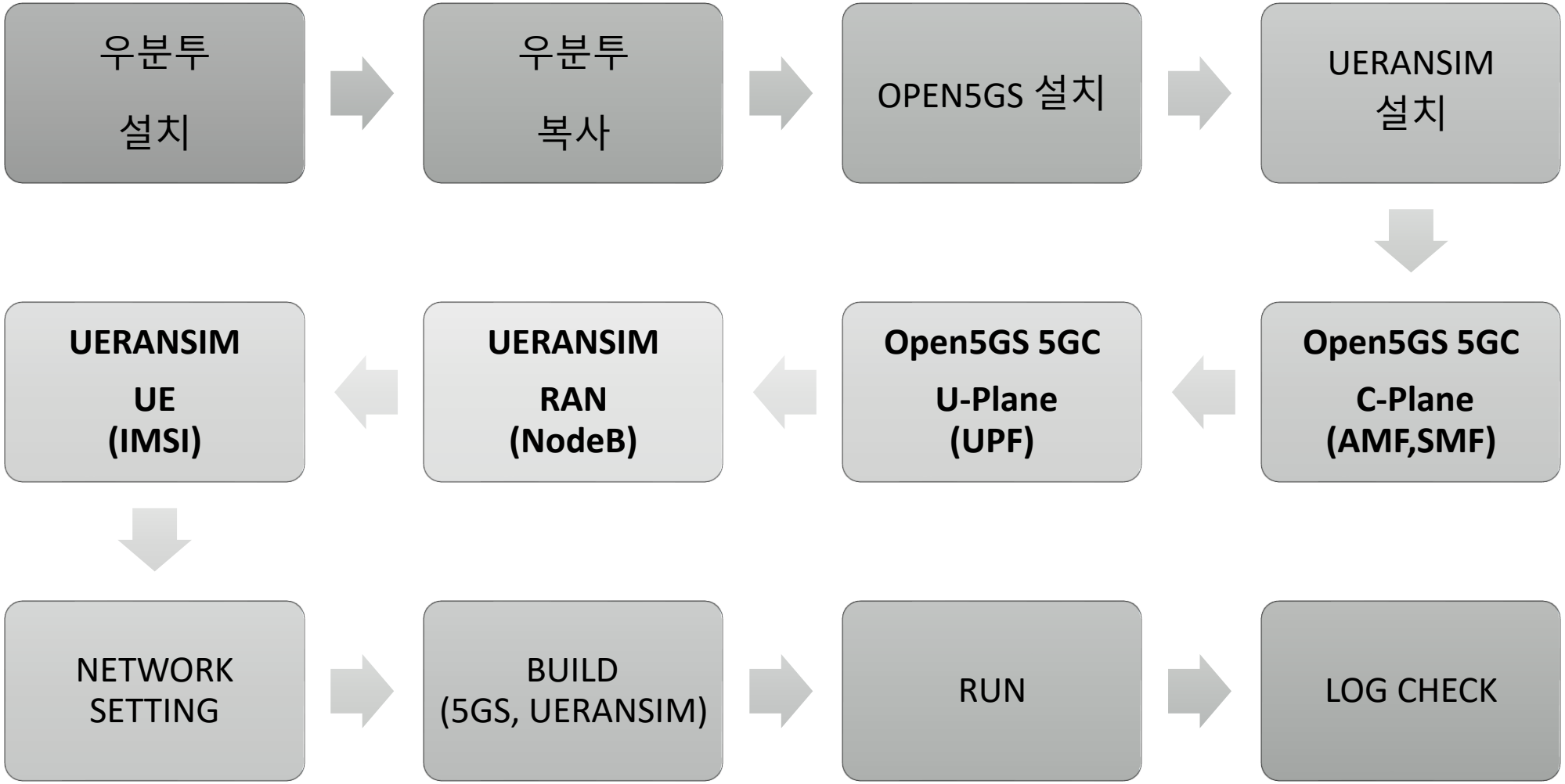
실습 Process



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Virtual Machine

VM #	SW & Role	IP address	OS	Memory (Min)	HDD (Min)
VM1	Open5GS 5GC C-Plane	192.168.0.111/24 192.168.0.112/24 192.168.0.113/24	Ubuntu 20.04	1GB	20GB
VM2	Open5GS 5GC U-Plane1	192.168.0.114/24	Ubuntu 20.04	1GB	20GB
VM3	Open5GS 5GC U-Plane2	192.168.0.115/24	Ubuntu 20.04	1GB	20GB
VM4	UERANSIM RAN (gNodeB1)	192.168.0.131/24	Ubuntu 20.04	1GB	10GB
VM5	UERANSIM RAN (gNodeB2)	192.168.0.132/24	Ubuntu 20.04	1GB	10GB
VM6	UERANSIM UE	192.168.0.133/24	Ubuntu 20.04	1GB	10GB

