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A Realistic Model and Simulation Parameters of LTE-Advanced Networks

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ABSTRACT—***Long Term Evolution Advanced (LTE-Advanced) network is the continuation of 3GPP-LTE (3GPP: 3rd Generation Partnership Project) and it targets to advanced develop of the requirements of LTE in terms of throughput and coverage. Then, LTE-Advanced is not new as a radio access technology, but it is an evolution of LTE to enhance the performance. LTE-Advanced was accomplished in late of 2010 and it enhanced the LTE spectrum flexibility over carrier aggregation, further its extended multi antenna broadcast, where that introduced a supporting for the relaying and provided an enhancement in the part of inter-cell interference coordination in heterogeneous network utilizations. Recently, LTE-Advanced network is the promised candidate for 4G cellular systems to run into top rates of data reaches to 100 Mbps with high mobility and 1Gbps with low mobility, where that are wanted in 4G system. Furthermore, LTE-Advanced must be capable to upkeep broader bandwidth than it provided by LTE. This article offered the designing and the architecture of LTE-Advanced further to the key features with the full configurations and the simulation tools to model the traffic links of it using network simulator 2 (NS-2).***

Keywords**—LTE; LTE-Advanced; NS-2; TCP**

I. INTRODUCTION

3GPP is defined its private requirements and targets for LTE Release-10 and these requirements/targets is extended the requirements of International Telecommunication Union (ITU) to be more aggressive in addition to including supplementary requirements. One of the main requirements was backwards compatibility. Fundamentally, that’s mean an earlier release of LTE terminal must always be capable to access a carrier supporting of Release-10 functionality, though clearly not be able to employ all the features of Release-10 of this carrier [1][2]. LTE specified by 3GPP as very high flexible for radio interfacing. LTE deployment started in the last of 2009.

The first LTE release is providing greatest rate reaches to 300 Mbps, delay of radio network not as much of than 5 msec, a spectrum significant increasing in efficiency of spectrum if comparing with any other cellular systems, and a different regular architecture in radio network that is designed to shorten the operations and to decreasing the cost [3].

LTE systems are supporting Frequency Division Duplex (FDD) with Time Division Duplex (TDD) technique as a varied array of bandwidths to operating in a wide amount of dissimilar spectrum allocations.

The standardization of LTE in 3GPP is gotten an established state, and the modifications in the design are narrow. Form the end of 2009, the LTE system has been installed as a normal growth of Global System for Mobile communications (GSM) and Universal Mobile Telecommunication System (UMTS). The ITU has devised the IMT-Advanced term to recognize the new mobile systems that capable to going beyond IMT 2000 (International Mobile Telecommunications) [4]. Exactly, the requirements of data rate have been amplified. To providing applications and other advanced facilities, then, 1 Gbps for low and 100 Mbps for high mobility scenarios should be comprehended. Since 2009, 3GPP has operated on a research with objective to identify the required enhancements for LTE systems to achieve the requirements of IMT-Advanced. In September 2009, the partners of 3GPP have prepared the official suggestion to the proposed new ITU systems, represented by LTE with Release 10 and beyond to be the appraised and the candidate toward IMT-Advanced.

II. PROPOSED MODEL OF LTE-ADVANCED NETWORK

The requirements and expectation of forthcoming wireless communication networks remain to develop and grow.

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Thus, the test of the behaviour of protocols or any other components of these networks requires providing an experiment model for the candidate networks to ensure its performance over different scenarios. The modelling and simulation is an operative method to exploration the difficulties and resolve the problems because the modelling is easy to create an experiment scenarios and low-cost in varying experiment arrangements and executing many test scenarios. This section introduces how to figure a precise enough traffic model of LTE-Advanced.

The proposed model of LTE-Advanced based on the structure of LTE/SAE where the architecture of it represents a challenge in the future of wireless broadband. The LTE/SAE presents an advanced radio interfacing with main improvement upcoming from using of Orthogonal Frequency Division Multiplexing (OFDM) with compound antenna technique [5]. These technologies previously exist and in employment in WiMAX as itemized in IEEE 802.16. Sideways with the advanced radio interfacing, LTE/SAE states the development in the architecture of network.

