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Significant Role Analysis of Transmission Control Protocols in 4G Cellular Systems

Ghassan A. Abed, Bayan M. Sabbar

***Abstract*—**The society of 3rd Generation Partnership Project (3GPP) is completed developing Long Term Evolution Advanced (LTE-Advanced) systems as a standard 4G cellular system. This generation goals to produce conditions for a new radio-access technology geared to higher data rates, low latency, and better spectral efficiency. LTE-Advanced is an evolutionary step in the continuing development of LTE where the description in this article is based on LTE release 10. This paper provides a model of the traffic links of 4G system represented by LTE-Advanced system with the effect of the Transmission Control Protocols (TCP) and Stream Control Transmission Protocol (SCTP) in term of throughput and packet loss. Furthermore, the article presents the investigation and the analysis the behavior of SCTP and TCP variants over the 4G cellular systems. The traffic model and the scenario of the simulation developed using the network simulator NS-2 using different TCP source variants.

***Keywords*—**LTE-Advanced, LTE, SCTP, TCP, 4G, NS-2.

I. Introduction

IN September 2009, the partners of 3GPP have prepared the official suggestion to the proposed new ITU (International Telecommunication Union) systems, represented by LTE with Release 10 and beyond to be the appraised 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 at an edge of 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 downlink (DL) [4]. With LTE-Advanced starting, there are many keys of requests and features that are up come to the light.

Ghassan A. Abed is now with Ministry of Science and Technology, Baghdad, Iraq (e-mail: dr.ghassan.abed@ieee.org).

Bayan M. Sabbar is now with Al-Nahrain University, Baghdad, Iraq (e-mail: dr_b2012@yahoo.co.uk).

II. Architecture of LTE-Advanced

3GPP identified in Release 8 the requirements and features and requirements of the architecture of 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. Each of these parts corresponded respectively to the network core, system air interface, and the radio access network. EPC is responsible to provide IP connection between an external packet data network by using E-UTRAN and the User Equipment (UE).

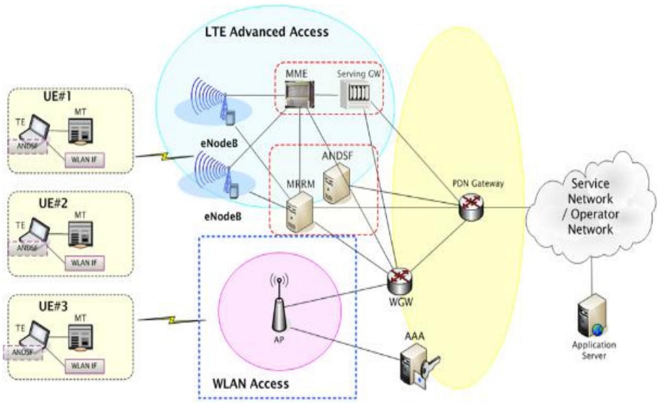

Fig. 1 LTE-Advanced architecture

In the environment of 4G systems, the radio access network and the air interface are actuality improved, while the architecture of core network (i.e., EPC) is not suffering large modifications from the previously 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 Packet Data Network Gateway (P-GW).

TABLE I
MODEL PARAMETERS

Parameter	Value
Protocol	SCTP, TCP-Reno, TCP-Vegas, TCP-Tahoe
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	20,128 Packets
Simulation Time	8,30 sec

The Serving Gateway (S-GW) is acted as 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 of 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).

III. Modeling of LTE-Advanced

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. 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's library, and it has been proven that the development mode of NS2 is very successful [8]. As mentioned before, the modeling in this article based on NS-2 as a modeler NS-2 not just a simulator, but it’s a discrete event aimed to support the research and studies that deal with communications and networks analysis. In addition, NS-2 provides environments to simulate and modeling multicast protocols; networks traffic, handovers, and other networks resources and conditions for wireless and wired channels. 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 shows in Fig. 2. It involves one main server to serving data as FTP and HTTP, also to providing source connection for the SCTP. The routers Gateway1 and Gateway2 are connected directly with the Server with a duplex links with bandwidth reach to 1Gbps, and propagation delay of three msec [9], [10].