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AMF & SMF

NF	IP address	IP address on SBI	Supported TACs
AMF	192.168.0.111	127.0.0.5	1, 2
SMF1	192.168.0.112	127.0.0.4	1
SMF2	192.168.0.113	127.0.0.24	2

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NodeB

gNodeB #	Location #	TAC #	IP address
gNodeB1	Loc1	1	192.168.0.131
gNodeB2	Loc2	2	192.168.0.132

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UE(Subscriber Information)

UE	IMSI	DNN	OP/OPc	gNodeB #
UE	001010000000000	internet	OPc	gNodeB1 in Loc1 gNodeB2 in Loc2

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DN & TUNnel

DN	Location #	TUNnel interface of DN	DNN	TUNnel interface of UE	U-Plane #
10.45.0.0/16	Loc1	ogstun	internet	uesimtun0	U-Plane1
10.46.0.0/16	Loc2	ogstun	internet	uesimtun0	U-Plane2

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DN & TUNnel

DN	Location #	TUNnel interface of DN	DNN	TUNnel interface of UE	U-Plane #
10.45.0.0/16	Loc1	ogstun	internet	uesimtun0	U-Plane1
10.46.0.0/16	Loc2	ogstun	internet	uesimtun0	U-Plane2

OpenSrc(2)

Open5GS Install & Build

>> https://open5gs.org/open5gs/docs/guide/02-building-open5gs-from-sources/

Building Open5GS

Install the dependencies for building the source code.

```
$ sudo apt install python3-pip python3-setuptools python3-wheel ninja-build build-essential flex bison git cmake libsctp-dev libgnutls28-dev
libgcrypt-dev libssl-dev libidn11-dev libmongoc-dev libbson-dev libyaml-dev libnghttp2-dev libmicrohttpd-dev libcurl4-gnutls-dev libnghttp2-
dev libtins-dev libtalloc-dev meson
```

Git clone.

```
$ git clone https://github.com/open5gs/open5gs
```

To compile with meson:

```
$ cd open5gs
$ meson build --prefix=`pwd`/install
$ ninja -C build
```

OpenSrc(2)

Open5GS Configuration(AMF)

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

Changes in configuration files of Open5GS 5GC C-Plane

- open5gs/install/etc/open5gs/amf.yaml

```
--- amf.yaml.orig       2023-01-12 20:33:18.555295469 +0900
+++ amf.yaml    2023-01-12 22:23:40.014107855 +0900
@@ -342,26 +342,26 @@
       - addr: 127.0.0.5
         port: 7777
     ngap:
-      - addr: 127.0.0.5
+      - addr: 192.168.0.111
     metrics:
       - addr: 127.0.0.5
         port: 9090
     guami:
       - plmn_id:
-          mcc: 999
-          mnc: 70
+          mcc: 001
```

OpenSrc(2)

Open5GS Configuration(SMF1)

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

- open5gs/install/etc/open5gs/smf1.yaml

```
--- smf.yaml.orig       2023-01-12 20:33:18.526295426 +0900
+++ smf1.yaml   2023-01-12 22:24:13.992333976 +0900
@@ -19,7 +19,7 @@
 #    domain: core,fd,pfcp,gtp,smf,event,tlv,mem,sock
 #
 logger:
-    file: /root/open5gs/install/var/log/open5gs/smf.log
+    file: /root/open5gs/install/var/log/open5gs/smf1.log

 #
 # tls:
@@ -508,20 +508,17 @@
       - addr: 127.0.0.4
         port: 7777
     pfcp:
-      - addr: 127.0.0.4
-      - addr: ::1
+      - addr: 192.168.0.112
     gtpc:
       - addr: 127.0.0.4
-      - addr: ::1
```

