

Emulation of 4G/5G Network Using OpenAirInterface

Cleverson Nahum, José Soares, Pedro Batista and Aldebaro Klautau

Abstract—Sophisticated communication technologies are developed using simulators, emulators and prototypes. In many situations emulators represent a good tradeoff in terms of flexibility and realism. OpenAirInterface (OAI) is an open-source emulation platform of 4G/5G networks that implements EPC, access network and user equipment (E-ULTRAN). This work describes a testbed created with OAI modules and OASIM (OpenAirInterface System Emulation) to emulate a LTE network. The system proved to be effective on creating a functional 4G/5G network that achieves realistic results to facilitate research.

Keywords—OpenAirInterface, OASIM, Emulation, LTE.

I. INTRODUCTION

According to [1] global data traffic grew 63% in 2016, reaching 7.2 exabytes per month in the end of 2016. To support the increase of mobile data traffic systems and other applications, technologies such as LTE (Long Term Evolution) and SDN (Software Defined Networking) are evolving, and the fifth generation of mobile networks (5G) is being designed.

To develop new features for technologies such as LTE and 5G, extensive experiments, tests and debugging must be conducted. Many times networks simulators are used, but they may be not enough and rigorous real-world evaluation are required [2]. Another option is to do real-world evaluations over testbeds using commercial LTE equipments, however, this scenario present many restrictions such as: commercial equipments does not have flexible deployment, have a restrict configuration capabilities due the commercial considerations made by operators and vendors [2].

To solve some of these issues, OpenAirInterface (OAI) was created as an open-source alternative to emulate 4G/5G networks [3]. OAI offers modules that emulate the User Equipment (UE), eNodeB and Evolved Packet Core (EPC). OAI can be used to implement a network by itself or can be used together with commercial modules. This paper describes the created 4G/5G network using OAI, emphasizing the required steps that complement OAI's documentation, and it will also demonstrate the testbed efficiency.

II. OPENAIRINTERFACE

OpenAirInterface is an open-source platform that is compliant with the 3rd Generation Partnership Project (3GPP) standards. OAI is being developed by EURECOM and offers the possibility of operating with closed-source equipment in any portion of the network [4]. Using the platform it is possible

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to build and customize LTE networks on personal computers and connect them to commercial UEs, like smartphones, or connect to software-based UEs. Besides, it can incorporate new 5G features.

Using OpenAirInterface, it is possible to monitor the entire network, including mobile devices, in real-time. It is also possible to easily configure the network making simple the deployment of tests. OAI runs on X86_64 computers with considerable high minimum requirements, because of kernel requirements the EPC has to be in different computers than the UE and eNodeB. The system can be used with a transceiver to create a real physical interface or using OASIM (OpenAir-Interface System Emulation) to emulate part of the network.

According to [5], OASIM allows for simulation and emulation of an LTE network using OAI. It provides either simulation with full physical layer (PHY) and synthetic radio channels, or using PHY abstraction. The OpenAirInterface has an advanced development environment with many tools such as highly emulation modes, soft monitoring, debugging tools and configurable logging for all layers and channels [3].

OAI EPC is composed of Home Subscriber Server (HSS), Packet Data Network Gateway and Serving Gateway (S-PGW) and Mobility Management Entity (MME). It is important to emphasize that OAI implements the functionality of the Packet Data Network Gateway and Serving Gateway in one module: the S-PGW, and it must have the GPRS Tunneling Protocol (GTP) Linux kernel module to work correctly. Figure 1 shows the modules and interfaces of the OAI.

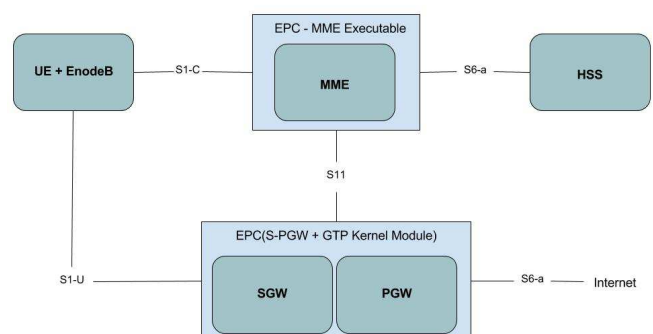


Fig. 1. OAI modules and their interfaces.

