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An Empirical Model of Correlated Traffics in LTE-Advanced System through an Innovative Simulation Tool

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***Abstract*—**Long Term Evolution Advanced (LTE-Advanced) LTE-Advanced is not new as a radio access technology, but it is an evolution of LTE to enhance the performance. This generation is the continuation of 3GPP-LTE (3GPP: 3rd Generation Partnership Project) and it is targeted for advanced development of the requirements of LTE in terms of throughput and coverage. The performance evaluation process of any network should be based on many models and simulations to investigate the network layers and functions and monitor the employment of the new technologies especially when this network includes large-bandwidth and low-latency links such as LTE and LTE-Advanced networks. Therefore, it's necessary to enhance the proposed models of high-speed and high-congested link networks to make these links and traffics fulfill the needs of the huge data which transferred over the congested links. This article offered an innovative model of the most correlated links of LTE-Advanced system using the Network Simulator 2 (NS-2) with investigation of the link parameters.

***Keywords*—**3GPP, LTE, LTE-Advanced, NS-2.

I. Introduction

IN September 2009, the partners of 3GPP have prepared the official suggestion to the propose new (International Telecommunication Union) systems, presented by LTE with Release 10 and beyond to be the oppressed and the candidate toward IMT-Advanced (IMT: International Mobile Telecommunications). After attaining the requirements, the main object to bring LTE to the line call of IMT-Advanced is that IMT systems must be candidates for coming novel spectrum bands that are still to be acknowledged [1] [2]. LTE-Advanced is applying various bands of the spectrum which are already valid in LTE along with the future of bands of IMT-Advanced. More developments of the spectral efficacy in downlink and uplink are embattled, specifically if users serve as an edge of the cell.

In addition, LTE-Advanced aims quicker exchanging between the resource of radio states and between additional enhancements of the figures of latency. All at once, the bit cost must be decreased [3]. IMT-Advanced represents the next generation in systems of wireless communications, which aim to accomplish other main advances of the current third-generation systems, by reaching to uplink (UL) rate of 500 Mbps and to 1Gbps in the downlink (DL) [4]. With LTE-Advanced starts, there are many keys of requests and features that are upcoming to the light.

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II. Architecture of LTE-Advanced Networks

3GPP identified in Release 8 the requirements and features and requirements of the architecture of the Evolved Packet Core (EPC) which that serving as a base for the next-generation systems [5]. This identification specified two main work objects, called LTE and system Architecture Evolution (SAE) that leading to the description of the Evolved Packet Core (EPC), Evolved Universal Terrestrial Radio Access Network (E-UTRAN), and Evolved Universal Terrestrial Radio Access (E-UTRA). Fig. 1 illustrates the architecture of LTE-Advanced networks based on EPC and E-UTRAN.

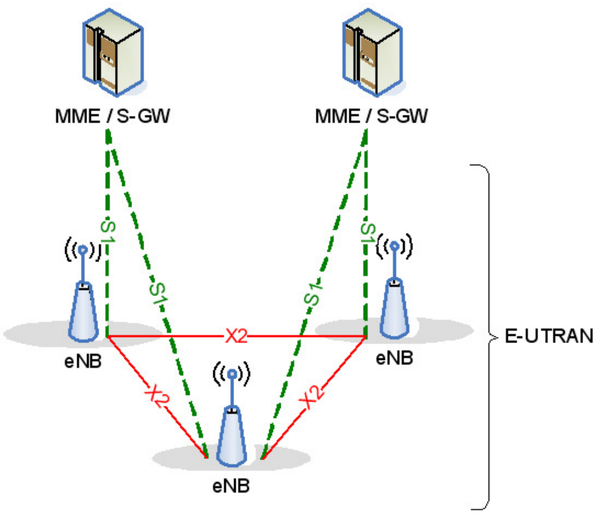

Fig. 1 General architecture of LTE-Advanced system

Each of these parts corresponded respectively to the network core, system air interface, and the radio access network. EPC is responsible to provide an IP connection between an external packet data network by using E-UTRAN and the User Equipment (UE). In the environment of 4G systems, the radio access network and the air interface are actually improved. In other hand, the architecture of the core network (i.e., EPC) is not suffering large modifications from the previous systematized architecture of SAE.

