EPC User’s Guide

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Abstract

The deliverable presents the EPC developed by EURECOM, its configuration, installation testing and running.

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History

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Lionel GAUTHIER	11/06/2015	0.2	Minor corrections
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Lionel GAUTHIER	08/03/2016	0.12	Updated for GTP kernel 4.7.

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Abbreviations

3GPP	Third Generation Partnership Project.
APN	Access Point Name.
CIDR	Classless Inter-Domain Routing.
eNB	e Node B.
EPC	Evolved Packet Core.
EPS	Evolved Packet System.
FQDN	Fully qualified domain name.
HSS	Home Subscriber Server.
IMEI	International Mobile Station Equipment Identity.
IMEISV	International Mobile Station Equipment Identity Software Version.
LTE	Long Term Evolution.
MME	Mobility Management Entity.
MSISDN	Mobile Station International Subscriber Directory Number.
NW	Network.
P-GW	PDN Gateway, Packet Data Network Gateway.
PDN	Packet Data Network.
QoS	Quality of Service.
SCTP	Stream Control Transmission Protocol.
S-GW	Serving Gateway.
SIM	Subscriber Identity Module.
TCP	Transmission Control Protocol.
USIM	Universal Subscriber Identity Module.

1 Introduction

1.1 Overview

The EURECOM EPC is a bundle of software components that provides the MME, S+P-GW, HSS functions of the LTE core EPC architecture (http://www.3gpp.org/DynaReport/23002.htm).

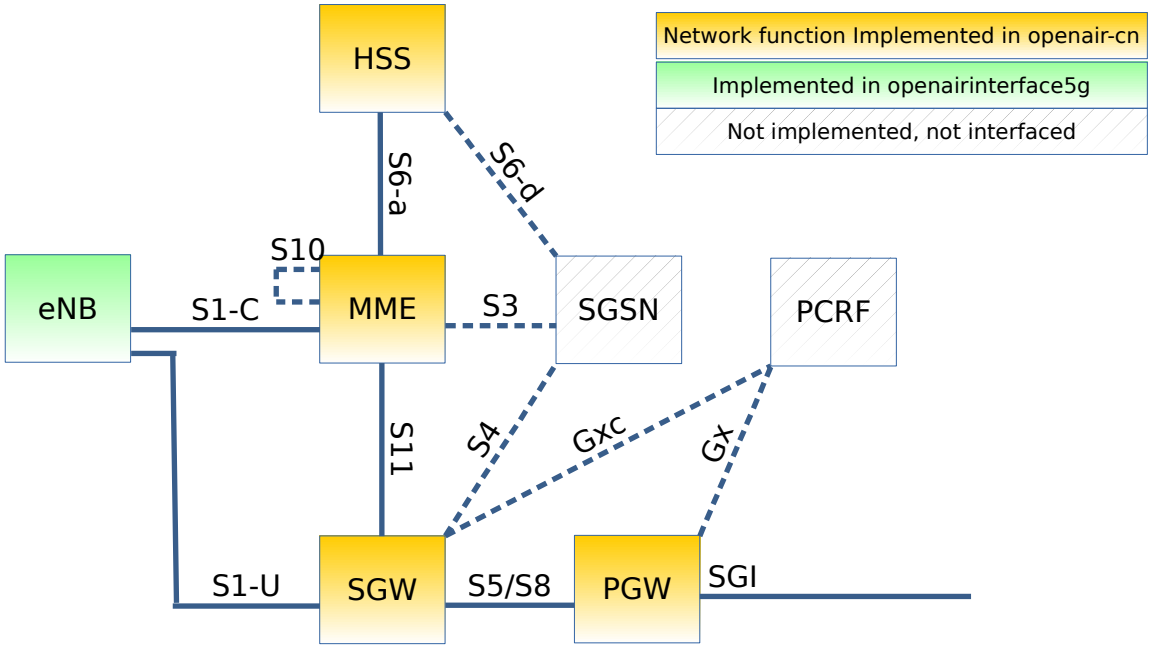


Figure 1 EURECOM core network entities overview

The link to other network entities such as a SGSN, PCRF is actually studied.

1.2 Deployment scenario

One deployment scenario is considered with the EURECOM EPC.

Actually the SGW and the PGW are merged together, there is no S5/S8 interfaces between the two functional entities.

The MME is a network entity that can be deployed on its own host or can be co-located with any other LTE network entity (SPGW, HSS). Even if it works we do not recommand the deployment of the MME on a eNB.

The SPGW is a network entity that can be deployed on its own host or can be co-located with the MME or/and with the HSS.

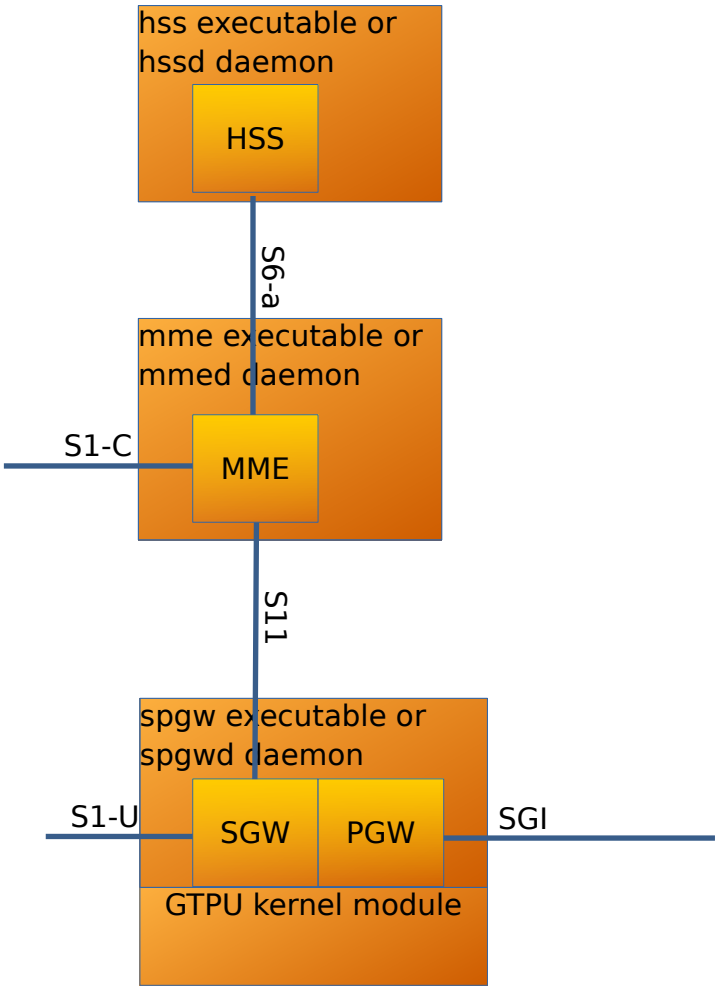


Figure 2 EPC Deployment view

2 EPC Installation

2.1 Operating system

The EPC software has only been tested on **UBUNTU 14.04x64** LINUX distribution on Intel x86 64 bits platforms. Actually on the host running the SP-GW, the GTPv1-U implementation **requires** that your host run a **kernel version greater or equal to 4.7 (we use 4.7-rc7)**.

2.2 EPC source code

Important!

In this document OPENAIRCN_DIR is the path to the EPC source code top directory (i.e. openair-cn working directory).

It is assumed that you are logged onto your machine(s) as a non root user and you configured your system to be a sudoer user.

The EPC software can be obtained from our git server. You will need a git client to get the sources.

If git is not installed on your computer, execute in a shell the following command (Ubuntu):

```
user@host:~ sudo apt-get install git
```

Configure git with your name/email address (only important if you are developer and want to checkin code to Git):

```
git config --global user.name "Your Name"
git config --global user.email "Your email address"
```

Add a certificate from gitlab.eurecom.fr to your Ubuntu 14.04 installation (you need to be root user):

```
root@host:~# echo -n | openssl s_client -showcerts -connect gitlab.eurecom.fr:443 2>/dev/null |
sed -ne '/-BEGIN CERTIFICATE-/,/-END CERTIFICATE-/p' >> /etc/ssl/certs/ca-certificates.crt
```

Important!

In this document OPENAIRCN_DIR is the path to the EPC source code top directory (i.e. openair-cn working directory).

2.2.1 Get the code without login

In order to checkout the Git repository (for OAI Users without login to gitlab server)

```
user@host:~ git clone https://gitlab.eurecom.fr/oai/openair-cn.git
```

2.2.2 Get the code with login (contributors)

In order to check out the Git repository (for OAI Developers/admins with login to gitlab server)
Please send an email to openair_tech@eurecom.fr to be added to the repository as a developer (only important for users who want to commit code to the repository). If you do not have an account on gitlab.eurecom.fr, please register yourself to gitlab.eurecom.fr.

Checkout with using ssh keys:

You will need to put your ssh keys in https://gitlab.eurecom.fr/profile/keys to access to the git repo. Once that is done, checkout the git repository using:

```
git clone git@gitlab.eurecom.fr:oai/openair-cn.git
```

Checkout with user name/password prompt:

```
git clone https://YOUR_USERNAME@gitlab.eurecom.fr/oai/openair-cn.git
```

2.3 Additional software

Some software installations have to be done prior to build the core network entities.

Please find for information, bellow a summary of third party software included in source tree or that must be installed prior to EPC components compilation.