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Open5GS Configuration(SMF2)

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

- open5gs/install/etc/open5gs/smf2.yaml

```
--- smf.yaml.orig       2023-01-12 20:33:18.526295426 +0900
+++ smf2.yaml   2023-01-12 22:24:24.289402198 +0900
@@ -19,7 +19,7 @@
 #    domain: core,fd,pfcp,gtp,smf,event,tlv,mem,sock
 #
 logger:
-    file: /root/open5gs/install/var/log/open5gs/smf.log
+    file: /root/open5gs/install/var/log/open5gs/smf2.log

 #
 # tls:
@@ -505,23 +505,20 @@
 #
 smf:
     sbi:
-      - addr: 127.0.0.4
+      - addr: 127.0.0.24
         port: 7777
     pfcp:
-      - addr: 127.0.0.4
-      - addr: ::1
+      - addr: 192.168.0.113
     gtpc:
```

OpenSrc(2)

Open5GS Configuration(SMF1, SMF2)

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

- `open5gs/install/etc/freeDiameter/smf1.conf`
  `smf1.conf` is equal to the original `smf.conf`.
- `open5gs/install/etc/freeDiameter/smf2.conf`

```
--- smf.conf.orig       2023-01-12 20:33:20.131297687 +0900
+++ smf2.conf   2023-01-12 22:22:40.352706816 +0900
@@ -79,7 +79,7 @@
 #ListenOn = "202.249.37.5";
 #ListenOn = "2001:200:903:2::202:1";
 #ListenOn = "fe80::21c:5ff:fe98:7d62%eth0";
-ListenOn = "127.0.0.4";
+ListenOn = "127.0.0.24";


 ######################################################################
```

OpenSrc(2)

Open5GS Configuration(UPF1)

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

Changes in configuration files of Open5GS 5GC U-Plane1

- `open5gs/install/etc/open5gs/upf.yaml`

```
--- upf.yaml.orig       2023-01-12 20:44:33.674609278 +0900
+++ upf.yaml    2023-01-12 22:26:40.722648205 +0900
@@ -173,12 +173,13 @@
 #
 upf:
     pfcp:
-      - addr: 127.0.0.7
+      - addr: 192.168.0.114
     gtpu:
-      - addr: 127.0.0.7
+      - addr: 192.168.0.114
     subnet:
       - addr: 10.45.0.1/16
-      - addr: 2001:db8:cafe::1/48
+        dnn: internet
+        dev: ogstun
     metrics:
       - addr: 127.0.0.7
         port: 9090
```

OpenSrc(2)

Open5GS Configuration(UPF2)

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

Changes in configuration files of Open5GS 5GC U-Plane2

- `open5gs/install/etc/open5gs/upf.yaml`

```
--- upf.yaml.orig       2023-01-12 20:53:25.948221315 +0900
+++ upf.yaml    2023-01-12 22:28:01.751564228 +0900
@@ -173,12 +173,13 @@
 #
 upf:
     pfcp:
-      - addr: 127.0.0.7
+      - addr: 192.168.0.115
     gtpu:
-      - addr: 127.0.0.7
+      - addr: 192.168.0.115
     subnet:
-      - addr: 10.45.0.1/16
-      - addr: 2001:db8:cafe::1/48
+      - addr: 10.46.0.1/16
+        dnn: internet
+        dev: ogstun
     metrics:
       - addr: 127.0.0.7
         port: 9090
```

OpenSrc(2)

Open5GS Configuration(RAN(NodeB1)

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

Changes in configuration files of UERANSIM UE / RAN

Changes in configuration files of RAN (gNodeB1)