The design built on to be packet based and contains less network components, which decrease the deployment costs, the protocol processing, and the latency in the network. Fig. 1 highpoints the reference architecture for LTE/EPC. E-UTRAN is the authorized 3GPP name for the radio access network of LTE/LTE-Advanced. In Fig. 1, X2 interface between eNodeBs carries the traffic of user plane (X2-U) and control plane (X2-C). The core network contains control plane elements MME with S1 control plane (S1-C) traffic and user plane gateways S-GW with S1 user plane (S1-U) traffic.

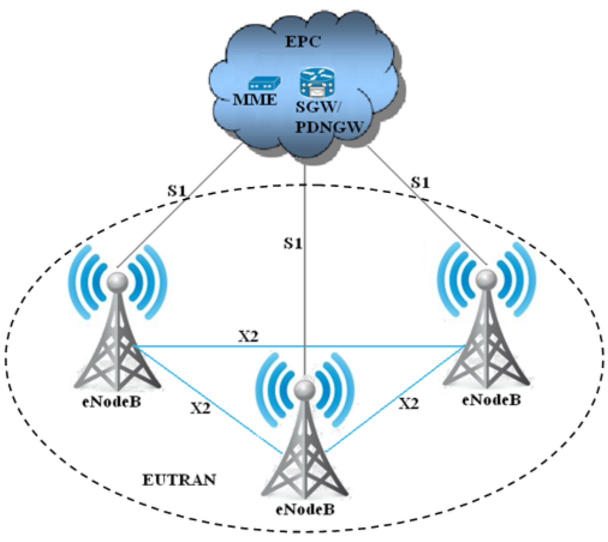

Fig. 1 LTE/EPC Reference Architecture

The X2 interfaces are a straight communication among eNodeBs. These interfaces will be used for control plane and bursts of user plane traffic through handover event. Presently, the estimations specify that the mutual X2-C and X2-U traffics could be between %4 and %10 of the core facing bandwidth (S1-U) and the propagation delay must be less than 30 msec. These traffics are of the highest significance, and it is clear for LTE-Advanced that additional user plane traffic will negotiate these interfaces. Furthermore, in LTE-Advanced specifications, there will be strict latency necessities required to apply the features for example, cooperative Multiple Input Multiple Output (MIMO). The requirements in the area of 10 msec latency are presently being considered. That means, the time compassion will increment and maybe there are other value to route these requirements locally specifically in areas of upper network latency.

In LTE-Advanced systems, may a different base stations are cooperated together using the X2 interface, where this interface is simply a logical one and so it’s not guaranteed that there is continuously a straight link among cooperating sites [6]. Therefore, structure of the network possibly will have to be adjusting by the operator to allow the effective application of the schemes for Coordinated Multipoint (CoMP) in practice. The Coordinated Multipoint (CoMP) techniques used in reception and transmission are built on the cooperation among different base stations via fast backhaul network to meaningfully enhance the interference condition and consequently the whole system performance. In the downlink, this attitude can be used for comprehending cooperative transmission, such as, where an UE is instantaneously served by many base stations. In this way, not only the strength of the signal proposed for the corresponding UE can extensively improve, but also the interference creating from transmission to other UEs can be decreased. Nevertheless, in common multiple UEs must be mutually served by a set of cooperative cells [6]. In other side, in the uplink, the supporting of CoMP procedures is generally considered as employment detailed issue and for several schemes, it is essentially satisfactory to systematize the data switched by the X2 interface only.

III. SIMULATION PARAMETERS

The proposed topology consists of three eNodeBs, which are connected to the access routers, Router 1 and Router 2 with 20 Mbps bandwidth link. The Gateway (aGW) represents the network core includes the MME/SAE where it connected to the access routers with large bandwidth link of 1Gbps and with the server with 100 Mbps.