The main part in the architecture of E-UTRAN is the improved Node B (eNB or eNodeB), that provide the air interface between the termination of control plane protocol and the user plane towards the user equipment (UE). Both eNodeBs are a logical element that serving one or more E-UTRAN cells and the interfacing between the eNodeBs is termed the X2 interface. The interfaces of network are built on IP protocols. The eNodeBs are connected by an X2 interface and to the MME/GW (Mobility Management Entity/Gateway) object by an S1 interface. The interface S1 supported many relationships between eNodeBs and MME/GW [6]. The two entities of the logical gateway are termed Serving Gateway (S-GW), and the other is a Packet Data Network Gateway (P-GW).

The Serving Gateway (S-GW) acts as a limited anchor for the mobility service to receiving and forwarding packet rates from and to the eNodeB to serve the UE, while the P-GW is interfaced with the exterior Packet Data Networks (PDNs) for example, the IMS (Internet Multimedia Server) and the Internet. P-GW provides other IP functions such as packet filtering, routing, policy statement, and address allocation. The MME is an entity to provide signaling only and later the user packets on the IP do not pass over the MME. The main benefit of separating the network entities is for indicating if the capacity of network for traffic and signaling can independently grow. Actually, the core tasks of MME are too idle mode the reach ability of UE together with controlling the retransmission of paging, roaming, authorization, P-GW/S-GW selection, tracking area list management, bearer management, including dedicated bearer establishment, authentication, security negotiations and signaling of NAS[7]. The eNodeB is implementing the functions of eNodeB along with protocols usually applied in Radio Network Controller (RNC).

The eNodeB functions are ciphering, packet reliable delivery, and header compression. However, in controlling side, eNodeB is incorporating functions such as:

- Radio resource management (radio bearer control, radio admission and connection mobility control, dynamic scheduling).
- Routing the user plane data towards SAE Gateway.

Several benefits of using one node in the network accessing are to reduce the latency and the RNC processing distribution load into many eNodeBs.

III. User Plane and Control Plane Protocols

As shown in Fig. 2, Radio Link Control (RLC) and the Packet Data Convergence Protocol (PDCP) layers usually concluded in RNC on the network side are now concluded in eNodeB. Radio Resource Control (RRC) functional conventionally applied in RNC is integrated into eNodeB [8]. The layers of Medium Access Control (MAC) and Radio Link Control (RLC) are implementing similar roles to the user plane.

The RRC functions include paging, system information broadcast, radio bearer control, connection management for RRC, measurement reporting to UE, and mobility functions. On the MME network side, the Non-Access Stratum (NAS) protocol is terminated while on the terminal side, the UE executes functions such as Evolved Packet System (EPS), authentication, security control, and bearer management. The interface protocol stacks S1 and X2 are presented where the protocols that used are similar in the two interfaces. The interface between S-GW and anode are interconnected by the S1 user plane interface (S1-U).

This interfacing is using GPRS Tunneling Protocol-User Data Tunneling (GTP-U) over UDP/IP transport. Moreover, it provided none numerated delivery to the user plane PDUs between S-GW and eNodeB [6]. GTP-U is a comparatively simple IP and is based on tunneling protocol that allows a lot of tunnels between end point's sets. In details, the S1 interfacing is separating the EPC and the E-UTRAN. It is split into two interfaces; the first is S1-U that are transfer's traffic data among S-GW and the eNodeB, and the second is S1-MME that is a signaling the interface between the MME and eNodeB.

