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Open Air Interface – Adaptability Perspective

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Abstract

This paper presents the working of Open Air Interface, advantages and limitations of an Open Air Interface. Open Air Interface is an outcome of experimental research by the Mobile Communications Department at EURECOM. The primary aim of the Open Air Interface technology is to improve the emerging industrial air interface standards such as LTE and 5G regarding spectral, algorithmic and protocol efficiency. In this OAI development the operators can access the software and get the hardware to a large scale networks making it open source and experimenting on original ideas in probable radio propagation and applications. This paper presents the working of OpenAirInterface, advantages and limitations of an Open Air Interface. It also presents the support it is giving to the network world and how it can be improvised.

Keywords: EURECOM, Long Term Evolution, OpenAirInterface, Repository

1. Introduction

In March 2008, a set of requirements for Fourth Generation (4G) standards is specified by the International Telecommunications Union-Radio communications sector. In addition to the third generation services, 4G provides mobile broadband internet access to laptops, tablets, smartphones and other devices. Commonly known as LTE (Long Term Evolution), it works similar to a 3G network but has better speed and is more expensive. Only criteria for a 4G network to display its speed is to be present in an area where it has been enabled and is in range. If a 4G network is unavailable then a network immediately transfers to the Telstra's NextG which is considered faster than 3G, and if that is not available then it goes to 3G until no networks are detected[1].

Long Term Evaluation is considered archaic as it is not open source software. The connection to the base station is quite complicated and a developer can upload a file to the base station and validate it only then. But in case of an OpenAir, the base stations are easily accessible on their own computers. An ordinary developer can merely sit in front of their personal systems and access the base station. A virtual machine is available in their system and they can trial run a file and upload it to the base station without much inconvenience.

Prior to the invention of OpenAir, LTE was too complex and esoteric a technology for a community of open source developers to manage. OpenAirInterface is an open forum and open source platform that aims not on finding solutions that are deployment-ready but on algorithmic, spectral and protocol efficiency research, permitting supporters based on high performance architectures, and the test, validation and analysis of wireless systems.

The EURECOM has collaborated with French ANR, Pole de Compétitivité and European Framework programs in the initiative of open medium for new ideas in digital radio communications area. The research was focused in fields of study of Real-time Radio Signal Processing, All-IP Wireless Networking, Agile RF System Design, Design and Simulation Methodologies, Propagation and System Measurements and their Analysis (eMOS) and Cognitive Radio which will be discussed later. These attempts triggered in validation tools for wireless system, abstraction models

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for the distinct entities in a wireless communication device, protocol validation, and testing and performance analysis[2]. OpenAirInterface, unlike LTE is not deployed. It just acts as a testing tool while communicating to a base station.

As mentioned earlier OpenAirInterface's principal objective is to ameliorate standard interfaces like LTE, 5G regarding spectral, protocol and algorithmic efficiency. Consecutively, to manifest disorder in high-performance computing architectures that is based on system development, open-source design tools and analysis methodologies (like wireless systems, abstraction models for various entities in wireless communication device, protocol validation, and testing and performance analysis. The hardware can be purchased; the software can be developed and eventually deployed as a large-scale network. To demonstrate and to come up with new ideas through experimentation, and to deploy reduced-scale test networks, this can be used[3].

A very significant impact in the current networks like Android ecosystem, cloud infrastructure, due in part to the OpenStack ecosystem has been made by the Open-source. EURECOM has recently created OpenAirInterface (OAI) Software Alliance (OSA). This is a separate legal entity and focuses on providing an environment for access-network (EUTRAN) and the core (EPC) of 3GPP cellular systems to operate with the closed-source equipment in both network portions. This will be a stupendous tool for industry as well as academia. While the access network will be known as openair5G[13], the EPC software is already known and openairCN. A much-needed communication mechanism will be ensured between the two to bring complex real-world systems collaborate with the academia. While moving towards 5G, there will be a big gap if the tools are developed independently and there will be a huge need for open source tools which makes sure that a common research takes place and we get a rapid proof-of-concept design in short span of time[2]. This study aims at bridging this gap and support for more open source tools.