- `UERANSIM/config/open5gs-gnb.yaml`

```
--- open5gs-gnb.yaml.orig       2022-07-03 13:06:43.000000000 +0900
+++ open5gs-gnb.yaml    2023-01-12 22:31:00.200921228 +0900
@@ -1,17 +1,17 @@
-mcc: '999'          # Mobile Country Code value
-mnc: '70'           # Mobile Network Code value (2 or 3 digits)
+mcc: '001'          # Mobile Country Code value
+mnc: '01'           # Mobile Network Code value (2 or 3 digits)

 nci: '0x000000010'  # NR Cell Identity (36-bit)
 idLength: 32        # NR gNB ID length in bits [22...32]
 tac: 1              # Tracking Area Code

-linkIp: 127.0.0.1   # gNB's local IP address for Radio Link Simulation (Usually same with local IP)
-ngapIp: 127.0.0.1   # gNB's local IP address for N2 Interface (Usually same with local IP)
-gtpIp: 127.0.0.1    # gNB's local IP address for N3 Interface (Usually same with local IP)
+linkIp: 192.168.0.131   # gNB's local IP address for Radio Link Simulation (Usually same with local IP)
+ngapIp: 192.168.0.131   # gNB's local IP address for N2 Interface (Usually same with local IP)
+gtpIp: 192.168.0.131    # gNB's local IP address for N3 Interface (Usually same with local IP)

 # List of AMF address information
 amfConfigs:
-  - address: 127.0.0.5
+  - address: 192.168.0.111
     port: 38412

 # List of supported S-NSSAIs by this gNB
```

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Open5GS Configuration(RAN(NodeB2)

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

Changes in configuration files of RAN (gNodeB2)

- `UERANSIM/config/open5gs-gnb.yaml`

```
--- open5gs-gnb.yaml.orig       2022-07-03 13:06:43.000000000 +0900
+++ open5gs-gnb.yaml    2023-01-12 22:32:12.052740137 +0900
@@ -1,17 +1,17 @@
-mcc: '999'          # Mobile Country Code value
-mnc: '70'           # Mobile Network Code value (2 or 3 digits)
+mcc: '001'          # Mobile Country Code value
+mnc: '01'           # Mobile Network Code value (2 or 3 digits)

 nci: '0x000000010'  # NR Cell Identity (36-bit)
 idLength: 32        # NR gNB ID length in bits [22...32]
-tac: 1              # Tracking Area Code
+tac: 2              # Tracking Area Code

-linkIp: 127.0.0.1   # gNB's local IP address for Radio Link Simulation (Usually same with local IP)
-ngapIp: 127.0.0.1   # gNB's local IP address for N2 Interface (Usually same with local IP)
-gtpIp: 127.0.0.1    # gNB's local IP address for N3 Interface (Usually same with local IP)
+linkIp: 192.168.0.132   # gNB's local IP address for Radio Link Simulation (Usually same with local IP)
+ngapIp: 192.168.0.132   # gNB's local IP address for N2 Interface (Usually same with local IP)
+gtpIp: 192.168.0.132    # gNB's local IP address for N3 Interface (Usually same with local IP)

 # List of AMF address information
 amfConfigs:
-  - address: 127.0.0.5
+  - address: 192.168.0.111
     port: 38412

 # List of supported S-NSSAIs by this gNB
```

OpenSrc(2)

Open5GS Configuration(UE(IMSI-001010000000000)

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

Changes in configuration files of UE for Loc1 (IMSI-001010000000000)

- `UERANSIM/config/open5gs-ue-loc1.yaml`

```
--- open5gs-ue.yaml.orig        2022-07-03 13:06:43.000000000 +0900
+++ open5gs-ue-loc1.yaml        2023-01-12 22:33:47.598481682 +0900
@@ -1,9 +1,9 @@
 # IMSI number of the UE. IMSI = [MCC|MNC|MSISDN] (In total 15 digits)
-supi: 'imsi-999700000000001'
+supi: 'imsi-001010000000000'
 # Mobile Country Code value of HPLMN
-mcc: '999'
+mcc: '001'
 # Mobile Network Code value of HPLMN (2 or 3 digits)
-mnc: '70'
+mnc: '01'

 # Permanent subscription key
 key: '465B5CE8B199B49FAA5F0A2EE238A6BC'
@@ -20,7 +20,7 @@

 # List of gNB IP addresses for Radio Link Simulation
 gnbSearchList:
-  - 127.0.0.1
+  - 192.168.0.131

 # UAC Access Identities Configuration
 uacAic:
```

OpenSrc(2)

Open5GS Configuration(UE(IMSI-001010000000000)

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

Changes in configuration files of UE for Loc2 (IMSI-001010000000000)