X2 is the interfacing between the eNodeBs and also involving two interfaces; the first is X2-C, which is the control plane interface between eNodeBs, and X2-U are the user plane interface between eNodeBs. It is always supposed that there is an X2 interface between eNodeBs which is to provide communicating between each other [9]. S1-MME represents the S1 control plane interfacing between MME and eNodeB. Similarly, the transport network layer and user plane are based on IP transport and in case of a reliable transport to the signaling messages; the Stream Control Transmission Protocol (SCTP) is applied over IP top. These protocol functions analogously to TCP confirming a reliable, in sequence transmission of all messages with congestion control. SCTP drives analogous to TCP certifying reliable and offer in-sequence transport of messages with congestion control [10].

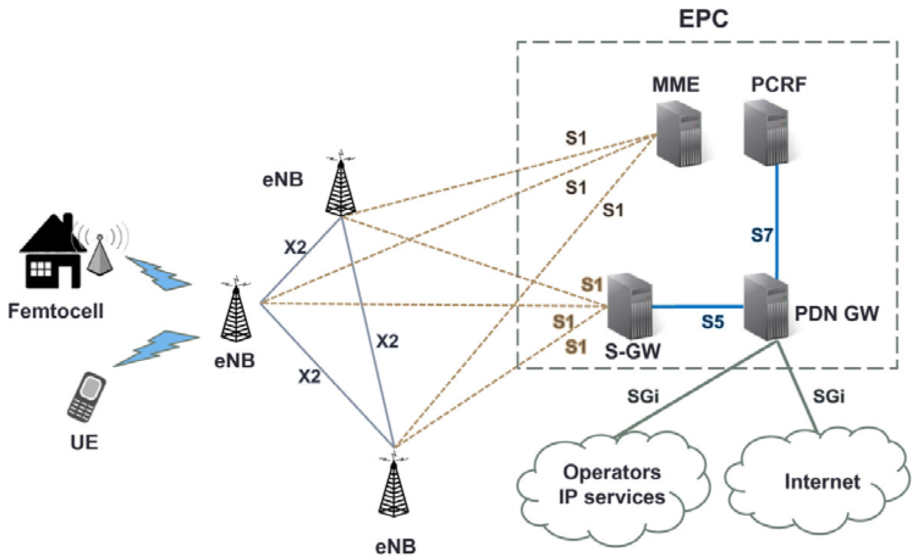

Fig. 2 Proposed model of LTE-Advanced system with three base stations and femtocell

The application layer signaling protocols is mentioned to S1 application protocol (S1-AP) and X2 application protocol (X2-AP) for S1 and X2 interface control planes respectively. LTE, 3GPP is also defining IP-based, flat network architecture. This architecture is defined as part of the (SAE) effort. The LTE/SAE architecture and concepts have been designed for efficient support of mass-market usage of any IP based service.

IV. Traffic Model and Simulation

The next generation and challenging network govern a set many guidelines that state movement, behavior, and the mobility (if mobile nodes supposed to be movable). Network simulators can then, by using this information, create random topologies based on node's position, parameters, and the tasks between the nodes [11]. Currently, there are many network simulators that have different features in different aspects. A short list of the current network simulators includes OPNET, NS-2, NS-3, OMNeT++, REAL, SSFNet, J-Sim, and QualNet. NS-2 is the most popular one in academia because of its open-source and plenty of component's libraries. A lot of non-benefit organizations contribute a lot in the component library, and it has been proven that the development mode of NS2 is very successful [12].

As mentioned before, the modeling in this article based on NS-2 as a modeler where NS-2 not just a simulator, but it’s a discrete event aimed to support the research and studies that deal with communications and network analysis. In addition, NS-2 provides environments to simulate and modeling multicast protocols; network traffic, handovers, and other network resources and conditions for wireless and wired channels [13]. In our research, we used NS-2 version 2.34, and this version installed over Windows XP or using Cygwin, where Cygwin provides a Linux-like environment under Windows, because NS-2 is supported by Linux operating system only.