Installed software	MME entity	S/P-GW entity	HSS entity	Licence
UBUNTU packages	**Removed packages:** libgnutls-dev 'libgnutlsxx2?' nettle-dev nettle-bin. **build/dev/debug tools:** autoconf automake bison build-essential cmake cmake-curses-gui doxygen doxygen-gui flex gccxml gdb git pkg-config subversion valgrind Kcachegrind. **Network tools:** ethtool iperf iproute vlan tshark **Libraries:** guile-2.0-dev libconfig8-dev libgcrypt11-dev libgmp-dev libhogweed2 libgtk-3-dev libidn2-0-dev libidn11-dev libpthread-stubs0-dev libsctp1 libsctp-dev libssl-dev libtool libxml2 libxml2-dev mscgen openssl python. **Others:** check phpmyadmin python-dev python-pexpect unzip	**build/dev/debug tools:** autoconf, automake, bison, build-essential, cmake, cmake-curses-gui, doxygen, doxygen-gui, flex, gccxml, gdb, git, pkg-config, subversion. **Removed packages:** libgnutls-dev 'libgnutlsxx2?' nettle-dev nettle-bin.	**Removed packages:** libgnutls-dev 'libgnutlsxx2?' nettle-dev nettle-bin. **build/dev/debug tools:** autoconf automake bison build-essential cmake cmake-curses-gui doxygen doxygen-gui flex gdb pkg-config. git subversion. **Libraries:** libconfig8-dev libgcrypt11-dev libidn2-0-dev libidn11-dev libmysqlclient-dev libpthread-stubs0-dev libsctp1 libsctp-dev libssl-dev libtool mysql-client mysql-server openssl. **Others:** phpmyadmin python-pexpect	...
Nettle (ftp://ftp.lysator.liu.se/pub/security/lsh/nettle-2.5.tar.gz)	Yes **Dependancy:** autoconf automake build-essential libgmp-dev.	No	Yes	LGPL
Gnutls (ftp://ftp.gnutls.org/gcrypt/gnutls/v3.1/gnutls-3.1.23.tar.xz)	Yes **Dependancy:** autoconf automake build-essential libtasn1-6-dev libtasn1-6-dbg libp11-kit-dev libp11-kit0-dbg libtspi-dev libtspi1 libidn2-0-dev libidn11-dev	No	Yes	LGPLv2.1+

Installed software	MME entity	S/P-GW entity	HSS entity	Licence
FreeDiameter (http://www.freediameter.net/hg/freeDiameter/archive/1.2.0.tar.gz)	Yes **Dependancy:** autoconf automake bison build-essential cmake cmake-curses-gui debhelper flex g++ gcc gdb libgcrypt-dev libidn11-dev libmysqlclient-dev libpq-dev libsctp1 libsctp-dev libxml2-dev mercurial python-dev ssl-cert swig	No	Yes	BSD 3 clause license. Check subdirs for copyright informations: extensions/dict_sip/* extensions/app_sip/* extensions/app_radgw/rgwx_sip.c extensions/app_diameap/* extensions/dict_mip6a/* extensions/dict_mip6i/* extensions/dict_nas_mipv6/* extensions/dict_rfc5777/*
Asn1c **(**https://github.com/vlm/asn1c/trunk revision 1516**)**	Yes **Dependancy:** autoconf automake bison build-essential flex gcc libtool	No	No	BSD 2-Clause Licence
SRC/UTILS/**tree.h**	Yes	Yes	No	BSD 2-Clause Licence
SRC/UTILS/**queue.h**	Yes	Yes	No	BSD 3-Clause Licence
SRC/UTILS/LFDS/**liblfds6.1.1.** **(**http://liblfds.org/**)**	Yes	Yes	No	No license
SRC/**GTPV2-C/nwgtpv2c-0.11**	Yes	Yes	No	Free licence
xtables_addons patched for OAI (https://gitlab.eurecom.fr/oai/xtables-addons-oai.git)	No	Yes **Dependancy:** autoconf automake build-essential dkms iptables iptables-dev linux-headers. Run a kernel version equal to 3.19 (we use 3.19.0-28)	No	GPLv2
The Better String Library (http://bstring.sourceforge.net/)	Yes	Yes	No	BSD 3-Clause Licence
Libgtpnl (http://git.osmocom.org/libgtpnl/)	No	Yes	No	GNU LESSER GENERAL PUBLIC LICENSE Version 2.1

Table 1: 3rd party software

These softwares will mostly be installed by helper scripts, this will be described in following sections.

2.4 HSS

2.4.1 HSS pre-installation

In OPENAIRCN_DIR/SCRIPTS directory, execute the following command:

```
user@hss-host:~/openair-cn/SCRIPTS$ ./build_hss -i
```

This command will install the required softwares on your host.

Find bellow some hints for some interactive software installations (mysql-server, phpmyadmin).

2.4.1.1 Mysql server installation

Enter here a password for root user, lets call it MS_PW_ROOT.

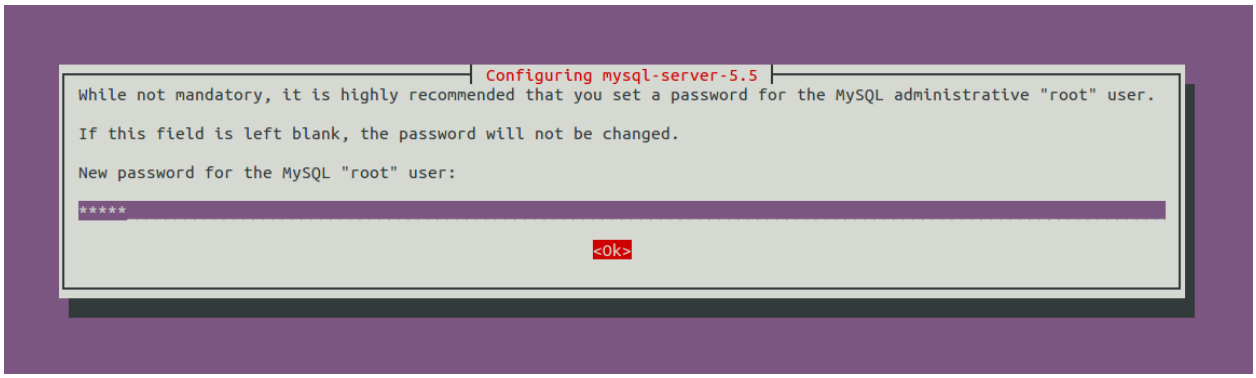


Figure 3 Mysql installation root password

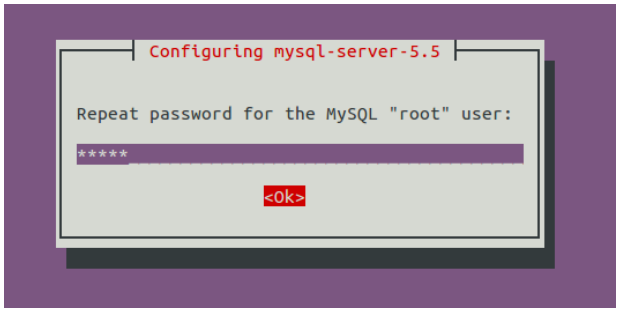


Figure 4 Mysql installation root password repeat

The mysql-server installation process ends here.

2.4.1.2 Phpmyadmin installation details

You should prefer the easiest way

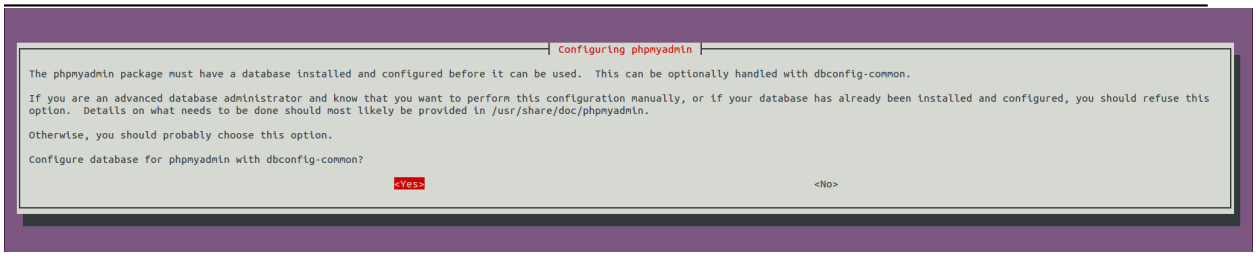


Figure 5 Phpmyadmin installation conf DB

Enter here the MS_PW_ROOT.:

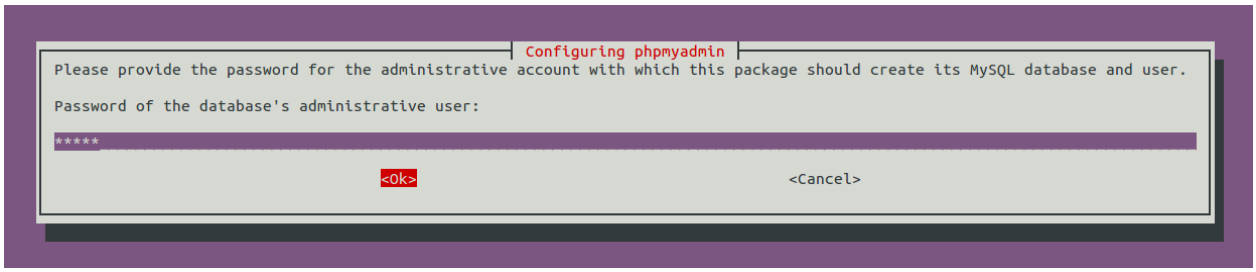


Figure 6 Phpmyadmin installation DB admin password

Please, enter here what will be the phpmyadmin application password, lets call it MS_PW_PHP:

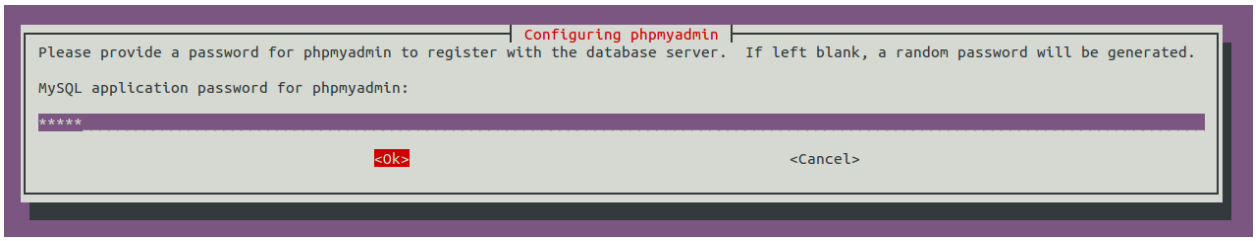


Figure 7 Phpmyadmin installation application password

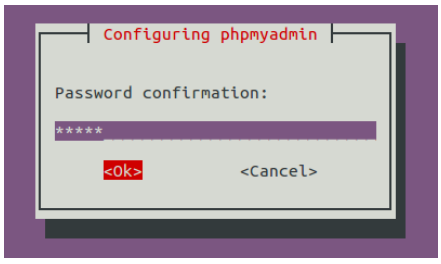


Figure 8 Phpmyadmin installation application password confirmation

Choose the web server that has to be configured: Apache.

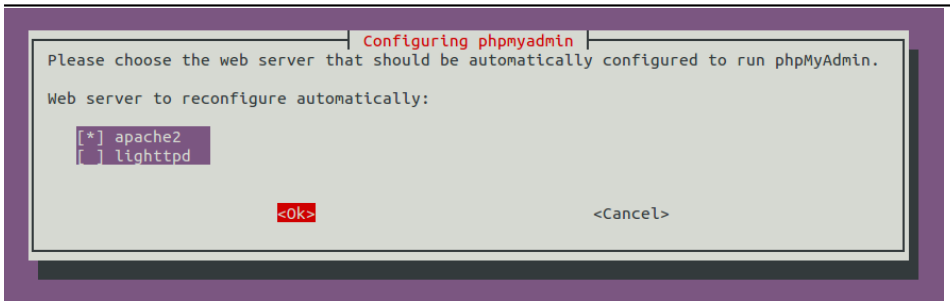


Figure 9 Phpmyadmin installation web server selection

2.4.2 HSS configuration

In this section is describd the step by step configuration of the HSS, any parameter can be customized upon your need (mysql server address, mySQL user name, mySQL password, HSS OP key, location of freeDiameter configuration file, realm).

A template of the HSS configuration file can be found at OPENAIRCN_DIR/ETC/hss.conf. This configuration file follows the libconfig file syntax (http://www.hyperrealm.com/libconfig).

Content of OPENAIRCN_DIR/ETC/hss.conf:

```
HSS :
{
## MySQL mandatory options
MYSQL_server = "127.0.0.1";
MYSQL_user   = "@MYSQL_user@";
MYSQL_pass   = "@MYSQL_pass@";
MYSQL_db     = "oai_db";

## HSS options
OPERATOR_key = "1006020f0a478bf6b699f15c062e42b3"; # OP key for oai_db.sql

RANDOM = "true";

## Freediameter options
FD_conf = "/usr/local/etc/oai/freeDiameter/hss_fd.conf";
};
```

2.4.2.1 Step 1

Copy the file OPENAIRCN_DIR/ETC/hss.conf in /usr/local/etc/oai directory:

```
user@hss-host:~/openair-cn/SCRIPTS$ sudo mkdir -p /usr/local/etc/oai/freeDiameter
user@hss-host:~/openair-cn/SCRIPTS$ sudo cp $OPENAIRCN_DIR/ETC/hss.conf \
/usr/local/etc/oai
```

Please take care of the permissions of your hss.conf file.

Then customize your copied HSS configuration file:

Parameter	Type	
MYSQL_server	String	IP address of the MySQL server instance where the HSS DB is stored.
MYSQL_user	String, user login	HSS administrator login, could be “hssadmin”.

MYSQL_pass	String, password	HSS administrator password, should be MS_PW_PHP.
MYSQL_db	String, database name	Database name, default is oai_db for EURECOM subscribers.
OPERATOR_key	String	Operator key in plain text.
RANDOM	String, allowed values “yes”, “no”.	Default value is “true”. Set false when you want to capture or replay S1-C scenarios.
FD_conf	String	Path to HSS freeDiameter configuration file.

Table 2: HSS configuration fields

2.4.2.2 Step 2

Copy the files OPENAIRCN_DIR/ETC/hss_fd.conf, OPENAIRCN_DIR/ETC/acl.conf in /usr/local/etc/oai/freeDiameter directory:

```
user@hss-host:~/openair-cn/SCRIPTS$ sudo cp $OPENAIRCN_DIR/ETC/acl.conf $OPENAIRCN_DIR/ETC/hss_fd.conf /usr/local/etc/oai/freeDiameter
```

Please take care of the permissions of your configuration files.

Then customize your copied hss_fd.conf, acl.conf configuration files if necessary, if you follow this document, it should not be necessary, otherwise please refer to freeDiameter documentation.

2.4.2.3 Step 3

A FQDN has to be set for the HSS (see hss_fd.conf). An easy way to do that is to fill this FQDN in the /etc/hosts file:

For example on a host with hostname 'yang':

```
yang@yang:$ cat /etc/hosts
127.0.0.1       localhost
127.0.1.1       yang.openair4G.eur yang  #Your hostname here
127.0.1.1       hss.openair4G.eur hss
```

2.4.2.4 Step 4

Generate HSS certificates:

```
user@hss-host:~/openair-cn/SCRIPTS$ ./check_hss_s6a_certificate /usr/local/etc/oai/freeDiameter hss.openair4G.eur
```

2.4.3 HSS build

HSS can be built in two different ways: an executable that can run in a controlling terminal, or a daemon that run in the background.

In OPENAIRCN_DIR/SCRIPTS directory, depending on the chosen target execute the following command:

```
user@hss-host:~/openair-cn/SCRIPTS$ ./build_hss --clean --debug
```

or

```
user@hss-host:~/openair-cn/SCRIPTS$ ./build_hss --clean --debug --daemon
```

This command will compile the right target oai_hss or oai_hssd.

2.4.4 HSS run

In OPENAIRCN_DIR/SCRIPTS directory, a helper script called run_hss is provided for running the HSS.

Here are the run_hss options:

```
./run_hss -h

Usage: run_hss [OPTION]...
Run the HSS executable (experimental).

Options:
Mandatory arguments to long options are mandatory for short options too.
  -c, --config-file filename      Config file to be used by HSS if you don't want to use the default one: /usr/local/etc/oai/hss.conf
  -e, --export-db  filename       Export current database to a SQL file, file prefix is $OPENAIRCN_DIR/SRC/OAI_HSS/db. (useful for replaying test scenarios)
  -D, --daemon                    Run the daemon.
  -i, --import-db   filename      Import SQL file to current database, file prefix is $OPENAIRCN_DIR/SRC/OAI_HSS/db. (useful for replaying test scenarios or restoring original database content)
  -I, --install-hss-files         Install HSS config files.
  -g, --gdb                       Run with GDB.
  -h, --help                      Print this help.
  -k, --kill                      Kill the running local HSS.
```

2.4.4.1 First run

2.4.4.1.1 Customize HSS database content

SQL operations (display, update, export, etc) can be done easily with the help of phpMyAdmin, you have to open the following URL with your browser: http://yourhsshost/phpmyadmin.

Otherwise you can use any other MySQL tool, script compatible with MySQL.

The steps for adding a subscriber are the following:

- Add your MME(s) in table mmeidentity

- Add subscriber(s) in table users

    user.imsi=IMSI of your USIM.

    user.msisdn= MSISDN of your USIM (unused).

    users.imei=NULL

    users.imei_sv=NULL

    users.ms_ps_status=’PURGED’

    users.rau_tau_timer=120

    users.ue_ambr_ul=50000000

    users.ue_ambr_dl=100000000

    users.access_restriction=47

    users.mme_cap=0

users.mmeidentity_idmmeidentity=’your MME key’

users.RFSP-Index=1

users.urrp_mme=0

users.sqn=’your USIM programmed SQN’

users.rand=0

users.OPc=’the OPc key’ (will be computed by the oai_hss executable)

- Add subscriber(s) in table pdn.

Table mmeidentity:

Structure:

Field	Type	Null	Key	Default	Extra
idmmeidentity	int(11)	NO	PRI	NULL	auto_increment
mmehost	varchar(255)	YES		NULL	
mmerealm	varchar(200)	YES		NULL	
UE-Reachability	tinyint(1)	NO		NULL	

Table 3: SQL Table structure mmeidentity

Column idmmeIdentity is the primary key of a MME.

Column mmehost contains the FQDN of a MME.

Column mmerealm contains the realm of a MME.