An important scenario added to this topology by adding relay nod to provide coverage to 5 nodes. These nodes can only access eNodeB1 via Relay Node with 20Mbps bandwidth link. Each eNodeB interconnected with 10 UEs with 2 Mbps bandwidth, so the total UEs used in this scenario become 35 and all used wired link instead of wireless due to the proposed UE not have full mobility features to avoid the handover scenario that may happen if the one or more UE move from one eNodeB to another. In fact, the assumption of use wired UEs to achieve high data streaming between each UE and the server or to other UE, while the wireless assumption of UEs cannot provide high congestion network

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where that represents a major goal to test the developed congestion control mechanism. However, the using of full mobility feature of UE will be a continued project to this research to develop a new congestion control technique taking into account the probability of handover over LTE-Advanced. For each link in proposed model, it's necessary to assign the bandwidth and the propagation delay (latency).

Actually, in LTE-Advanced (and LTE) networks we should expected low latency connection because it one of the main requirement of IMT-Advanced where the latency has come to be a significant performance pointer in wireless communication systems. Practically, in first release of LTE, it provides a radio-link delay of less than 5 msec. One of the proposed techniques to enhance the latency in LTE-Advanced are by immediate processing of RRC and NAS requirements at the eNodeB, decreasing the delay in message processing at different nodes, and decreasing the Random Access Channel (RACH) and Physical Uplink Control Channel (PUCCH) duration. There are two categories of latency are defined. The first is the control plane latency where that related with the connection setup latency. The second is the user plane latency, which related with the transferring delay in RAN [7]. Idyllically, for best circumstance scenario, the latency of all links in proposed LTE-Advanced model set to 3msec where this value represents the best latency expected for any developed LTE network and to achieve high-speed link over the simulated model to experiment the all expected risks and degradation may cause by the new congestion control mechanism. But in applied scenarios, it is sensible to adopt an extra delay of 10 msec for S1-C transfer delay plus MME processing of NAS application.

In NS-2, every link requires to indicate the queue scheme [8]. The schemes of queue management can generally distribute into two sets. The first scheme uses the immediate queue size such as Drop-Tail. The second scheme advocates elements of averaging the queue size such as Random Error Detection (RED) queue [9].

TABLE 1
TOPOLOGY LINKS PARAMETERS

Link	Bandwidth	Delay
Server-aGw	100 Mbps	100 msec
aGW-Router 1	1 Gbps	3 msec
aGW-Router 2	1 Gbps	3 msec
Router 1-eNodeB 1	20 Mbps	3 msec
Router 2-eNodeB 2	20 Mbps	3 msec
Router 2-eNodeB 3	20 Mbps	3 msec
eNodeB1-Relay Node	20 Mbps	3 msec
eNodeB-UE	2 Mbps	3 msec
Server-aGw	100 Mbps	100 msec

TABLE 2
SIMULATION PARAMETERS

Parameter	Value
Number of UEs with Relay Node	5
Number of UEs with eNodeB	10
Packet size	1500Bytes
Advertised window size	48Kbytes
Queue scheme	Drop-Tail
Maximum window size	128 packets
Simulation time	100 sec
TCP protocol	TCP Reno and SCTP

Actually, Drop-Tail queuing is the simplest queue management strategy where its drop totally the inward packets when the buffer is filled. For this reason, it is suitable to choose Drop-Tail queue to support the model access links. The proposed LTE-Advanced model can uses several TCP source variants such as Vegas [10], Sack, Fack [11], Tahoe, Reno, Newreno [12] plus STCP [13] but only one variant can be used in each scenario. The maximum advertised window size sets 48 Kbytes and the maximum TCP/IP packet size sets to 1500 Bytes [14], while the maximum TCP's window size set to different values to monitor the behaviour in slow-start phase. Table 1 shows the links parameters of the proposed model including the bandwidth and propagation delay for each link while Table 2 illustrates the other simulation parameters.

IV. TOPOLOGY ANIMATION

It's important to demonstrate the traffic session after the links and nodes of the topology establish.

