Configuration and Demonstration of Relay-Enhanced Technique in LTE-Advanced Systems

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Abstract— **LTE (Long Term Evolution) specified by 3GPP (3rd Generation Partnership Project) as very high flexible for radio interfacing. LTE deployment started in the last of 2009 and the first LTE release is providing greatest rate reaches to 300 Mbps, delay of radio network not as much of as 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. Long Term Evolution Advanced (LTE-Advanced) network is the continuation of 3GPP-LTE and it targets to advanced develop of the requirements of LTE in terms of throughput and coverage. 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 architecture and the model of LTE-Advanced with the configurations of the relay-Enhanced technology used in this system that are improved to enhance the radio signal between the mobile station and the base station in LTE-Advanced system.**

Keywords— **LTE; LTE-Advanced; Relay-Enhanced.**

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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]. 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 [2].

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). 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. LTE-ADVANCED ARCHITECTURE

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. This identification specified two main work objects, called LTE and System Architecture Evolution (SAE) that leading to the description of EPC, Evolved Universal Terrestrial Radio Access Network (E-UTRAN), and Evolved Universal Terrestrial Radio Access (E-UTRA).

Each of them is correspond 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). 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.

In Fig. 1, E-UTRAN architecture of LTE-Advanced is shown. The main part in the architecture of E-UTRAN is the improved Node B (eNB or eNodeB), that is provide the air interface between the control plane protocol terminations and the user plane towards user equipment.
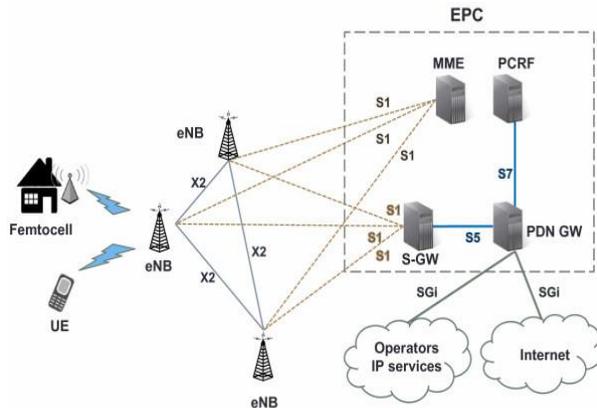
Figure 1.   LTE-Advanced E-UTRAN architecture

Each one of the eNodeBs is a logical element that serving one or more E-UTRAN cells and the interfacing between the eNodeBs is termed the X2 interface. Completely, 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 as illustrated in Fig. 1. The interface S1 is support a many relationship between eNodeBs and MME/GW.

III.   LTE-ADVANCED RELAYING

LTE-Advanced spreads coverage approaches for in-band and out-band relaying. LTE-Advanced adopted a relay technology to achieve self-backhauling of the radio signal between the mobile station and the base station on the level of layer 3. This technology targets to enhance the received signal and to improve the cell interface in addition to enhance the throughput. In this manner, the radio signal can be broadcasted more competently and the cell coverage is extended plus the throughput improved at the edge of the cell [1].

The Relay Node (RN) is linked with by Uu interface and connected to a contributor cell (eNodeB) through the Un interface as shown in Fig. 2.
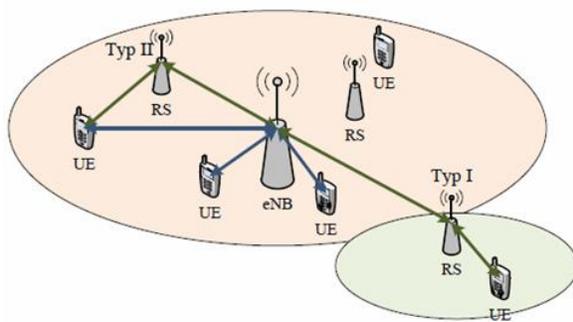

Figure 2.   LTE-Advanced relaying architecture and types

RN separates cell with individual physical cell ID and synchronizing channels, reference symbols, etc., where that means wholly Uu control plane and user plane protocols are concluded in the RN [3]. Two types of relaying have been defined in 3GPP LTE-Advanced standards, Type 1 and Type 2, or can classify to transparency and non-transparency [4].

In detail, a Type 1, which is non-transparency relaying, can assist the remote UE that which locates far-off from an eNodeB to contact the eNodeB. Thus, Type 1 requires sending a general reference signal and to adjust the information for the eNodeB.

Hence, the core objective is to cover signal and service coverage where that can help to contribute to the system capacity by enabling extra communication services and data transmission for the isolated UEs [4]. On the other type (Type 2), the transparency relaying helps local UEs, which is positioned within the coverage of an eNodeB and has a straight connection with the eNodeB to enhance the link capacity and the service quality.

Therefore, Type 2 cannot send a common reference signal or control the information, but its central objective is to growth the capacity of the network via realizing multipath range for the local UEs.

IV.   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 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 [2].

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 [5]. 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. 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 [6].

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 Tahoe, Reno, Newreno, Vegas, Sack, and Fack, plus STCP 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 [7], while the maximum TCP's window size set to different values to monitor the behavior in slow-start phase. Table I shows the links parameters of the proposed model including the bandwidth and propagation delay for each link while Table II illustrates the other simulation parameters.

TABLE II.
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

V. TOPOLOGY IMPLEMENTATION

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 analyzed. 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 [8]. 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 [9].

Fig. 3 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.

TABLE I.
TOPOLOGY LINKS PARAMETERS

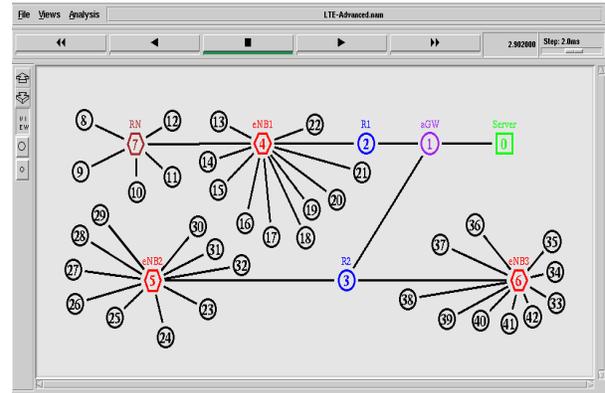| Link	Bandwidth	Delay
Server-aGw	100 Mbps	100 msec
aGW-Router 1	1 Gbps	3 msec
aGW-Router 2	1 Gbps	3 msec
Router 1-eNodeB 1	20 Mbps	3 msec
Router 2-eNodeB 2	20 Mbps	3 msec
Router 2-eNodeB 3	20 Mbps	3 msec
eNodeB1-Relay Node	20 Mbps	3 msec
eNodeB-UE	2 Mbps	3 msec

Figure 3. LTE-Advanced model animation in NS-2

One of the most important scenarios added in this model is by using Relay Node to achieve additional coverage to five separated UEs. 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.

VI.　CONCLUSION AND DISCUSSION

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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