- `UERANSIM/config/open5gs-ue-loc2.yaml`

```
--- open5gs-ue.yaml.orig        2022-07-03 13:06:43.000000000 +0900
+++ open5gs-ue-loc2.yaml        2023-01-12 22:33:56.743500724 +0900
@@ -1,9 +1,9 @@
 # IMSI number of the UE. IMSI = [MCC|MNC|MSISDN] (In total 15 digits)
-supi: 'imsi-999700000000001'
+supi: 'imsi-001010000000000'
 # Mobile Country Code value of HPLMN
-mcc: '999'
+mcc: '001'
 # Mobile Network Code value of HPLMN (2 or 3 digits)
-mnc: '70'
+mnc: '01'

 # Permanent subscription key
 key: '465B5CE8B199B49FAA5F0A2EE238A6BC'
@@ -20,7 +20,7 @@

 # List of gNB IP addresses for Radio Link Simulation
 gnbSearchList:
-  - 127.0.0.1
+  - 192.168.0.132

 # UAC Access Identities Configuration
 uacAic:
```

OpenSrc(2)

Open5GS Network Setting

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

Network settings of Open5GS 5GC C-Plane

Add IP addresses for SMF1 and SMF2.

```
ip addr add 192.168.0.112/24 dev enp0s8
ip addr add 192.168.0.113/24 dev enp0s8
```

Note. `enp0s8` is the network interface of `192.168.0.0/24` in my VirtualBox environment. Please change it according to your environment.

Network settings of Open5GS 5GC U-Plane1

First, uncomment the next line in the `/etc/sysctl.conf` file and reflect it in the OS.

```
net.ipv4.ip_forward=1
```

```
# sysctl -p
```

Next, configure the TUNnel interface and NAPT.

```
ip tuntap add name ogstun mode tun
ip addr add 10.45.0.1/16 dev ogstun
ip link set ogstun up

iptables -t nat -A POSTROUTING -s 10.45.0.0/16 ! -o ogstun -j MASQUERADE
```

OpenSrc(2)

Open5GS Network Setting

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

Network settings of Open5GS 5GC U-Plane2

First, uncomment the next line in the `/etc/sysctl.conf` file and reflect it in the OS.

```
net.ipv4.ip_forward=1
```

```
# sysctl -p
```

Next, configure the TUNnel interface and NAPT.

```
ip tuntap add name ogstun mode tun
ip addr add 10.46.0.1/16 dev ogstun
ip link set ogstun up

iptables -t nat -A POSTROUTING -s 10.46.0.0/16 ! -o ogstun -j MASQUERADE
```

Part 1

OpenSrc(2)

Open5GS Network Setting

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

OpenSrc(2)

Open5GS Install & Build

>> https://open5gs.org/open5gs/docs/guide/02-building-open5gs-from-sources/

Building Open5GS

Install the dependencies for building the source code.

```
$ sudo apt install python3-pip python3-setuptools python3-wheel ninja-build build-essential flex bison git cmake libsctp-dev libgnutls28-dev
libgcrypt-dev libssl-dev libidn11-dev libmongoc-dev libbson-dev libyaml-dev libnghttp2-dev libmicrohttpd-dev libcurl4-gnutls-dev libnghttp2-
dev libtins-dev libtalloc-dev meson
```

Git clone.

```
$ git clone https://github.com/open5gs/open5gs
```

To compile with meson:

```
$ cd open5gs
$ meson build --prefix=`pwd`/install
$ ninja -C build
```

OpenSrc(2)

Open5GS Install & Build

>> https://open5gs.org/open5gs/docs/guide/02-building-open5gs-from-sources/

Check whether the compilation is correct.

```
$ ./build/tests/attach/attach ## EPC Only
$ ./build/tests/registration/registration ## 5G Core Only
```

Run all test programs as below.

```
$ cd build
$ meson test -v
```

Tip: You can also check the result of `ninja -C build test` with a tool that captures packets. If you are running `wireshark`, select the `loopback` interface and set FILTER to `s1ap || gtpv2 || pfcp || diameter || gtp || ngap || http2.data.data || http2.headers`. You can see the virtually created packets. testattach.pcapng/testregistration.pcapng

You need to perform the **installation process**.

```
$ cd build
$ ninja install
$ cd ../
```

OpenSrc(2)

Open5GS RUN

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

Run Open5GS 5GC C-Plane

First, run Open5GS 5GC C-Plane.

