Studying the Performance of Streaming Data over LTE-A Networks based on HARQ Mechanism

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Abstract— The transmission of streaming information faces numerous issues, for example, an Expansive number of packet's drops; Lower estimations of SNR; the abnormal state of the likelihood for packet's Collusion's; and diverse instances of interference. 4G systems, for example, WiMAX and LTE can deal with impeccably with the basic issues for gushing innovations that fulfill elite of access and reasonable use for all clients under system over-burdening conditions. In this paper, we have altogether assessed the impact of various portability cases with the irregular movement of information and information in light of IP packets with and without the impact of hybrid automatic repeat request (HARQ) that is the critical strategy to enhance the nature of access in any correspondence framework. Likewise, we have proposed to think about the impact of LTE organizes on the streaming information with fixed and portable client equipment (UE's) at 10 MHZ FDD1 at 1.925 GHz, FDD2 at 2.115 GHz and FDD3 at 2.12 GHz uplink (UL) base frequency. The simulation results had been shown that HARQ execution is required because of the random movement of packets between the 2 cells to limit the packet's drops and maximize the general SNR under the impact of LTE connect with adaptable data transmission. At last; because of the higher number of retransmission data at the immersion of DL channel; the UE Portable can send all movement without the interference and expanding SNR.

Index Terms— Worldwide Interoperable Microwave Access (WiMAX), Long Term Evolution (LTE), Signal to Noise Ratio (SNR), Hybrid Automatic Repeat Request (HARQ), Bit Error Rate (BER), Channel Quality Indicator (CQI), Automatic Repeat Request (ARQ)

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1 Introduction and Motivations

The nature of access for media over wireless systems has numerous difficulties as per the delay of transmission and reception procedure and general packet's misfortunes. The transmission and reception process for streaming information over 4G systems controlled by the base station of the wireless system so the irregular access of streaming information over 4G systems may cause the higher level of information misfortunes and lower SNR rates that it is an unsatisfactory issue in information quality. These advances are considered as the favored schemes for enhancing the general framework quality as per the system principles. The significant challenges that faces the access of these services over 4G systems are: (I) the base station and (II) the subscriber station and separation between them through a specified bandwidth so in 4G systems the channel has an adaptable data transmission extended from 1.4 up to 20 MHz because of frequency division duplexing and time division duplexing to permit adaptable access to the channel data transfer capacity. The foundation of the convention stack for LTE and WiMAX systems is the PHY layer that called Layer 1 so the PHY layer is the stander of BS to versatile station accessibility [1]. The inspirations for our work are outlined as Conquered the problems of Streaming multimedia over wireless Systems; Enhancing the nature of access streaming multimedia over wireless Systems and Concentrate the Effect of Changing the position of UE amongst fixed and mobile on the general services.

In 2015, Mapoka, Trust T., et al. [2] talked about a dispersed handover streamlined authentication scheme based on free session key per get to organize (HOKA) that produced for the decentralized multi-benefit assemble key administration conspire over remote versatile multicast. It empowers a handover client engaged with different multicast benefit memberships to safely reuse the long-haul certification at first issued by the put stock in authentication server (As) for determining one of a kind session keys per get to organize as it performs handover verification crosswise over different access arranges that rearrange handover by lessening handover trade flagging constituting to handover delays.

In 2016, 2017 and 2018, S. Zhou, et al. [3-5] clarified the examination of the execution of First-In, First-Out (FIFO) lines over remote systems by portray the security locale of a general situation where a self-assertive number of FIFO lines, which are served by a remote medium, is shared by a self-assertive number of streams. All in all, the solidness locale of this framework is non-arched. In this manner, it builds up a raised internal bound on the soundness locale, which is most likely tight in specific cases. The Reenactment comes about demonstrate that the talked about calculations essentially enhance the throughput of remote systems with FIFO lines when contrasted with the outstanding line-based stream control.