Example of content:

```
+---------------+------------------------+---------------+-----------------+
| idmmeidentity | mmehost                | mmerealm      | UE-Reachability |
+---------------+------------------------+---------------+-----------------+
|             2 | yang.openair4G.eur     | openair4G.eur |               0 |
|             1 | ng40-erc.openair4G.eur | openair4G.eur |               0 |
|             3 | ABEILLE.openair4G.eur  | openair4G.eur |               0 |
+---------------+------------------------+---------------+-----------------+
```

Table pdn:

This table contains mainly the association between a subscriber (users_imsi) and a APN (apn), and its QOS parameters.

Structure:

Field	Type	Null	Key	Default	Extra
id	int(11)	NO	PRI	NULL	auto_increment
apn	varchar(60)	NO		NULL	
pdn_type	enum('IPv4','IPv6','IPv4v6','IPv4_or_IPv6')	NO		NULL	
pdn_ipv4	varchar(15)	YES		NULL	0.0.0.0
pdn_ipv6	varchar(45)	YES		NULL	0:0:0:0:0:0:0:0
aggregate_ambr_ul	int(10) unsigned	YES		50000000	
aggregate_ambr_dl	int(10) unsigned	YES		100000000	

pgw_id	int(11)	NO	PRI	NULL	
users_imsi	varchar(15)	NO	PRI		
qci	tinyint(3) unsigned	NO		9	
priority_level	tinyint(3) unsigned	NO		15	
pre_emp_cap	enum('ENABLED','DISABLED')	YES		DISABLED	
pre_emp_vul	enum('ENABLED','DISABLED')	YES		DISABLED	
LIPA-Permissions	enum('LIPA-prohibited','LIPA-only','LIPA-conditional')	YES		LIPA-only	

Table 4: SQL Table structure pdn

Column id is the primary key of a pdn entry.

Column pdn_type contains the type of PDN, actually only IPv4 is supported.

Column pdn_ipv4 contains the IPv4 address of the PDN (unused).

Column pdn_ipv6 contains the IPv6 address of the PDN (unused).

Column aggregate_ambr_ul TODO

Column aggregate_ambr_dl TODO

Column pgw_id TODO

Column users_imsi TODO

Column qci TODO

Column priority_level TODO

Column pre_emp_capability TODO

Column pre_emp_vulnerability TODO

Column LIPA_Permissions TODO

Table users

This table contains mainly the informations about a subscriber: its IMSI, IMEI, key LTE K, SQN, operator key OP, QOS parameters, the last known MME identity where the subscriber registered.

Structure:

Field	Type	Null	Key	Default	Extra
imsi	varchar(15)	NO	PRI	NULL	
msisdn	varchar(46)	YES		NULL	
imei	varchar(15)	YES		NULL	
imei_sv	varchar(2)	YES		NULL	
ms_ps_status	enum('PURGED','NOT_PURGED')	YES		PURGED	
rau_tau_timer	int(10) unsigned	YES		120	
ue_ambr_ul	bigint(20) unsigned	YES		50000000	
ue_ambr_dl	bigint(20) unsigned	YES		100000000	
access_restriction	int(10) unsigned	YES		60	
mme_cap	int(10) unsigned zerofill	YES		NULL	
mmeidentity_idmmeidentity	int(11)	NO	PRI	0	
key	varbinary(16)	NO		0	
RFSP-Index	smallint(5) unsigned	NO		1	

urrp_mme	tinyint(1)	NO		0	
sqn	bigint(20) unsigned zerofill	NO		NULL	
rand	varbinary(16)	NO		NULL	
OPc	varbinary(16)	YES		NULL	

Table 5: SQL Table structure users

TODO column description.

2.4.4.2 Later runs

By default (otherwise you know what you are doing) for all following runs of the HSS, use:

```
user@hss-host:~/openair-cn/SCRIPTS$ ./run_hss
```

or

```
user@hss-host:~/openair-cn/SCRIPTS$ ./run_hss --daemon
```

2.5 MME

2.5.1 MME pre-installation

In OPENAIRCN_DIR/SCRIPTS directory, execute the following command:

```
user@mme-host:~/openair-cn/SCRIPTS$ ./build_mme -i
```

This command will install the required softwares on your host.

2.5.2 MME configuration

A template of the MME configuration file can be found at OPENAIRCN_DIR/ETC/mme.conf. This configuration file follows the libconfig file syntax (http://www.hyperrealm.com/libconfig).

2.5.2.1 Step 1

Copy the file OPENAIRCN_DIR/ETC/mme.conf in /usr/local/etc/oai directory:

```
user@mme-host:~/openair-cn/SCRIPTS$ sudo mkdir -p /usr/local/etc/oai/freeDiameter
user@mme-host:~/openair-cn/SCRIPTS$ sudo cp $OPENAIRCN_DIR/ETC/mme.conf /usr/local/etc/oai
```

Please take care of the permissions of your mme.conf file.

Then customize your copied MME configuration file:

2.5.2.2 MME section

Parameter	Type	
RUN_MODE	String	Allowed values: “OTHER”, “TEST”. Set “OTHER” for normal operations, set “TEST” for S1C scenario player.
REALM	String	Diameter realm of the MME, default is openair4G.eur.
MAXENB	Num/Integer	Maximum number of eNB that can connect to MME.
MAXUE	Num/Integer	For debug purpose, used to restrict the number of served UEs the MME can handle.
RELATIVE_CAPACITY	Num/Integer	Even though this parameter is not used by the MME for controlling the MME load balancing within a pool (at least for now), the parameter has to be forwarded to the eNB during association procedure. Values going from 0 to 255, (Default value is 15)
MME_STATISTIC_TIMER	Num/Integer	Displayed statistic period in logs.
EMERGENCY_ATTACH_SUPPORTED	String	Actually only “no” is supported
UNAUTHENTICATED_IMSI_SUPPORTED	String	Actually only “no” is supported
EPS_NETWORK_FEATURE_SUPPORT_IMS_VOICE_OVER_PS_SESSION_IN_S1	String	Actually only “no” is supported
EPS_NETWORK_FEATURE_SUPPORT_EMERGENCY_BEARER_SERVICES_IN_S1_MODE	String	Actually only “no” is supported
EPS_NETWORK_FEATURE_SUPPORT_LOCATION_SERVICES_VIA_EPC	String	Actually only “no” is supported

EPS_NETWORK_FEATURE_SUPPORT_EXTENDED_SERVICE_REQUEST	String	Actually only “no” is supported
IP_CAPABILITY	String	Actually only IPV4 is supported, (Choice between IPV4, IPV4V6, IPV4ORV6)

Table 6: MME configuration main section

2.5.2.2.1 INTERTASK_INTERFACE subsection

Parameter	Type	
ITTI_QUEUE_SIZE	Num/Integer	Upper bound for the message queue size expressed in bytes (all messages exchanged by tasks have the same size). Restrict the number of messages in queues or detect a possible MME overload.

Table 7: MME configuration subsection ITTI

2.5.2.2.2 S6A subsection

Parameter	Type	
S6A_CONF	String	FreeDiameter MME config file path, default value is “/usr/local/etc/oai/freeDiameter/mme_fd.conf”.
HSS_HOSTNAME	String	HSS hostname, default value is “hss”.

Table 8: MME configuration subsection S6a

2.5.2.2.3 SCTP subsection

Parameter	Type	
SCTP_INSTREAMS	Num/Integer	Maximum number of SCTP input streams allowed for a S1-C connection.
SCTP_OUTSTREAMS	Num/Integer	Maximum number of SCTP output streams allowed for a S1-C connection.

Table 9: MME configuration subsection SCTP

2.5.2.2.4 S1AP subsection

Parameter	Type	
S1AP_OUTCOME_TIMER	Num/Integer	Once an outcome is sent from MME to eNB, the MME locally starts a timer to abort the procedure and release UE context if the expected answer to this outcome is not received at the expiry of this timer. This timer is expressed in seconds. (Default value = 5 seconds)

Table 10: MME configuration subsection S1AP

2.5.2.2.5 GUMMEI LIST subsection

This section contains the GUMMEIs of the MME, actually only one GUMMEI is supported.

Parameter	Type	
{MCC, MNC, MME_GID, MME_CODE}	String/String/String/String	Mobile country code of GUMMEI, Mobile network code of GUMMEI, MME group ID of GUMMEI, MME code of GUMMEI

Table 11: MME configuration subsection GUMMEI

2.5.2.2.6 TAI LIST subsection

The content of this section should be consistent with content of GUMMEI LIST section (MCC/MNC)

Parameter	Type	
{MCC/MNC/TAC}	String/String/String	Each entry of the list is a triplet of a MCC, MNC and TAC. There can be up to 16 tracking areas identity set in this list. Actually we do not support shared networks, so the MCC/MNC field should all be equal among the list

Table 12: MME configuration subsection TAI LIST

2.5.2.2.7 NAS subsection

Parameter	Type	
ORDERED_SUPPORTED_INTEGRITY_ALGORITHM_LIST	Array of String	Preference list in decreasing order of supported integrity algorithms, actually supported integrity algorithms are EIA0, EIA1, EIA2
ORDERED_SUPPORTED_CIPHERING_ALGORITHM_LIST	Array of String	Preference list in decreasing order of supported integrity algorithms, actually supported integrity algorithms are EEA0, EEA1, EEA2
T3402	Integer	EMM timer, duration in minutes.
T3412	Integer	EMM timer, duration in minutes.
T3485	Integer	ESM timer, duration in seconds, unused (TODO).
T3486	Integer	ESM timer, duration in seconds, unused (TODO).
T3489	Integer	ESM timer, duration in seconds, unused (TODO).
T3495	Integer	ESM timer, duration in seconds, unused (TODO).