- Open5GS 5GC C-Plane

```
./install/bin/open5gs-nrfd &
sleep 2
./install/bin/open5gs-scpd &
sleep 2
./install/bin/open5gs-amfd &
sleep 2
./install/bin/open5gs-smfd -c install/etc/open5gs/smf1.yaml &
./install/bin/open5gs-smfd -c install/etc/open5gs/smf2.yaml &
./install/bin/open5gs-ausfd &
./install/bin/open5gs-udmd &
./install/bin/open5gs-udrd &
./install/bin/open5gs-pcfd &
./install/bin/open5gs-nssfd &
./install/bin/open5gs-bsfd &
```

OpenSrc(2)

Open5GS RUN

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

Run Open5GS 5GC U-Plane1 & U-Plane2

Next, run Open5GS 5GC U-Plane.

- Open5GS 5GC U-Plane1

```
./install/bin/open5gs-upfd &
```

- Open5GS 5GC U-Plane2

```
./install/bin/open5gs-upfd &
```

OpenSrc(2)

Open5GS RUN

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

Then run `tcpdump` on one more terminal for each U-Plane.

- Run `tcpdump` on VM2 (U-Plane1)

```
# tcpdump -i ogstun -n
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on ogstun, link-type RAW (Raw IP), capture size 262144 bytes
```

- Run `tcpdump` on VM3 (U-Plane2)

```
# tcpdump -i ogstun -n
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on ogstun, link-type RAW (Raw IP), capture size 262144 bytes
```

OpenSrc(2)

Open5GS RUN

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

Run UERANSIM (gNodeBs)

Run each gNodeB with TAC=1 and TAC=2 in two locations.
Please refer to the following for usage of UERANSIM.

https://github.com/aligungr/UERANSIM/wiki/Usage

Start gNodeB1 with TAC=1 in Loc1

```
# ./nr-gnb -c ../config/open5gs-gnb.yaml
UERANSIM v3.2.6
[2023-01-12 23:10:51.017] [sctp] [info] Trying to establish SCTP connection... (192.168.0.111:3
[2023-01-12 23:10:51.020] [sctp] [info] SCTP connection established (192.168.0.111:38412)
[2023-01-12 23:10:51.020] [sctp] [debug] SCTP association setup ascId[9]
[2023-01-12 23:10:51.020] [ngap] [debug] Sending NG Setup Request
[2023-01-12 23:10:51.021] [ngap] [debug] NG Setup Response received
[2023-01-12 23:10:51.021] [ngap] [info] NG Setup procedure is successful
```

OpenSrc(2)

Open5GS RUN

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

Start gNodeB2 with TAC=2 in Loc2

```
# ./nr-gnb -c ../config/open5gs-gnb.yaml
UERANSIM v3.2.6
[2023-01-12 23:11:54.993] [sctp] [info] Trying to establish SCTP connection... (192.168.0.111:3
[2023-01-12 23:11:54.996] [sctp] [info] SCTP connection established (192.168.0.111:38412)
[2023-01-12 23:11:54.996] [sctp] [debug] SCTP association setup ascId[4]
[2023-01-12 23:11:54.996] [ngap] [debug] Sending NG Setup Request
[2023-01-12 23:11:54.996] [ngap] [debug] NG Setup Response received
[2023-01-12 23:11:54.996] [ngap] [info] NG Setup procedure is successful
```

The Open5GS C-Plane log when executed is as follows.

```
01/12 23:11:55.013: [amf] INFO: gNB-N2 accepted[192.168.0.132]:37118 in ng-path module (../
01/12 23:11:55.013: [amf] INFO: gNB-N2 accepted[192.168.0.132] in master_sm module (../src/amf/
01/12 23:11:55.013: [amf] INFO: [Added] Number of gNBs is now 2 (../src/amf/context.c:1034)
01/12 23:11:55.013: [amf] INFO: gNB-N2[192.168.0.132] max_num_of_ostreams : 10 (../src/amf/amf-
```

OpenSrc(2)

Open5GS RUN

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

Run UERANSIM (UE in Loc1)

Confirm that the packet goes through the DN of U-Plane1 in the same Loc1 by connecting to gNodeB1 in Loc1.