This framework is arranged in to two fundamental parts that have been produced to examine : (I) Fixed and Portable UE'S over LTE systems: This part talks about the irregular movement of information over LTE systems and make investigation for that movement in light of the SNR and packet loss ratio for both of UL and DL interfaces ; and (ii) HARQ Execution: in this part the reenactment had demonstrated that the movement of information in IP packets under the impact of HARQ can present a optimize performance for information misfortunes and noise decreases that will cause idealize access for these administrations over wireless systems. This framework speaks to the point of quality where we are utilizing a LTE organize that has numerous benefits empowering us to enhance the nature of access and increment the speed of access with higher rates for SNR and lower PLR whatever the quantity of SS and system over-burdening. Then again; this framework demonstrates that, the random movement of streaming data under the impact of LTE organize fulfill abnormal states for SNR that 30 dB for mobile UE's and 35 dB for fixed UE's and lower packet's misfortunes close to zero for both of fixed and mobile UE's at 10MHZ FDD3 at 2.12 GHZ base frequency; additionally we can build up this technology without squandering the channel data transmission by utilizing HARQ that we increment the transmission rates up to 700 packets / sec that causes SNR level expanded to 50 dB for mobile UE's and 40 dB for fixed UE's at level close to zero packets drops. The staying of this paper has been sorted out as takes after: (2) 4G networks; (3) Mobility in wireless networks; (4) HARQ in LTE networks; (5) simulation results and discussion; and (6) Conclusion and suggested Future Work.

2 4G Networks

4G organizes as WiMAX and LTE are thinking about as a standard technology for mobile data communication administrations. The principle focusses of utilizing 4G systems is to expand the general framework limit and speed of access of the remote systems. By Contrasting and alternate wireless system advancements, LTE has numerous highlights. The general QoS will be enhanced by LTE and information exchange rate will be controlled amid transmission, for example, downlink (DL) information rate of no less than 100 Mbps and uplink (UL) information rate of no less than 50 Mbps which in the meantime discharges the issue of postponement amid the web association. LTE likewise bring down the information exchange inactivity which is under 5ms. By utilizing OFDMA for DL a single carrier frequency division multiple access (SC-FDMA) for UL for LTE, it saves more energy to make the gadget been utilized for a longer time by the supporter that considered as the most basic highlights in LTE technology. LTE has the wide ranges for some scalable carrier bandwidths went from 1.4 MHz to 20 MHz [6].

3. Mobility in Wireless Networks

3.1 Spectrum Analysis for LF and HF

The radio frequency spectrum is divided into several bands, starting as low as 30 kHz for wireless communication and ranging up to 300 GHz. Low frequency radio waves easily pass through walls, water, etc. Higher frequencies are absorbed and reflected by obstacles [7].

3.2 Signal Strength and the Transmission Distance

The signal strength is fading with a power of two with respect to the distance. This implies that if one tries to send over a distance of d transmission power has to choose is proportional to (d^2) in empty space [7].

3.3 Cellular Networks

Cellular networks are defined by static base stations which divide the fields into cells. All radio communication is between these base stations and the clients. Usually, each static base station forwards and receives packets to other base stations by another network. It is not interesting where the node is exactly located within a cell. In some cellular networks (like UMTS) the size of the cell changes with the number of nodes [7].

3.4 Mobility Problems in Cellular Networks

The main mobility problems for cellular networks are: (I) Cellular Handoff: Provide a robust protocol that allows moving between cells without interrupting and disturbing communication; and (II) Location Service: Use the cell information and the power strength to locate a client within the network [8].

3.5 Main characteristics of Mobility Patterns

The main characteristics of mobility patterns in wireless networks can be explained as follow: (I) Group behavior: Is there a set of nodes staying together for a considerably long time? Clearly, exploiting group behavior improves the performance of radio communication by clustering; (II) Limitations: What are the speed and / or acceleration bounds in the mobility pattern? (III) Dimensions: Do the nodes move in three-dimensions or only planar or linear? and (IV) Predictability: How well can the behavior of the nodes are predicted? [9]

3.6 Challenges of Mobility over Wireless Networks

Mobility in wireless networks faces many challenges such as; (I) Find mobility models for specific mobility patterns and prove their validity by comparing them with reality; and (II) Prove the efficiency and reliability of a real network protocols with respect to a given mobility model [9-12].

4. HARQ in LTE Networks

In LTE system incremental redundancy (IR) based hybrid ARQ with Chase combining as a special case of IR is employed. In terms of timing and adaptively, asynchronous adaptive (AA) hybrid ARQ is used in the downlink while synchronous adaptive hybrid ARQ is employed in the uplink. The new data indicator (NDI) field in the uplink scheduling grant is used to indicate if the grant is for a retransmission of a previous transmission or grant for a new transport block transmission. If the control message is received with the NDI bit toggled, this means that eNB is scheduling a new uplink transmission. On the other hand, if NDI is not toggled, this means a retransmission of the previous transmission attempt. Moreover, if no uplink scheduling assignment is received while an ACK is received on the Physical Hybrid Automatic Repeat Request Indicator Channel (PHICH), this indicates successful transmission of the uplink transport block [13].