Table 13: MME configuration subsection NAS

2.5.2.2.8 Network interfaces subsection

Parameter	Type	
MME_INTERFACE_NAME_FOR_S1_MME	String	Interface name for S1-MME (S1-C), this interface name can be a real ethernet interface or a virtual ethernet interface. The script run_mme can configure it and bring it up if you provide the -i/--set-nw-interfaces option.
MME_IPV4_ADDRESS_FOR_S1_MME	String, CIDR	Binded address for S1-MME
MME_INTERFACE_NAME_FOR_S11_MME	String	Interface name for S11, this interface name can be a real ethernet interface or a virtual ethernet interface. The script run_mme can configure it and bring it up if you provide the -i/--set-nw-interfaces option.
MME_IPV4_ADDRESS_FOR_S11_MME	String, CIDR	Binded address for S11.

Table 14: MME configuration subsection Network Interfaces

2.5.2.2.9 Logging subsection

Parameter	Type	
OUTPUT	String	choice in { "CONSOLE", "UNBUFFERED_CONSOLE", "`path to file`", "`IPv4@`:`TCP port num`"}. Choise "CONSOLE" means that logs go to STDOUT, STDERR in a manner that even if multiple concurrent threads dump a lot of logs, traces cannot

		overlap (the cost here is that we need buffering). Choice "UNBUFFERED_CONSOLE" means that logs go directly to STDOUT, STDERR, traces may overlap. Choice "`path to file`", for example “/tmp/mme.log” is a file receiving the dump of logs without overlaping traces. Choice "`IPv4@`:`TCP port num`" (for example “192.168.12.17:6789”) dump the logs towards a TCP server. The logs cat be easily displayed or dumped into a file with netcat (nc -kl 6789).
COLOR	String	Choice in { "yes", "no" } means use of ANSI styling codes or no. TODO
SCTP_LOG_LEVEL	String	Log level choice in { "EMERGENCY", "ALERT", "CRITICAL", "ERROR", "WARNING", "NOTICE", "INFO", "DEBUG", "TRACE"}
S1AP_LOG_LEVEL	String	Idem as above
NAS_LOG_LEVEL	String	Idem as above
MME_APP_LOG_LEVEL	String	Idem as above
S6A_LOG_LEVEL	String	Idem as above
UTIL_LOG_LEVEL	String	Idem as above
MSC_LOG_LEVEL	String	Idem as above
ITTI_LOG_LEVEL	String	Idem as above
ASN1_VERBOSITY	String	Choice in {“none”, “info”, “annoying”}

Table 15: MME configuration subsection Network Interfaces

2.5.2.3 SGW section

The PGW, SGW selections are not implemented yet, so we need a mechanism that replace these selection: yet, we only support one PDN, one PGW, one SGW.

2.5.2.3.1 Network interfaces subsection

Parameter	Type	
SGW_IPV4_ADDRESS_FOR_S11	String, CIDR	Binded SGW address for S11.

Table 16: MME configuration section SGW

2.5.2.4 Step 2

Copy the file OPENAIRCN_DIR/ETC/mme_fd.conf in /usr/local/etc/oai/freeDiameter directory:

```
user@hss-host:~/openair-cn/SCRIPTS$ sudo mkdir -p /usr/local/etc/oai/freeDiameter
user@hss-host:~/openair-cn/SCRIPTS$ sudo cp $OPENAIRCN_DIR/ETC/mme_fd.conf /usr/local/etc/oai/freeDiameter
```

Please take care of the permissions of your configuration files.

Then customize your copied mme_fd.conf configuration files (Identity value, realm), please refer to freeDiameter documentation.

2.5.2.5 Step 3

A FQDN has to be set for the MME (see mme_fd.conf). An easy way to do that is to set this FQDN in the /etc/hosts file:

For example on a host with hostname 'yang':

```
yang@yang:$ cat /etc/hosts
```

```
127.0.0.1       localhost
127.0.1.1       yang.openair4G.eur yang # MME host
127.0.1.1       hss.openair4G.eur hss # HSS located on MME host
```

2.5.3 MME build

MME can be built in two different ways: an executable that can run in a controlling terminal, or a daemon that run in the background.

In OPENAIRCN_DIR/SCRIPTS directory, depending on the chosen target execute the following command:

```
user@mme-host:~/openair-cn/SCRIPTS$ ./build_mme --clean
```

or

```
user@mme-host:~/openair-cn/SCRIPTS$ ./build_mme --clean  --daemon
```

This command will compile the right target oai_mme or oai_mmed.

2.5.4 Before MME first run

Prior the first run of the MME, you will have to generate certificates:

```
user@hss-host:~/openair-cn/SCRIPTS$./check_mme_s6a_certificate
/usr/local/etc/oai/freeDiameter yang.openair4G.eur
```

2.5.5 MME run

In OPENAIRCN_DIR/SCRIPTS directory, a helper script called run_mme is provided for running the MME.

```
user@hss-host:~/openair-cn/SCRIPTS$ ./run_mme
```

or

```
user@hss-host:~/openair-cn/SCRIPTS$ ./run_mme --daemon
```


2.6 SP_GW

2.6.1 SP-GW pre-installation

First install a 4.7 linux kernel, even from source from kernel.org, then select gtp to be compiled as a module, and install the kernel and modules and boot on the 4.7 kernel

For example only

in your linux 4.7+ source tree:

make oldconfig

in .config, check that gtp is built as a module : CONFIG_GTP=m

make -jX

make modules_install

make install

Install libgtpnl from http://git.osmocom.org/libgtpnl/ and any software dependancy.

In OPENAIRCN_DIR/SCRIPTS directory, execute the following command:

```
user@mme-host:~/openair-cn/SCRIPTS$ ./build_spgw -i
```

This command will install the required softwares on your host.

2.6.2 SP-GW configuration

A template of the SP-GW configuration file can be found at OPENAIRCN_DIR/ETC/spgw.conf. This configuration file follows the libconfig file syntax (http://www.hyperrealm.com/libconfig).

2.6.2.1 Step 1

Copy the file OPENAIRCN_DIR/ETC/mme.conf in /usr/local/etc/oai directory:

```
user@mme-host:~/openair-cn/SCRIPTS$ sudo mkdir -p /usr/local/etc/oai
user@mme-host:~/openair-cn/SCRIPTS$ sudo cp $OPENAIRCN_DIR/ETC/spgw.conf /usr/local/etc/oai
```

Please take care of the permissions of your spgw.conf file.

Then customize your copied SP-GW configuration file:

2.6.2.2 SGW section

2.6.3 Network interfaces section

Parameter	Type	
SGW_INTERFACE_NAME_FOR_S11	String	Interface name for S11.
SGW_IPV4_ADDRESS_FOR_S11	String, CIDR notation	Binded address for S11.
SGW_INTERFACE_NAME_FOR_S1U_S12_S4_UP	String	Interface name for S1-U, this interface name can be a real

		ethernet interface or a virtual ethernet interface. The script run_spgw can configure it and bring it up if you provide the -i/--set-nw-interfaces option.
SGW_IPV4_ADDRESS_FOR_S1U_S12_S4_UP	String, CIDR notation	Binded address for S1-U
SGW_IPV4_PORT_FOR_S1U_S12_S4_UP	Num/Integer	Port number for S1-U (IANA), Should be 2152
SGW_INTERFACE_NAME_FOR_S5_S8_UP	String,	Interface name for S5 or S8, set to “none” because unused
SGW_IPV4_ADDRESS_FOR_S5_S8_UP	String, CIDR notation	Binded address for S5 or S8, set to 0.0.0.0/xx because unused

Table 17: S-GW configuration subsection Network Interfaces

2.6.3.1.1 INTERTASK_INTERFACE subsection

Parameter	Type	
ITTI_QUEUE_SIZE	Num/Integer	Upper bound for the message queue size expressed in bytes (all messages exchanged by tasks have the same size). Restrict the number of messages in queues or detect a possible overload.

Table 18: MME configuration subsection ITTI

2.6.3.1.2 Logging subsection

Parameter	Type	
OUTPUT	String	choice in { "CONSOLE", "SYSLOG", "`path to file`", "`IPv4@`:`TCP port num`"}. Choise "CONSOLE" means that logs go to STDOUT, STDERR. Choice "`path to file`", for example “/tmp/spgw.log” is a file receiving the dump of logs. Choice "`IPv4@`:`TCP port num`" (for example “192.168.12.18:6789”) dump the logs towards a TCP server. The logs cat be easily displayed or dumped into a file with netcat (nc -kl 6789).
THREAD_SAFE	String	Choice in { "yes", "no" }, yes means that logs cannot overlaps on output.
COLOR	String	Choice in { "yes", "no" } means use of ANSI styling codes or no. TODO
UDP_LOG_LEVEL	String	Log level choice in { "EMERGENCY", "ALERT", "CRITICAL", "ERROR", "WARNING", "NOTICE", "INFO", "DEBUG", "TRACE"}
GTPV1U_LOG_LEVEL	String	Idem as above
GTPV2C_LOG_LEVEL	String	Idem as above
SPGW_APP_LOG_LEVEL	String	Idem as above
S11_LOG_LEVEL	String	Idem as above

Table 19: MME configuration subsection Network Interfaces

2.6.3.2 PGW section

2.6.3.2.1 Main section

Parameter	Type	
DEFAULT_DNS_IPV4_ADDRESS	String, IPv4 dot decimal	IPv4 address of primary default DNS that can be queried by UEs
DEFAULT_DNS_SEC_IPV4_ADDRESS	String, IPv4 dot decimal	IPv4 address of secondary default DNS that can be queried by UEs
FORCE_PUSH_PROTOCOL_CONFI	String	Non standard feature, normally should be set to "no", but you may need to