2. Materials and Methods

2.1 Web Tools

The OpenAirInterface team imparts the subsequent tools for web-based development. They are:

- SVN Repository.
- TWiki Site.
- Mailing lists.
- Bulletin Board Forum.
- Bugzilla.

Successively describing them in brief

2.2 OpenAirInterface SVN Repository

OpenAirInterface hardware and software (FPGA related) development is retained with SVN server hosted by EURECOM which can be acquired by read-only mode[4].

2.3 OpenAirInterface TWiki

TWiki software contains practical information on software installation, machine configuration, code compilation and many more[5].

2.4 OpenAirInterface Mailing Lists

A mailing list for developers is hosted and contained in EURECOM's majordomo server.

2.5 OpenAirInterface Forum

This is created for communication between people and the developers. This can be considered as a direct information exchange[6].

2.6 OpenAirInterface Bugzilla

This is created for reporting bugs[7].

3. Study of OAI

Although OAI is now a united attempt traversing the globe, EURECOM will prevail as the urging power behind the OpenAirInterface Software Alliance and will advance in the interpretation of its scientific strategy. The elementary forthcoming aspiration is to use OAI to stimulate inventiveness in the 5G standardization process and to escort the academic world closer to 3GPP. This technology was also available to small enterprises to escalate development of 3GPP-based systems in France with the help of FUI and other similar projects[8]. OAI intends to substantiate novelty in the hereunder subject sectors:

3.1 Real-Time Radio Signal Processing

OpenAirInterface systems can be made to run in real-time with real RF signals using existing real-time RF hardware developed at EURECOM

- Hardware/software architectures for real-time processing of the signals (Software defined Radio, multi-processor SoC).
- Optimization of algorithms at the Physical layer of the OSI model.

3.2 All-IP Wireless Networking

- Cellular mobile network protocols (Routers of IPv6 base station and mobility management).
- Layer 2 Protocols for cellular and mesh network topologies.
- IP/MPLS conventions modified to MESH topologies.
- Proxy Mobile IPv6 for Mobile Node management.

3.3 Agile RF System Design

- Linear and receivers of wide-dynamic range, Wideband radio design.
- Intelligent RF support.

3.4 Analysis of Propagation and System Measurements (eMOS)

- Channel characterization of wideband frequency and modeling.
- Empirical performance analysis offline and collection of Real-time measurement data.

3.5 Cognitive Radio

- New methodologies development focused on sensor networks, that will support the presence of both unlicensed and licensed users of wireless data in a same area.
- Dimensioning, design, analysis and internetworking of intellectual networks.

3.6 Design and Simulation Methodologies

- Proficient simulation systems (functional, performance and behavioral).
- Hiding methods (Physical sub-system modeling, hardware and traffic modeling, etc).
- Distributed real-time simulation of wireless networks through RF emulation architectures.

4. Soft Modems and Protocol Stack Implementations

The protocol stack is the realization of a networking group. The OAI approach enhances protocol stack execution and open-source MODEM for x86 based PC and express MIMO baseband engines. These operations currently emphasis on long term evolution and 802.11p air interfaces. The LTE implementation introduced in 3GPP R8 presents a standard-compliant implementation of physical and media access control for a subclass of the third generation partnership project LTE specifications.

OpenAir4G protocol stack: OpenAir4G provides a full real-time protocol stack for a gnu gcc environment implementing a subset of LTE Rel. 8/9 of access stratum. A full software implementation of the 3GPP LTE protocol stack is also included in the Open Air Interface platform both for the RAN (OpenAir4G) and the EPC (OpenairCN)[9].