Start UE connected to gNodeB1 in Loc1

```
# ./nr-ue -c ../config/open5gs-ue-loc1.yaml
UERANSIM v3.2.6
[2023-01-12 23:12:52.498] [nas] [info] UE switches to state [MM-DEREGISTERED/PLMN-SEARCH]
[2023-01-12 23:12:52.499] [rrc] [debug] New signal detected for cell[1], total [1] cells in cov
[2023-01-12 23:12:52.499] [nas] [info] Selected plmn[001/01]
[2023-01-12 23:12:52.500] [rrc] [info] Selected cell plmn[001/01] tac[1] category[SUITABLE]
[2023-01-12 23:12:52.500] [nas] [info] UE switches to state [MM-DEREGISTERED/PS]
[2023-01-12 23:12:52.500] [nas] [info] UE switches to state [MM-DEREGISTERED/NORMAL-SERVICE]
[2023-01-12 23:12:52.500] [nas] [debug] Initial registration required due to [MM-DEREG-NORMAL-S
[2023-01-12 23:12:52.502] [nas] [debug] UAC access attempt is allowed for identity[0], category
[2023-01-12 23:12:52.502] [nas] [debug] Sending Initial Registration
[2023-01-12 23:12:52.502] [rrc] [debug] Sending RRC Setup Request
[2023-01-12 23:12:52.503] [nas] [info] UE switches to state [MM-REGISTER-INITIATED]
```

OpenSrc(2)

Open5GS RUN

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

The Open5GS U-Plane1 log when executed is as follows.

```
01/12 23:12:52.743: [upf] INFO: [Added] Number of UPF-Sessions is now 1 (../src/upf/conte 1
01/12 23:12:52.743: [gtp] INFO: gtp_connect() [192.168.0.112]:2152 (../lib/gtp/path.c:60)
01/12 23:12:52.743: [upf] INFO: UE F-SEID[UP:0x1 CP:0x1] APN[internet] PDN-Type[1] IPv4[10.45.0
01/12 23:12:52.743: [upf] INFO: UE F-SEID[UP:0x1 CP:0x1] APN[internet] PDN-Type[1] IPv4[10.45.0
01/12 23:12:52.748: [gtp] INFO: gtp_connect() [192.168.0.131]:2152 (../lib/gtp/path.c:60)
```

The TUNnel interface `uesimtun0` is created as follows.

```
# ip addr show
...
7: uesimtun0: <POINTOPOINT,PROMISC,NOTRAILERS,UP,LOWER_UP> mtu 1400 qdisc fq_codel state UNKNOW
    link/none
    inet 10.45.0.2/32 scope global uesimtun0
       valid_lft forever preferred_lft forever
    inet6 fe80::1154:8c2f:e0f9:b5b8/64 scope link stable-privacy
       valid_lft forever preferred_lft forever
...
```

OpenSrc(2)

Open5GS RUN

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

Ping google.com going through DN=10.45.0.0/16 on Loc1

Confirm by using `tcpdump` that the packet goes through `if=ogstun` on U-Plane1.

```
# ping google.com -I uesimtun0 -n
PING google.com (142.251.42.206) from 10.45.0.2 uesimtun0: 56(84) bytes of data.
64 bytes from 142.251.42.206: icmp_seq=1 ttl=61 time=20.6 ms
64 bytes from 142.251.42.206: icmp_seq=2 ttl=61 time=18.2 ms
64 bytes from 142.251.42.206: icmp_seq=3 ttl=61 time=18.7 ms
```

The `tcpdump` log on U-Plane1 is as follows.

```
23:15:04.363011 IP 10.45.0.2 > 142.251.42.206: ICMP echo request, id 3, seq 1, length 64
23:15:04.381573 IP 142.251.42.206 > 10.45.0.2: ICMP echo reply, id 3, seq 1, length 64
23:15:05.365527 IP 10.45.0.2 > 142.251.42.206: ICMP echo request, id 3, seq 2, length 64
23:15:05.381333 IP 142.251.42.206 > 10.45.0.2: ICMP echo reply, id 3, seq 2, length 64
23:15:06.366274 IP 10.45.0.2 > 142.251.42.206: ICMP echo request, id 3, seq 3, length 64
23:15:06.382585 IP 142.251.42.206 > 10.45.0.2: ICMP echo reply, id 3, seq 3, length 64
```

Open5GS RUN

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

Run UERANSIM (UE in Loc2)

Then the UE disconnects from gNodeB1 and connects to gNodeB2 in Loc2. Confirm that the packet goes through the DN of U-Plane2 in the same Loc2.