GURATION_OPTIONS		set to yes for UE that do not explicitly request a PDN address through NAS signalling, MTU, DNS are also pushed even if not requested.
UE_MTU	Integer	UE MTU to be pushed in protocol configuration options if option "**FORCE_PUSH_PROTOCOL_CONFIGURATION_OPTIONS**"is set to "yes"

Table 20: P-GW configuration main section

2.6.3.2.2 Network interfaces section

Parameter	Type	
PGW_INTERFACE_NAME_FOR_S5_S8	String	Interface name for S5 or S8, "none" because unused
PGW_INTERFACE_NAME_FOR_SGI	String	Interface name for SGi
PGW_MASQUERADE_SGI	String	Should outgoing UE IPv4 traffic be masqueraded (source NAT), "yes" or "no".
UE_TCP_MSS_CLAMPING	String	Choice in { "yes", "no" }, "yes" should be choose if you are unable to set the MTU on the S1U path to a value greater or equal to 1536. If set to "yes", then **PGW_INTERFACE_NAME_FOR_S5_S8** should be set to the same value as **SGW_IPV4_PORT_FOR_S1U_S12_S4_UP.**

Table 21: P-GW configuration subsection Network Interfaces

2.6.3.2.3 IP Address Pool section

Parameter	Type	
IPV4_LIST	String, CIDR notation	List of IPv4 netmasks that designate a list of available IPv4 addresses for Ues. Actually only one pool of IP addresses is supported.

Table 22: P-GW configuration subsection IP Address Pool Selection

2.6.4 `SPGW run`

In OPENAIRCN_DIR/SCRIPTS directory, a helper script called run_spgw is provided for running the SPGW.

```
user@hss-host:~/openair-cn/SCRIPTS$ ./run_spgw -r
```

or

```
user@hss-host:~/openair-cn/SCRIPTS$ ./run_spgw -r --daemon
```

3 Supported scenarios in EPC

3.1 E-UTRAN Initial attach

3.1.1 Attach with IMSI

TODO Add MSCGEN SEQ diagram

3.1.2 Attach with GUTI

TODO Add MSCGEN SEQ diagram

3.2 Tracking Area Update procedures

TODO Add MSCGEN SEQ diagram

3.3 Routing Area Update procedures

Not supported yet.

3.4 Service Request procedures

3.4.1 UE triggered Service Request

TODO Add MSCGEN SEQ diagram

3.4.2 Network triggered Service Request

Not supported yet.

3.5 S1 Release procedure

TODO Add MSCGEN SEQ diagram

3.6 GUTI Reallocation procedure

Not supported yet.

3.7 Detach procedure

3.7.1 UE-Initiated Detach procedure for E-UTRAN

TODO Add MSCGEN SEQ diagram

3.7.2 MME-Initiated Detach procedure for E-UTRAN

3.7.3 HSS-Initiated Detach procedure for E-UTRAN

Not supported.

3.8 HSS User Profile management function procedure

Not supported.

3.9 Bearer deactivation

3.9.1 PDN GW initiated bearer deactivation

Not supported

3.9.2 MME initiated Dedicated Bearer Deactivation

Not supported yet

3.10 Intra E-UTRAN handover

Not supported yet

4 Annex A: Tools for observing, debugging.

4.1 Wireshark/tshark

You can launch wireshark instances on S1 (filter s1ap, gtpu), S6A (filter diameter, if TCP is the undelying protocol, you can select a TCP packet relative to the DIAMETER exchange and the select decode as DIAMETER).

4.2 Mscgen

Extract from http://www.mcternan.me.uk/mscgen/: “Mscgen is a small program that parses Message Sequence Chart descriptions and produces PNG, SVG, EPS or server side image maps (ismaps) as the output. Message Sequence Charts (MSCs) are a way of representing entities and interactions over some time period”…” Mscgen aims to provide a simple text language that is clear to create, edit and understand, which can also be transformed into common image formats for display or printing.”…

Openair use mscgen to offer another view of events (SDUs, timers, etc) that happens inside an executable and also (still under development) PDUs exchanged between protocol entities.

Openair HSS don't have the msgen feature.

Important:
Check that mscgen traces are configured for being generated (CFLAG MESSAGE_CHART_GENERATOR set to true in OPENAIRCN_DIR/BUILD/MME/CMakeLists.template)
You have to instruct the mme executable to dump the ITTI messages to a file with the argument -m *path_to_directory*. The mscgen files will be located under the specified directory, in a directory containing the time of the generated traces (text and png files).

Example:

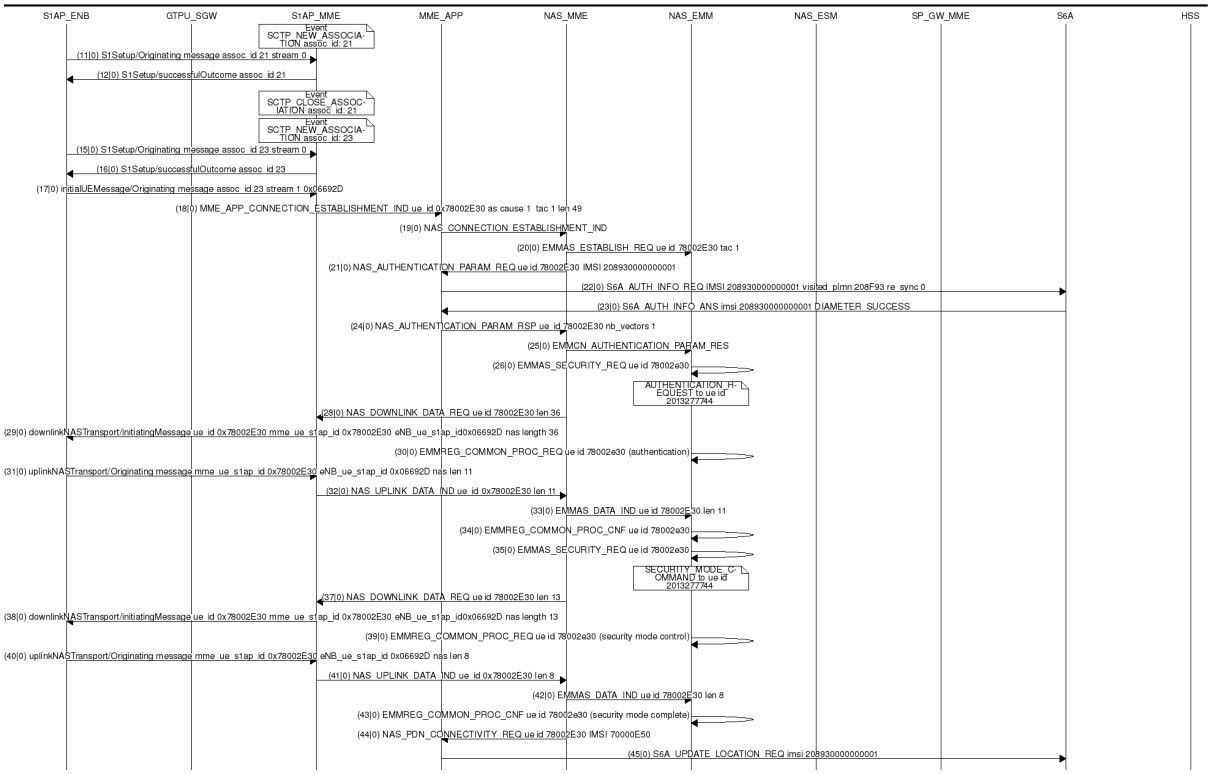


Figure 9 Mscgen output example

4.3 S1AP scenario replay

The aim of this tool is helping for MME bug reports, MME development, non-regression test, debug purpose, it allows to replay without the help of any eNB(s) or UE(s) a S1AP scenario previously captured as a pcap dumped file.

4.3.1 Overall process

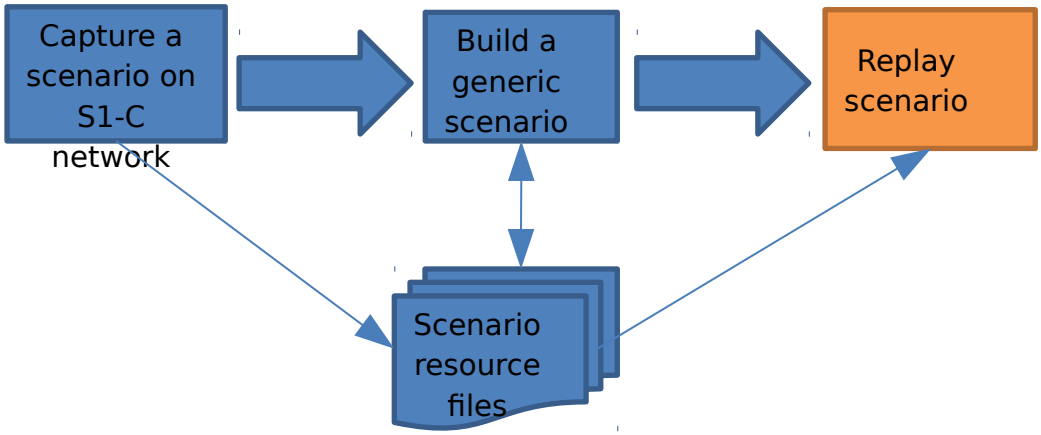


Figure 10 Workflow of scenario replay

In order to replay a scenario, a scenario has to be played/captured (step 1), then the captured artefacts have to processed in order to generate a generic scenario (step 2) ready to be replayed on any other testbed (step 3).