4.1 Number of Hybrid ARQ Process

The N-channel SAW (Stop and Wait) deployed in LTE consists of number of channels or number of HARQ processes depending on the buffering and delays. This is defined as the number of HARQ processes that can be initiated at a given time. This Number is given by:

$$N_{HARQ} = \frac{2T_P + T_{sb} + T_{uep} + T_{ack} + T_{nbp}}{T_{sb}} \quad (1)$$

Where

T_P: Propagation Time between eNB and UE

T_{sb}: Sub-block transmitter Time
T_{uep}: Processing time of UE
T_{ack}: Transmitter Time of ACK / NACK
T_{nbp}: Processing Time of eNB

Table 1 summarizes all the values used in the Round-Trip Time (RTT). Using all the values from the table in the equation for N_HARQ:

TABLE 1
RTT PARAMETERS FOR LTE

Parameter	Symbol	Value
Propagation Time	T_P	Negligible
Sub block transmitter Time	T_{sb}	1ms
UE Processing Time	T_{uep}	3ms
Ack Transmission Time	T_{ack}	1m
Processing Time of eNB	T_{nbp}	3ms

4.2 HARQ Model and Algorithm

The HARQ process used is asynchronous HARQ process in the downlink and a synchronous HARQ process in the uplink. Both these processes have been discussed earlier. Asynchronous will allow eNB to transmit whenever it has packet available to be scheduled. While a synchronous HARQ can only transmit in a fixed time slot. Given the SINR and MCS equation that used in deriving the BLER:
Where:

$$BER = 0.2e\frac{-1.5\gamma}{M-1} \quad (2)$$

Where:

γ: $SINR, Valid\ from\ 0\ to\ 30\ dB$ can be written as

$$\gamma = \frac{S}{N_0 B} \quad (3)$$

S: Signal received power; N0=Noise density; and B=Bandwidth
M= Modulation Coding Scheme used where $M = 2^n$
The efficiency of modulation code rate is given by

$$n = \log_2 M \quad (4)$$

A Channel Quality Indicator (CQI) concept is used here which maps the SINR to the transmitted data bits and the modulation coding scheme. Based on some previous work, a simplified version of the CQI table is used here in the implementation. This CQI is used by eNB to determine the modulation and coding scheme. A flowchart of the ACK / NACK process is depicted in the figure 1 up to 3. It can be seen that if the random assigned number is below a threshold BLER, the packet seemed to be corrupted or contain error. Therefore, a NACK is being sent in this case. The working of chase combining as well as incremental redundancy was previously discussed. These 2 flowcharts explain the operations that take place in these methodologies. The CQI is mapped using some simplified values for this model. SINR is included in here. The eNB uses the CQI to calculate the MCS. Table 2 depicts the downlink SINR to data rate mapping.