Start UE connected to gNodeB2 in Loc2

```
# ./nr-ue -c ../config/open5gs-ue-loc2.yaml
UERANSIM v3.2.6
[2023-01-12 23:16:29.622] [nas] [info] UE switches to state [MM-DEREGISTERED/PLMN-SEARCH]
[2023-01-12 23:16:29.623] [rrc] [debug] New signal detected for cell[1], total [1] cells in cov
[2023-01-12 23:16:29.623] [nas] [info] Selected plmn[001/01]
[2023-01-12 23:16:29.624] [rrc] [info] Selected cell plmn[001/01] tac[2] category[SUITABLE]
[2023-01-12 23:16:29.624] [nas] [info] UE switches to state [MM-DEREGISTERED/PS]
[2023-01-12 23:16:29.624] [nas] [info] UE switches to state [MM-DEREGISTERED/NORMAL-SERVICE]
[2023-01-12 23:16:29.624] [nas] [debug] Initial registration required due to [MM-DEREG-NORMAL-S
[2023-01-12 23:16:29.626] [nas] [debug] UAC access attempt is allowed for identity[0], category
[2023-01-12 23:16:29.626] [nas] [debug] Sending Initial Registration
[2023-01-12 23:16:29.626] [rrc] [debug] Sending RRC Setup Request
[2023-01-12 23:16:29.627] [nas] [info] UE switches to state [MM-REGISTER-INITIATED]
[2023-01-12 23:16:29.627] [rrc] [info] RRC connection established
```

OpenSrc(2)

Open5GS RUN

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

The TUNnel interface `uesimtun0` is created as follows.

```
# ip addr show
...
8: uesimtun0: <POINTOPOINT,PROMISC,NOTRAILERS,UP,LOWER_UP> mtu 1400 qdisc fq_codel state UNKNOW
    link/none
    inet 10.46.0.2/32 scope global uesimtun0
       valid_lft forever preferred_lft forever
    inet6 fe80::e033:44b5:6554:8f0c/64 scope link stable-privacy
       valid_lft forever preferred_lft forever
...
```

OpenSrc(2)

Open5GS RUN

>> https://github.com/s5uishida/open5gs_5gc_ueransim_nearby_upf_sample_config

Ping google.com going through DN=10.46.0.0/16 on Loc2

Confirm by using `tcpdump` that the packet goes through `if=ogstun` on U-Plane2.

```
# ping google.com -I uesimtun0 -n
PING google.com (142.251.42.206) from 10.46.0.2 uesimtun0: 56(84) bytes of data.
64 bytes from 142.251.42.206: icmp_seq=1 ttl=61 time=20.6 ms
64 bytes from 142.251.42.206: icmp_seq=2 ttl=61 time=18.1 ms
64 bytes from 142.251.42.206: icmp_seq=3 ttl=61 time=18.6 ms
```

The `tcpdump` log on U-Plane2 is as follows.

```
23:18:26.481258 IP 10.46.0.2 > 142.251.42.206: ICMP echo request, id 4, seq 1, length 64
23:18:26.499338 IP 142.251.42.206 > 10.46.0.2: ICMP echo reply, id 4, seq 1, length 64
23:18:27.482355 IP 10.46.0.2 > 142.251.42.206: ICMP echo request, id 4, seq 2, length 64
23:18:27.498519 IP 142.251.42.206 > 10.46.0.2: ICMP echo reply, id 4, seq 2, length 64
23:18:28.484175 IP 10.46.0.2 > 142.251.42.206: ICMP echo request, id 4, seq 3, length 64
23:18:28.500714 IP 142.251.42.206 > 10.46.0.2: ICMP echo reply, id 4, seq 3, length 64
```

Next

- 5G Virtual Lab.

Q&A

감사합니다