4.3.2 Step0: Install required software on the “scenario replay”testbed

Note: If your “scenario replay” testbed and the “scenario capture testbed are the same” then step into section 4.3.2.1“openairinterface5g installation” only.

For the ease of all operations, the targeted testbed is only one host called here “testbed”.

On the host “testbed”, clone all 3 git repositories : **openairinterface5g** (git@gitlab.eurecom.fr:oai/openairinterface5g.git or https://gitlab.eurecom.fr/oai/openairinterface5g.git), **openair-cn-scenarios** (git@gitlab.eurecom.fr:oai/openair-cn-scenarios.git or https://gitlab.eurecom.fr/oai/openair-cn-scenarios.git) and **openair-cn** (git@gitlab.eurecom.fr:oai/openair-cn.git or https://gitlab.eurecom.fr/oai/openair-cn.git).

4.3.2.1 openairinterface5g installation

In the directory openairinterface5g**:**

```
user@testbed:~/openairinterface5g$ source .oaienv
user@testbed:~/openairinterface5g$ cd cmake_targets
```



```
user@testbed:~/cmake_targets$ ./build_oai -I --install-optional-packages
user@testbed:~/cmake_targets$ cd tools
user@testbed:~/tools$ ./build_test_epc_tools --clean --debug
```

4.3.2.2 openair-cn installation

In openair-cn directory:

```
user@testbed:~/openair-cn/SCRIPTS$ cd SCRIPTS
user@testbed:~/openair-cn/SCRIPTS$ ./build_hss --check-installed-software
user@testbed:~/openair-cn/SCRIPTS$ ./build_mme –check-installed-software
user@testbed:~/openair-cn/SCRIPTS$ ./build_mme --install-gtpu-kernel-module
user@testbed:~/openair-cn/SCRIPTS$ ./build_spgw –check-installed-software
user@testbed:~/openair-cn/SCRIPTS$ ./build_mme --clean --daemon
user@testbed:~/openair-cn/SCRIPTS$ ./build_spgw --clean --daemon
user@testbed:~/openair-cn/SCRIPTS$ ./build_hss --clean --daemon
```

4.3.2.3 openair-cn-scenarios installation

You should set an environment variable OPENAIRCN_DIR pointing to openair-cn directory, otherwise you will be later prompted for openair-cn directory location.

For example:

```
user@testbed:~$ echo 'export OPENAIRCN_DIR=/home/user/openair-cn' >> ~/.bashrc
```

4.3.3 Step1: Flowchart of network capture on S1-C

The goal of this step is to capture a SCTP/S1AP trace that we want to be able to replay.

Step a: Run HSS

The HSS database has first to be configured for not generating randoms in security algorithms, otherwise we will not be able to replay trace coming from UE(s).

In the HSS configuration file /usr/local/etc/oai/hss.conf, set RANDOM to false*:*

```
RANDOM = "false";
```

In order to be able to replay the scenario in the same conditions, the initial content of the database has to be saved.

The extra argument that has to be passed in addition to other arguments to the run_hss script is:
--export-db /tmp/hss_db.sql

Step b: run MME

No change here compared to standard case.

Step c: run SP-GW

No change here compared to standard case.

Step d: start a pcap-ng capture on S1-C

This step is not automated, you have to start on your own a tool to capture the network traffic on the S1-C network. (you can use wireshark).

VERY IMPORTANT 1: PLEASE filter the packets with the following filter string:

“s1ap or sctp.chunk_type == INIT or sctp.chunk_type == INIT_ACK or sctp.chunk_type == COOKIE_ECHO or sctp.chunk_type == COOKIE_ACK”.

VERY IMPORTANT 2: We need the scenario from the beginning, that means the we need to have the SCTP INIT and SCTP INIT_ACK messages captured, so you must start the capture before lauching the eNB(s).

Step e: start the eNB(s)

The eNB config files will be used later to make a scenario independent of IP addresses.

Step f: run your scenario

Step g: save the captured scenario

At the end of this process please save in a created subdirectory of openair-cn-scenarios/SCENARIOS/S1 whose name reflects the test case success or failure:

- The eNB(s) config file(s) with the name “**enb.conf**”
- The MME config file with the name “**mme.conf**”
- The MME freeDiameter config file with the name “**mme_fd.conf**”
- The SPGW config file with the name “**spgw.conf**”
- The exported database SQL file with the name “**hss_db.sql**”.
- The pcap-ng file containing all SCTP and S1AP traffic (filtered with “s1ap or sctp.chunk_type == INIT or sctp.chunk_type == INIT_ACK or sctp.chunk_type == COOKIE_ECHO or sctp.chunk_type == COOKIE_ACK”) occurred on S1-C network with the name “**s1.pcapng**”.
- The HSS and mySQL security parameters in a file named hss_credentials.txt:

```
OPERATOR_KEY="youroperatorkey"
MYSQL_USER="yourdbuser"
MYSQL_PASSWORD="yourdbpassword"
```

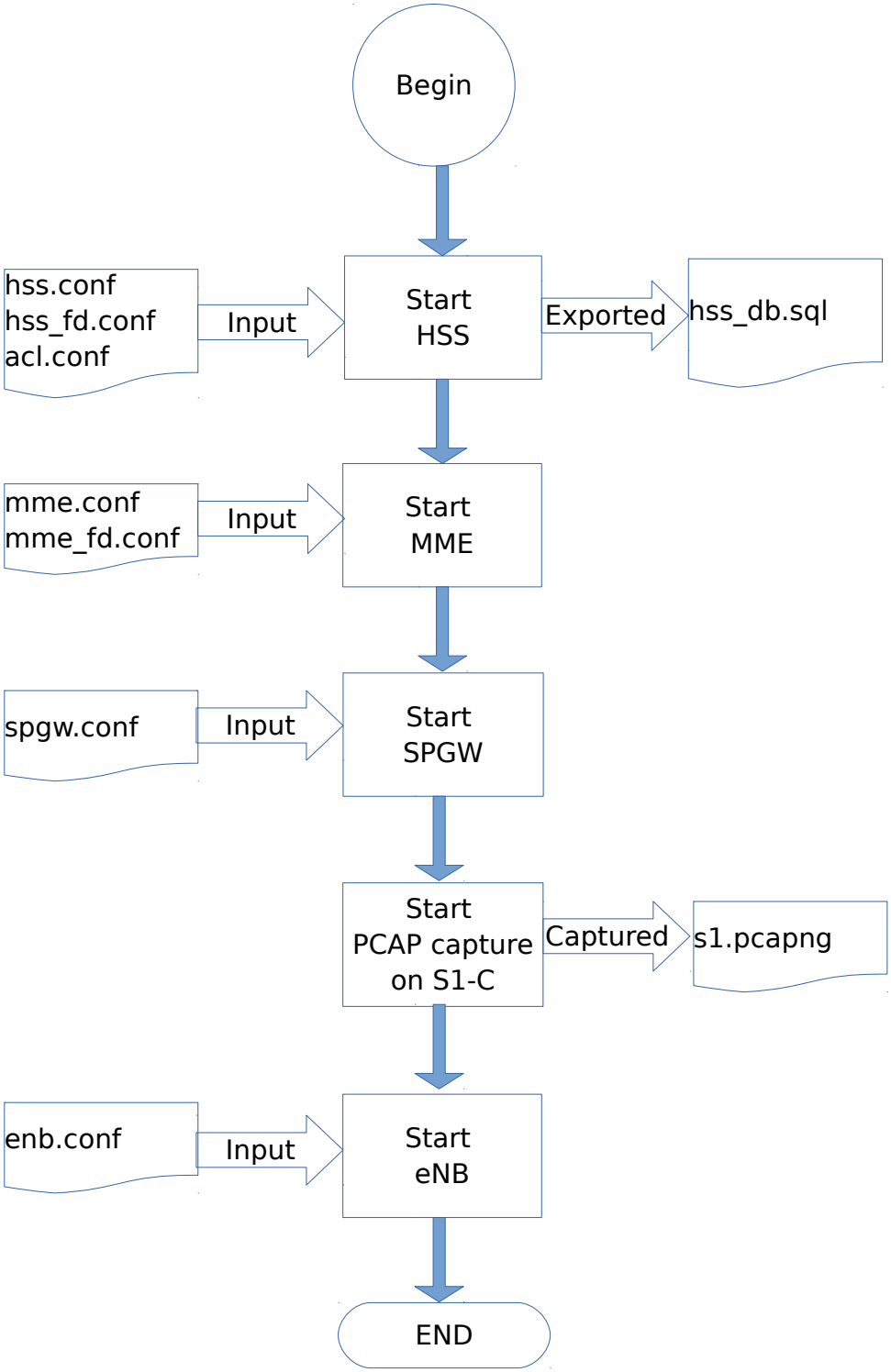



Figure 11 Workflow of scenario capture

The files listed in the flowchart figure are part of the “scenario resource files”, that means that if you want to replay the captured S1-C scenario, they will have to be saved in a created subdirectory of openair-cn-scenarios/SCENARIOS/S1 (on your personal git branch for most cases).

4.3.4 Step2: Generate a generic scenario

The scenario captured as a pcap file now have to be transformed in a XML file with abstracted IP addresses.