In NS-2 simulation, all the data in the network is available, thus the performance of the network can be easily analysed. NS-2 is free and open source code and suitable to build system level simulation, so it is deployed to simulate LTE/SAE, or any other network. Additionally, NS-2 is the most popular one in academia because of its open source and plenty of component's libraries. Many non-benefit organizations contribute a lot in the component's library, and it has been proven that the development mode of NS2 is very successful. Fig. 2 shows the screenshot of the real animation of the proposed model using NS-2 where the green node represents the server, which connected to the gateway directly. The two routers connected to aGW with 1 Gbps and 3 msec link parameter where these two links represents the bottleneck of the model. The first router is linked with base station and the second is linked with two base stations, eNB2 and eNB3. One of the most important scenarios added in this model is by using Relay Node to achieve additional coverage to five separated UEs.

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Each base station is connected with ten UEs to obtain 35 UEs, which connected to these three eNBs. The black nodes represent a UE nodes and all has similar link parameter of 2 Mbps as a bandwidth and 3 msec as latency. The activity of these UE nodes not always ON during the simulation, but all of them have a specific role and all of them used through the simulation.

This scenario includes many activities, such as connect some of UEs to the server or connect other UE in other base station. In addition, the status of the two bottlenecks R1-aGW and R2-aGw are monitored to indicate the queue size and the packet loss that may happen during the simulation period.

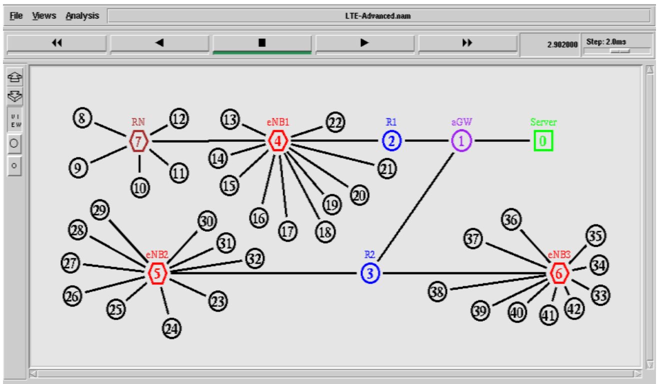

Fig. 2 Screenshot of LTE-Advanced Model Animation in NS-2

V. Conclusion

This paper provides the full details of the layering, architecture, and the configurations of the traffic model for LTE-Advanced networks. After explaining the development from LTE to LTE-Advanced, the paper focused on the benefits and the key features of it and illustrated how LTE-Advanced will become the major cellular system for the users in next decade. The architecture of E-UTRAN and EPC are specified in details with the links interfacing between the different elements of the network. The main contribution of this article is to present and configure the traffic model of LTE-Advanced using NS-2 simulator. One of the new concepts add to LTE-Advanced was the relaying node, where this technique add to the proposed model to support the model and to give it more credibility.Then, the simulation parameters also identified with all links parameters in sides of bandwidth and propagation delay. Lastly, the proposed topology implemented with an animation demonstration using SCTP/TCP protocols to monitor the traffics and the expected loss in packets during simulation scenario. In fact, this paper tried to provide an efficient model of LTE-Advanced to assist the researchers to experiment the developed items of this network over different conditions and situation such as improve the congestion control algorithm for the protocol used or to derive new technique to minimize the handover among base stations.

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Biography

Ghassan A. Abed received his B.Sc. and M.Sc. degree in Computer Engineering from University of Technology, Baghdad, Iraq, in 1996 and 2003 respectively. He was Head of Transmitters and Receivers Dept. in Microwave Research Centre in Ministry of Sciences and Technology, Iraq. Currently, he is PhD candidate in National University of Malaysia (UKM), Selangor, Malaysia. He is working in Mobile and Computer Wireless Networks and his research interests include developing new TCP mechanisms to improve performance of TCP over 4G systems and develop new high-speed protocols for high-speed and challenge networks.

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