The proposed model is shown in Fig. 3. It involves one main server for serving data as FTP and HTTP, also to providing source connection for the TCP.

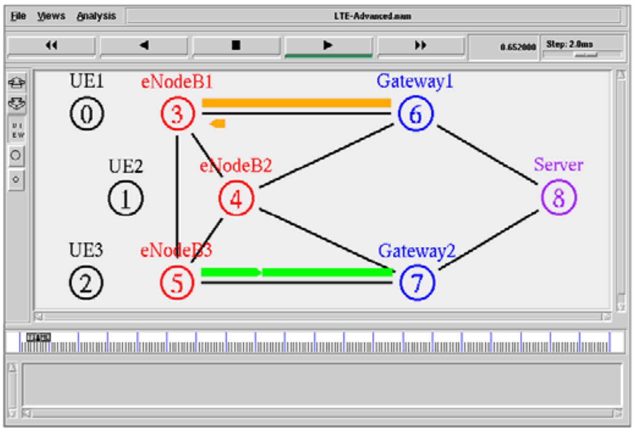

Fig. 3 Animation of LTE-Advanced layout model

The routers Gateway1 and Gateway2 are connected directly to the Server with a duplex link with bandwidth reach to 1Gbps, and propagation delay of three msec. In fact, the propagation delay for all links over the proposed model kept the same value of three msec, where this value represents the practical latency of the links interfacing and connections on LTE-Advanced networks.

The function of Gateway routers is to control the flow rate of the streaming data from the server to the base stations eNodeB1, eNodeB2, and eNodeB3. Gateway within the wired simplex link with Bandwidth reaches to 10 Mbps.

The interface between base stations (X2) is very important in a model setting due to the relation between eNodeBs will detect the handover scenario when the UEs move from one eNodeB to another. The base station nodes are responsible for buffering the data packets to the User Equipment's (UEs). Each base station (eNodeB) is connected to the corresponding the average bandwidth size of X2 proposed to be 20 Mbps and this represent the estimated and practical range. In the proposed model, three UEs used with wireless features and each UE coupled to eNodeB, these UE nodes don't have full mobility features because avoiding the handover scenario in this model where that represents the next step. The other main parameters of proposed LTE-Advanced model is illustrated in Table I, and we can note that all link kept for one propagation delay of 3msec, and the maximum packet size used sets to 1500 Byte, with minimum window size of 128 packets. The final model tested with simple experiments to evaluate the model. This experiment based on use TCP-Reno, TCP-Vegas, TCP-Tahoe, TCP-Newreno, TCP-Sack, and TCP-Fack to estimate and evaluate the performance of the proposed model to test the packet transfer, queuing, packet loss, and congestion window in the transport layer.

TABLE I
MODEL PARAMETERS

Parameters	Value
Protocol	TCP-Sack, TCP-Fack,TCP-Reno, TCP-Vegas, TCP-Tahoe, TCP-Newreno
Propagation Delay of all links	3 msec
Bandwidth eNodeB-eNodeB	20 Mbps
Bandwidth eNodeB-Gateway	10 Mbps
Bandwidth Server-Gateway	1 Gbps
Packet Size	1500 Byte
Window size	128 Packets

V. CONCLUSION

This article provides an experimented model to simulate the traffics and critical links of LTE-Advanced network using six TCP variants, Tahoe, Reno, Newreno, Sack, Fack and Vegas Furthermore, this article provides the basic procedures to implement the link interface for LTE-Advanced networks by using network simulator NS-2. In addition, it offers the main features of the user plane protocol, control plane protocol, and the link interface of the protocol stack and illustrate the parameter values which make the limitation to the behavior of these protocols over LTE-Advanced.

VI. FUTURE WORK

The future work of this research will focus to estimate the packet loss, queue size, and the throughput of the source TCP variants over the same model of LTE-Advanced.

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