In openair-cn-scenarios/SCRIPTS, run the following command:

```
user@testbed:~/openair-cn-scenarios/SCRIPTS$ ./s1_prepare_test_scenarios
```

This command generates a copy of the S1-C pcap scenario, but with abstract IP addresses, for example:

```
...
<ip.src value="enb0_s1c"/>
<ip.dst value="mme0_s1c_0"/>
...
```

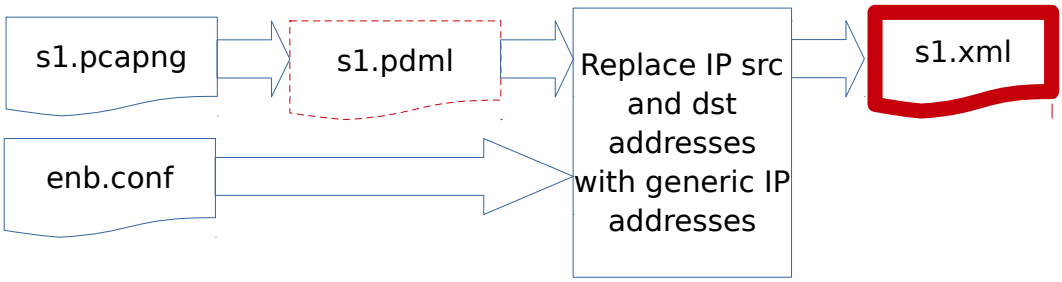


Figure 12 Captured scenario to generic scenario

4.3.5 Step3: Create configuration files for the “scenario replay” testbed

You have to create the network plan for the “scenario replay” testbed. The configuration files of the LTE network entities (eNB, MME, SPGW, HSS) will be a merge of the “scenario capture” testbed configuration files and the “scenario replay” network plan.

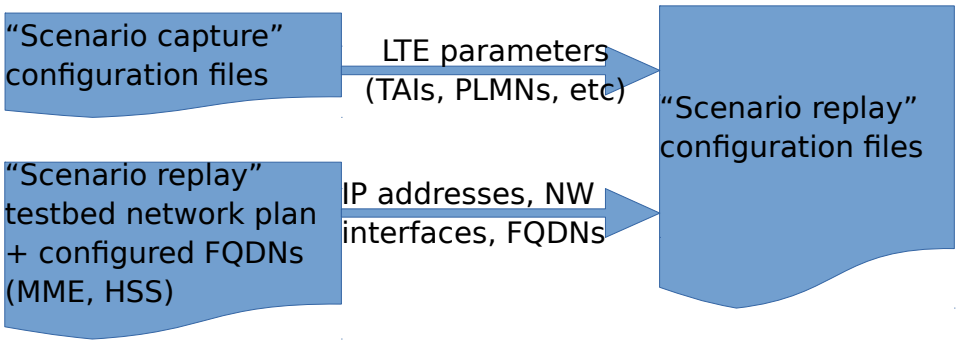


Figure 13 Scenario replay configuration files

Here is the network plan used by EURECOM for replaying scenarios.

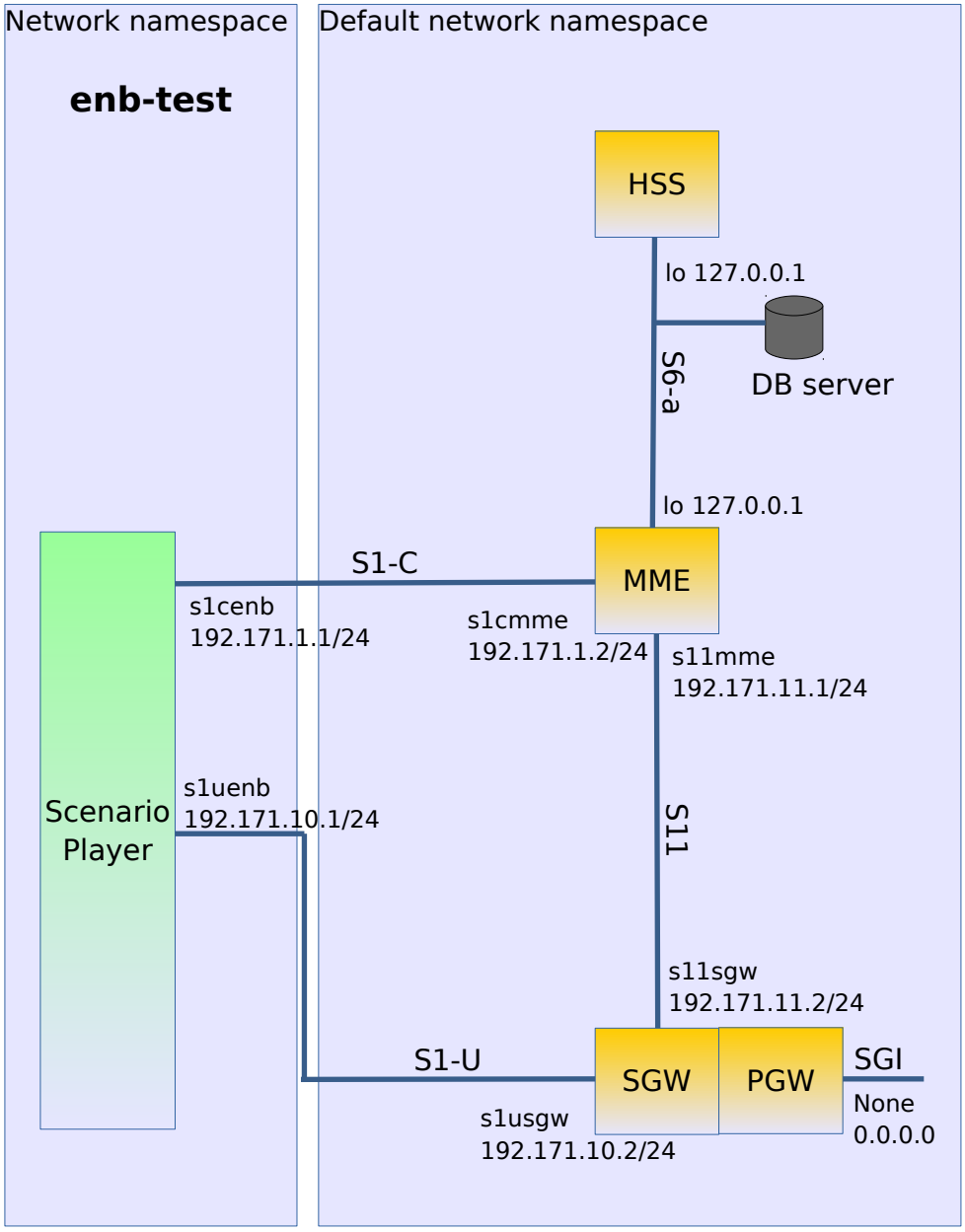


Figure 14 Proposed “replay network plan”

After the creation of the 3 configuration files for the 3 network entities, the content of the scenario directory should look like this example:

```
user@testbed:~/EURECOM/openair-cn-scenarios/SCENARIOS/S1/NR_TESTS/PON_POFF$ ls -1
enb.conf
enb.replay.conf
enb.replay.run_options.txt
hss_credentials.txt
hss_db.replay.sql
hss_db.sql
hss_fd.conf
mme.conf
mme_fd.conf
mme.replay.conf
s1.html
s1.pcapng
s1.pdml
s1.xml
spgw.conf
spgw.replay.conf
test_epc_generate_scenario.history
```

4.3.6 Replay a S1AP generic scenario

For replaying a scenario open a terminal and go into directory openair-cn-scenarios/SCRIPTS and run the following command:

```
user@testbed:~/EURECOM/openair-cn-scenarios/SCRIPTS$ ./s1_run_test_scenario -S
/home/eurecom/EURECOM/openair-cn-scenarios/SCENARIOS/S1/NR_TESTS/PON_POFF
```

5 Annex B: GTP fragmentation.

In order to avoid GTP fragmentation on the S1-U link, we strongly suggest to increase the MTU of S1-U network interfaces to at least 1536 (1536 + 8*x x in [0..N]).

Justification:

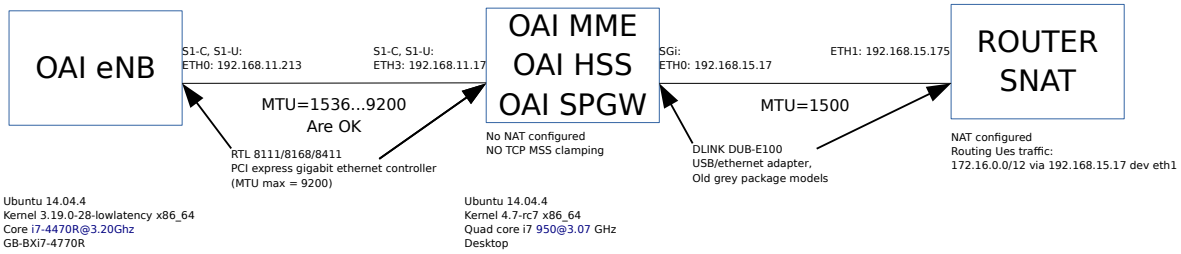
- IP fragmentation has an extra cost in network bandwidth, time and CPU.

- 3GPP TS 36.300 section 4.5 IP fragmentation:

Fragmentation function in IP layer on S1 and X2 shall be supported.

Configuration of S1-U (X2-U) link MTU in the eNB according to the MTU of the network domain the node belongs to shall be considered as a choice at network deployment. The network may employ various methods to handle IP fragmentation, but the specific methods to use are implementation dependant.

Here is an example of a testbed successfully tested at EURECOM:



UE is Nexus 5.