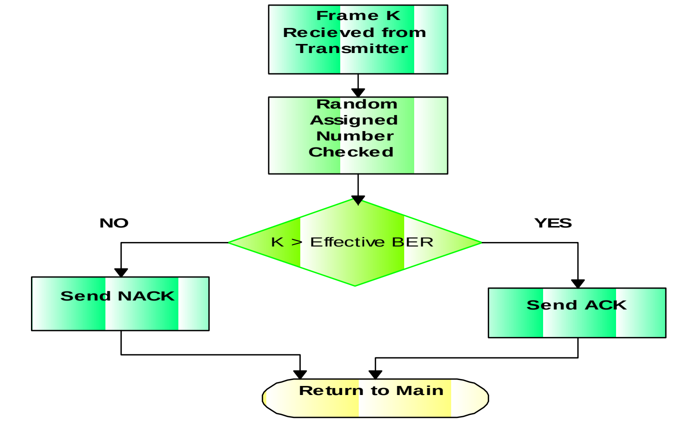

Fig. 1. Flow Chart of ACK/NACK Process

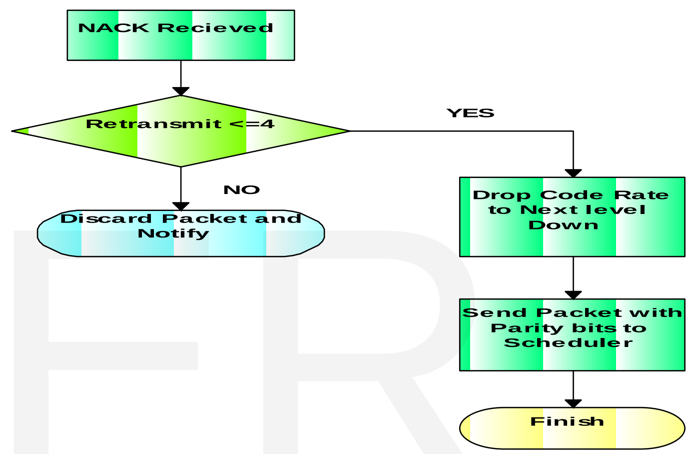

Fig. 2. Flowchart of Incremental Redundancy

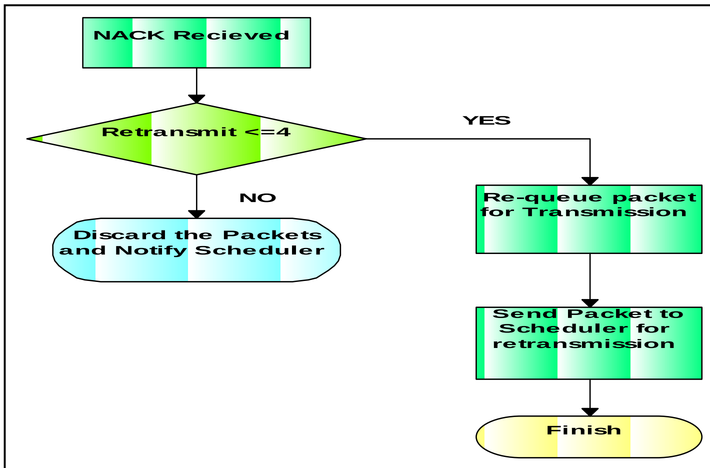

Fig. 3. Model of Chase Combing

LTE standards were emulated without introducing complexity to the system. But some extra requirements had to be added. Firstly, the eNB needs to wait for 8ms before it can send a retransmission of the packet. The time taken to send an ACK / NACK is 1ms by the UE. The eNB and UE takes 3ms each in processing the frame. Therefore, a total of 8ms is required for the data transmission to the receiving of the ACK / NACK by eNB [13-17].

TABLE 2
DL SNR TO DATA RATE MAPPING

Minimum Instantaneous DL SNR Value (dB)	Modulation and Coding	Data Rate (Kbps)
1.7	QPSK (1/2)	168
3.7	QPSK (2/3)	224
4.5	QPSK (3/4)	252
7.2	16 QAM (1/2)	336
9.5	16 QAM (2/3)	448
10.7	16 QAM (3/4)	504
14.8	64 QAM (2/3)	672
16.1	64 QAM (3/4)	756

5. SIMULATION RESULTS AND DISCUSSION

The simulation was performed to study the mobility effect on the performance of streaming data over the LTE networks. We used the OPNET simulator 17.5 Modeler to examine the behavior of streaming data over LTE networks in the real time domain with reasonably accurate emulation of multiple network topologies. Different eleven scenarios have been designed in our simulation as shown in Tables 1 and 2. Their simulated results were accumulated to analyze the effect on overall performance and all of results are monotonically and stable without any resonance.

5.1 Mobility Analysis for Fixed and Mobile UE's over LTE [Random Motion]

5.1.1 Network Topology and Simulation Parameters

The network topology as shown in figure 4 consists of LTE Configuration tool; LTE Base Station; LTE UE (Mobile and Fixed); Gateway; Ethernet Server; and IP Clouds. Assuming the bandwidth of the channel is 10 MHZ. two cells configured with 10 MHz FDD PHY Profile: On LTE BS, the attribute LTE PHY Profile is promoted to simulation level. Results of 3 simulation scenarios are presented in this run. In each run, this attribute is assigned to a different value: (I) LTE 10 MHz FDD 1: This is the standard 10 MHz FDD profile with 1.92 GHZ UL Base Frequency and 2.11 GHz DL Base Frequency. This profile is used by eNodeB_2 in each simulation run. (II) LTE 10 MHz FDD 2: This is a 10 MHz FDD profile with 1.925 GHz UL Base Frequency and 2.115 GHz DL Base Frequency; (III) LTE 10 MHz FDD 3: This is a 10 MHz FDD profile with 1.93 GHz UL Base Frequency and 2.12 GHz DL Base Frequency.

5.1.2 Results and Discussion for Fixed and Mobile UE's over LTE [Random Motion]

This simulated system takes around six minutes to configure each scenario. We considered the SNR, Packet losses and transmission and retransmission rates as a reference of quality measurements for this study. At the first view, the simulated system provided a stable delay response during the simulation time.