The physical layer implements 3GPP 36.211, 36.212, 36.213 and provides the following features:

- Long-Term Evolution release 8.6 compliant, and executes a subclass of release 10.
- Various transmission modes.
- Most Downlink (DL) channels are supported: Primary and Secondary Synchronization signals, PBCH, PHICH, PDCCH, PCFICH, PMCH, PDSCH.
- Frequency division and time division duplex configurations tested in various bandwidth.
- Uplink channel support: PRACH, PUCCH, PUSCH, DRS, Sounding Reference Signal.
- To indicate channel quality and precoding matrix indicator reporting.

Figure 1. Wireless IP network system.

- Optimized base band processing.
- Hybrid automatic repeat request support (UL and DL).

There is no support so far on:

- Physical Uplink Control Channel format 2 (and 3).
- Physical Random Access Channel formats x.

MAC: The medium access control layer provides a sub-class of the 3GPP 36-321 release v8.6 in support of broadcast channel, downlink shared channel, random access procedure, and uplink shared channels. The eNB MAC implementation includes:

- RRC interface for common control channel, dedicated control and traffic channels.
- Hybrid ARQ Support.
- Downlink control information generation.
- Radio link control interface (AM, UM).
- RA procedures and Radio Network Temporary Identifier management.
- Uplink power control.

User Equipment MAC implementation includes:

- Protocol Data Unit formats: all logical channels and control elements.

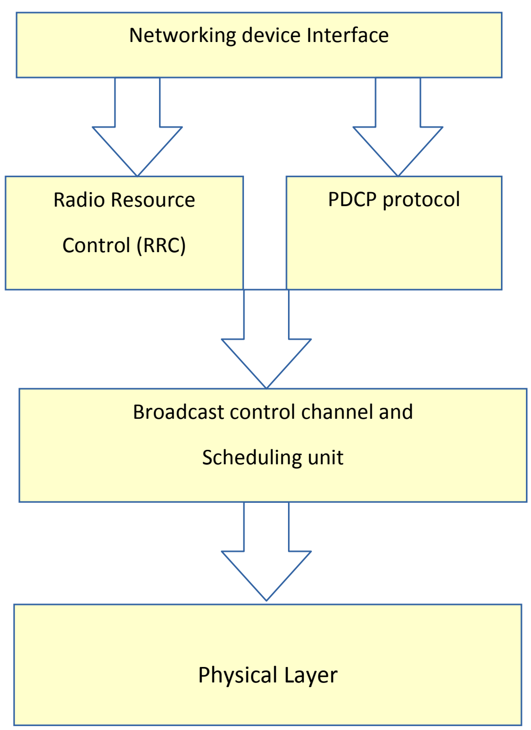

Figure 2. OpenAir LTE protocol stack.

- Scheduling request procedures and buffer status reporting.
- Power headroom reporting.
- RLC interface, TMRRC interface for common control and broadcast control channel.

PDCP: The current packet data convergence protocol is header compliant with 3GPP 36-323 Rel 10.1.0 and implement the following functions:

- Transfer of control data and user data.
- Radio bearer relation with PDCP entity.
- PDCP entity relation with one or more Radio Link Control entities.
- Management of sequence numbers.
- Check for integrity and encryption using the SNOW3G and advanced encryption standard algorithms.

RLC: The Radio Link Control layer effectuates a full specification of the 3GPP 36-322 release v9.3 for all three modes of operation: Unacknowledged Mode (UM), Acknowledge Mode (AM) and Transparent Mode (TM) with the following characteristics:

- Radio Link Control Transparent Mode (mainly used for BCCH and CCCH)
    - RLC header not included in the RLC Protocol Data Unit.
    - RLC Protocol Data Unit delivery status to upper layers.
    - Neither segment nor concatenate RLC Service Data Units.
- Radio Link Control UM (mainly used for dedicated traffic channel)
    - Add or divide RLC Service Data Units according to the TB size selected by MAC.
    - Detection of duplicate entries.
    - Protocol Data Unit reordering and reassembly.
    - RLC header inclusion in the RLC PDU.
- Radio Link Control AM, compatible with 9.3
    - Addition, division and reassembly.
    - Data/control generation.
    - Data transfer to the user.
    - RLC Protocol Data Unit retransmission in provision of error control and correction.
    - Padding.