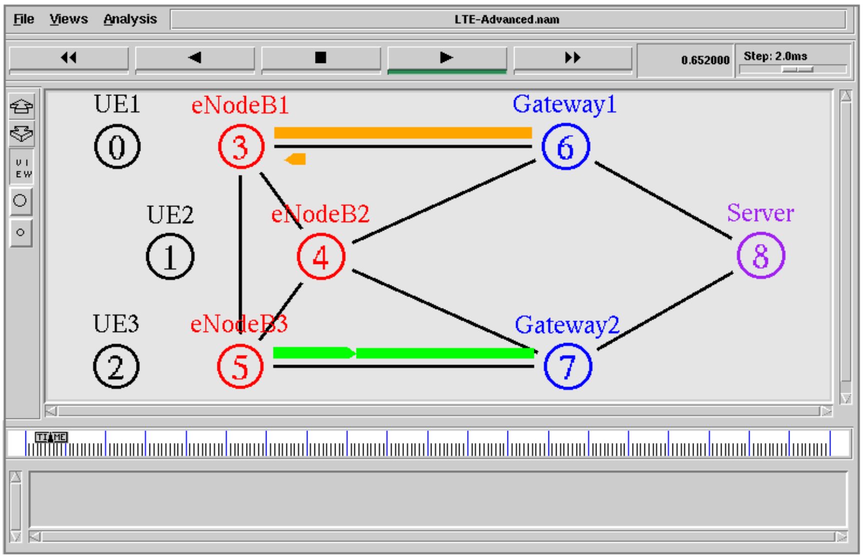

Fig. 2 Screenshot of LTE-Advanced interfacing in NS-2

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 in 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 wired simplex link with Bandwidth reaches to 10 Mbps. The interface between base stations (X2) is very important in 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 proposed model, three UEs used with wireless features and each UE coupled to eNodeB, these UE nodes not 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 are illustrated in Table I, and we can note that all link kept for one propagation delay of 3msec, and the maximum packet size of SCTP set to 1500 Byte, with minimum window size of 128 packets.

The final model tested with simple experiments to evaluate the model. This experiments based on use TCP-Reno, TCP-Vegas, TCP-Tahoe and SCTP to compare the behaviour of congestion window, throughput and the drops in packets for each protocol. Actually, window size set to 20 packets and short simulation time period for 8 seconds.

Fig. 3 demonstrates the throughput comparison between SCTP and TCP variants with probability of packet loss 10-8. SCTP and TCP-Reno are given a better throughput compared with Vegas and Tahoe.

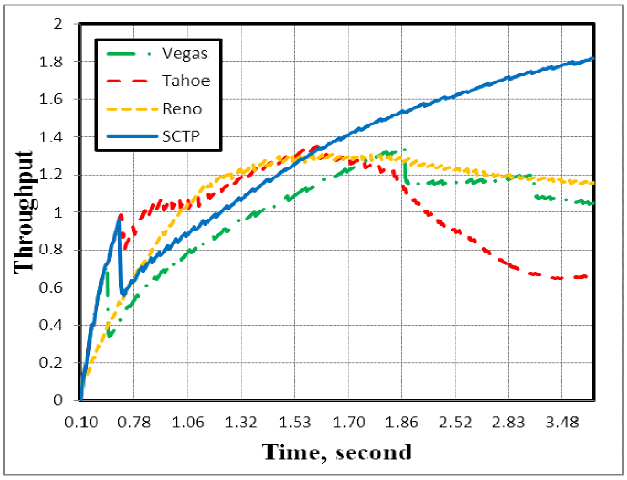

Fig. 3 Throughput comparison for TCP-Reno, TCP-Vegas, TCP-Tahoe, and SCTP

The reasonable level in packets dropping for Vegas due to the technique used in congestion control, while in other protocols (SCTP, Tahoe, and Reno) the congestion avoidance phase based on the detection to the first packet that drops to detect if congestion happened, where that lead to a lot of droppings just to detect the congestion point of the network path.

TCP-Tahoe not able to give high performance because still represents the ordinary TCP version, while Vegas use a new congestion control scheme by compare the actual window size with the expected size to give stable behavior and low level in packet dropping as shown in Fig. 4.

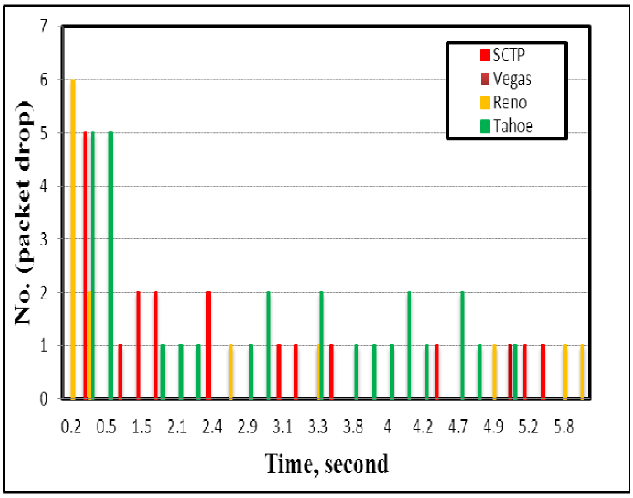

Fig. 4 Packets drop comparison for TCP-Reno, TCP-Vegas, TCP-Tahoe, and SCTP

IV. Conclusion

This paper 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 user plane protocol, control plane protocol, and the link interface of protocol stack and illustrate the parameters and values which make the limitation to the behavior of these protocols over LTE-Advanced. In addition, this paper explained the simulation link parameters in details and showed the real animation topology to the transport layer for LTE-Advanced system. The experimental test of the proposed model with SCTP and TCP variants proved that SCTP performs better than the other TCP variants while the number of packet dropped when using TCP-Vegas are less than packets dropped when used the other protocols.

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