Different scenarios are configured and listed as shown in table 3.

TABLE.3
STATE OF SCENARIOS FOR FIXED AND MOBILE UE'S OVER LTE [RANDOM MOTION]

No. of Scenario	FDD	State of scenarios
Scenario1	FDD1 (1.925 GHZ)	Fixed UE's
Scenario2	FDD2 (2.115 GHZ)	
Scenario3	FDD3 (2.12 GHZ)	
Scenario4	FDD1 (1.925 GHZ)	Mobile UE's
Scenario5	FDD2 (2.115 GHZ)	
Scenario6	FDD3 (2.12 GHZ)	

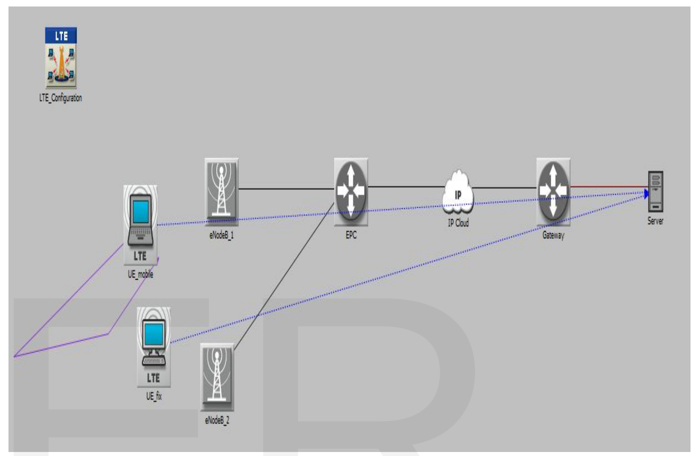

Fig. 4. Network Topology for Fixed and Mobile UE's over LTE [Random Motion]

- **Signal to Noise Ratio (SNR “dB")**

Figures 5 and 6 are shown below discussed the SNR at different three scenarios that in Uplink SNR there are two states SNR without collision and SNR with collisions. In Uplink SNR graphs, solid lines correspond to SNR without collision and dotted lines correspond to SNR with collisions. For UE Fixed in figure 5, we see that the response at FDD 3 is constant during the simulation run. This is because the node is not mobile. For UE Mobile in figure 6, we see that the response at FDD 2 is not constant during the simulation run this is due to path loss which is due to mobility. But for both nodes, we see lots of data points that correspond to collisions, except when LTE BS PHY Profile is set to LTE 10 MHz FDD 3. Because in this case there's no interference. We also see that average SNR is lowest with LTE 10 MHz FDD (full overlap) and a little higher with LTE 10 MHz FDD 2 (partial overlap). Noted that the accepted value for the SNR in QoS standards is 25dB that in our simulation at FDD3 10 MHz reaches to 35dB in case of fixed UE and 30dB in case of mobile UE.

- **Uplink Packets Drops (Packets/sec)**

Figures 7 and 8 are shown discussed the overall packet drops due to the packet collisions in case of signal mobility in comparison with fixed case. UE mobile SNR is Low and this causes packet drops in the first and second scenarios. We also see that drops are more in the first scenario with full overlap.