RRC: The Radio Resource Control layer, shared between the UE and the evolved Node B, performs the radio interface control. It is based on 3GPP 36.331 v9.2.0. The control procedures available in the LTE platform are the following:

- System Information broadcast (SIB 1, 2, 3, and 13).
- RRC connection establishment, reconfiguration and RRC connection release.
- Inter-frequency measurement collection and reporting at UE and eNB.
- eMBMS for multicast and broadcast.

Following are still under integration and testing

- Handover in Evolved Universal Terrestrial Radio Access.
- Re-establishment of Radio Resource Control connection.
- Paging.

Following are not supported

- Many System Information Block formats (except 1, 2, 3, and 13).
- Counter check.
- Inter-frequency, inter-RAT and inter-band measurements.

5. OAI PMIPv6

Proxy Mobile IPv6 has been standardized by Internet Engineering Task Force. It is a mobility management protocol based on network for localized domain[10]. PMIPv6 is a protocol for constructing a typical and access technology autonomous of core networks, considering various access technologies like 3GPP, Worldwide Interoperability for Microwave Access, 3GPP2 and Wireless Local Area Network based access architectures[11]. It is an application of RFC 5213 by EURECOM. OAI PMIPv6 is an example of open source software. This software is operated on top of UMIP from LINUX[10].
System Requirements[10]

- Access points should have SYSLOG client feature. Since the attachment or detachment phase will require message exchanged between the client access point and Server Syslog.
- The PMIP6D runs on Ubuntu 10.04 x86 LTS version.

Properties for PMIPv6[11]

- No client software required.
- Continuity of IP address.

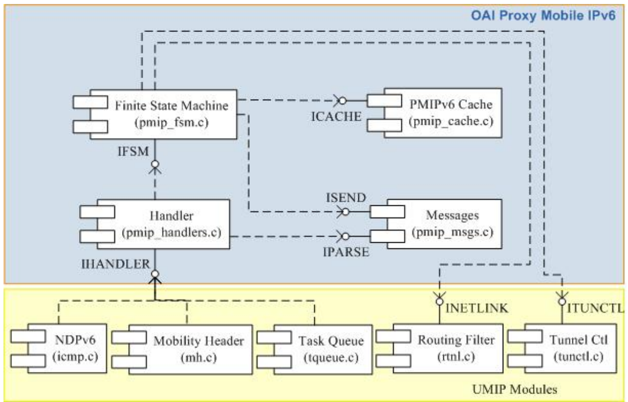

Figure 3. OAI PMIPv6 Software Architecture (Courtesy[12]).

- No fragmentation observed in packets.
- Based on Open Internet Standards.
- Can be executed with less cost access point.
- Roaming Session Continuity within a single access domain.
- Light weight protocol.
- Handover latency is very minimal.
- Protection through standard IPsec.
- 3GPP LTE packet data adopted and supported.

6. Conclusion

While we are moving towards 5G, from the above discussions, there is clearly the need for open-source tools in-order to make sure that we have a common Research and Development and prototyping framework for rapid PoC (Proof-of-Concept) design and analysis.

As of today, most industrial users of Open Air Interface for collaborative projects are Alcatel-Lucent, TCL, China Mobile, Orange, Intel, TCS, Thales, Canonical, Ercom, Keysight, Telekom Malaysia, National Instruments, Telecom Italia, Swisscom, ARELIS (Thomson Broadcast).

Open source made a huge impact in the limitations of current networks and OAI software foundation focuses on providing an ecosystem for EPC and EUTRAN with the chances of interoperating with closed-source kit in both portions of the network.

In this paper, we have reviewed the basics of open air-interface along with the tools, protocol stack and applications and brought out the importance of making it open source for a better 5G technology and experience.

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