III. IMPLEMENTATION OAI USING OASIM

A LTE network was created following OAI tutorial in [6]. It was used one computer 7th generation Intel Core i5 processor

with 8 GB of RAM memory and a virtual machine (VM). The components of the core network were installed in a VM that is an Ubuntu 14.04, kernel 4.7.7 with module GTP activated and project openair-cn [7]. A FQDN (Fully Qualified Domain Name) was set to the machine to communicate with EPC. The modules HSS, MME and S-PGW were compiled and configured with specified configurations of interfaces and address used. Then, the pieces of information about the SIM were filled in the HSS database to enable authentication.

For installing the OAI eNodeB, it was used a host machine with Ubuntu 14.04, kernel 3.19 low-latency and project openairinterface5G [8]. Many configurations were needed to run the eNodeB, such as disable C-States, P-States, hyper-threading, CPU frequency control and options related to power managements in Linux System. After that, the modules needed to run OAISIM, eNodeB and UE were built and all configurations of files to connect to EPC were provided.

Due to outdated OAI documentation some extra commands were needed, which were not part of the install scripts. The default route of network was changed manually using Linux command IP route to allow the data flow to go into OAI interface as default. Although OAI recommends old branches [6], it was used develop branches to both EPC and ENodeB+UE because of some incompatibilities with available Linux packets and old packages required by the recommended branches.

To connect and create the LTE network it was used a script of OAI that runs the OAISIM, UE and eNodeB in the host computer with E-UTRAN and connects them to OAI EPC and HSS which was executed in the virtual machine running the scripts which start HSS, MME and S-PGW.

IV. RESULTS

As described, the OpenAirInterface was used to create a LTE network and the network interface was made in the computer with E-ULTRAN to interact with OAI UE. It is then possible to make tests of new features in experimental 4G/5G networks using a computer to run it, obtaining reproducible results that are typically more realistic than simulations, and without the need to have all structures of a LTE network or to use commercial EPC, eNodeB or UE modules.

The code below shows the interface created in the computer with E-ULTRAN to interact with UE. Through this interface it is possible to send and receive data in UE.

```

1 oipl Link encap: AMPR NET/ROM HWaddr
2 inet addr : 10.16.0.2 Bcast: 10.255.255.255 Mask
   : 255.0.0.0
3 UP BROADCAST RUNNING NOARP MULTICAST MTU:1500
   METRIC:1
4 RX packets:2100 errors:0 dropped:0 overruns:0
   frame:0
5 TX packets:3113 errors:0 dropped:0 overruns:0
   carrier:0
6 collisions:0 txqueuelen:100
7 RX bytes: 199680 (199.6 KB) TX bytes: 290936
   (290.9 KB)

```

A traceroute tool was used to see packets of a requisition to "www.prodepa.pa.gov" sent through UE interface called "oipl". Table I shows the packet going out of UE using the IP address 10.16.0.1 and passing through all hosts. When data

plane packets arrive in the UE interface, they are forwarded to ENodeB and after to S-PGW through a GTP tunnel. The data path between UE interface until S-PGW cannot be seen by the user that made requests because it is a hidden process to the user.

TABLE I
TRACEROUTE INFORMATIONS OF THE UE INTERFACE.

Host	Loss(%)	Last(ms)	Avg(ms)	Best(ms)
10.16.0.1	0.0%	24.6	73.1	15.8
172.31.0.14	2.7%	224.6	162.3	21.5
10.200.3.6	0.0%	147.58	102.8	16.9
host-200-239-9.ufpa.br	0.0%	83.31	109.2	16.8
pa-peerpa.bkb.rnp.br	0.0%	154.3	110.8	17.0
as53016.belem.pa.ix.br	0.0%	107.1	124.5	16.7

V. CONCLUSIONS

This paper presented a testbed for 4G/5G networks using the OpenAirInterface. The work aims to provide a realistic wireless network experimental setup using this open-source tool instead of commercial modules to eNodeB, UE and EPC. It also has some advantages over simulators, specially with respect to the capability of providing more realistic results because it uses real computational resources to implement network. The testbed was validated by communication requests to Web sites.

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