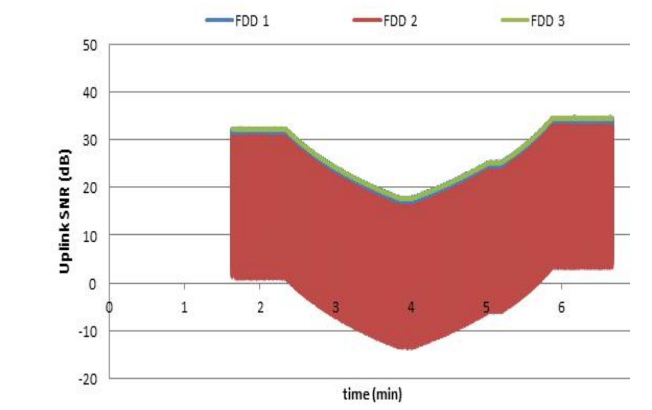

Fig. 5. UL SNR for Mobile UE

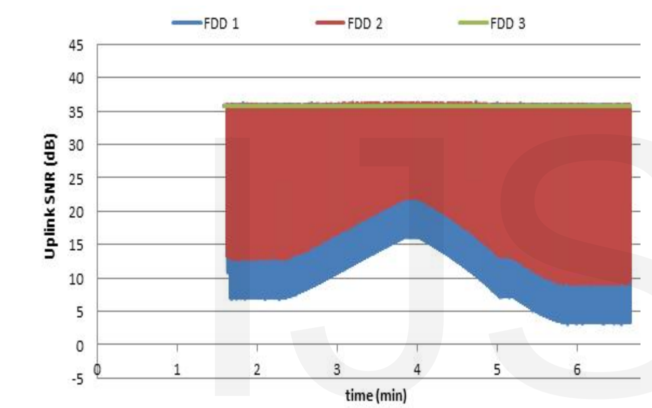

Fig. 6. UL SNR for Fixed UE

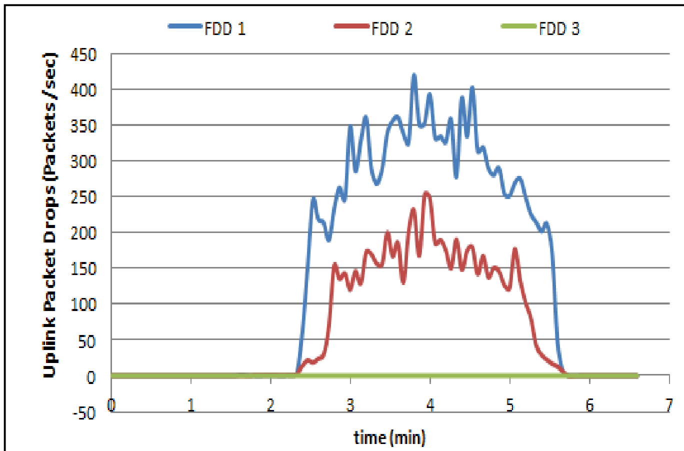

Fig. 7. UL PHY Packet Drops for Mobile UE

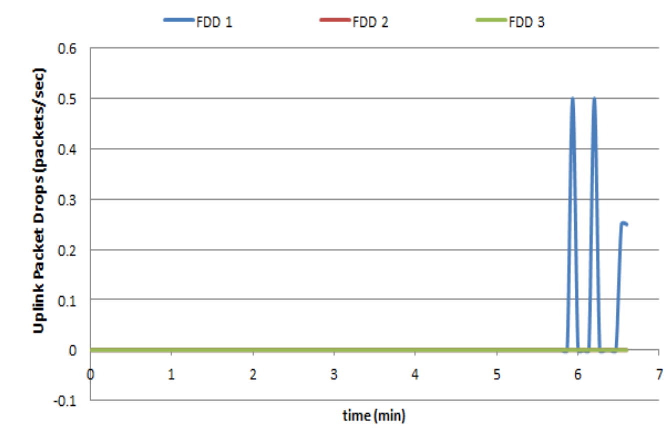

Fig. 8. UL PHY Packet Drops for Fixed UE

- HARQ Retransmission

In figures 9 and 10 that are shown below; HARQ retransmissions on the uplink direction in which we see that UE fixed receives the uplink traffic without any drops HARQ performance is required due to the random motion of packets between the 2 cells and in this case the total number of packet drops is decreased during HARQ retransmission in comparison with figures 5 and 6. The amount of packet loss is taken into account and the transmission of packet continues since there is no threshold mechanism for buffer size.

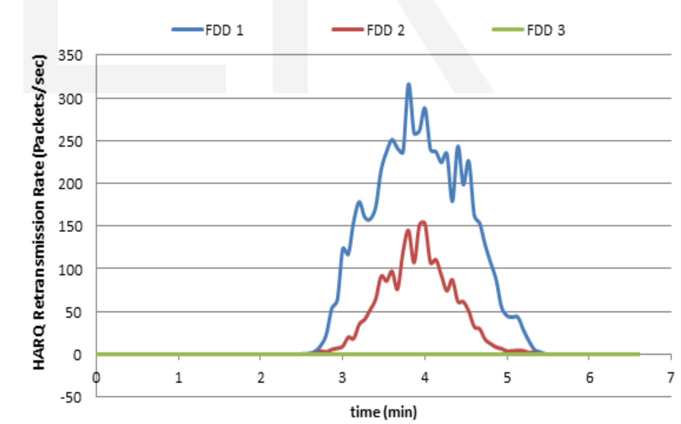

Fig. 9. UL HARQ Retransmission Rate for Mobile UE

In Uplink SNR there are two states SNR without collision and SNR with collisions. For UE Fixed, we see that the response is constant in all three scenarios because the node is not mobile. For UE Mobile, we see that the response is not constant this is due to path loss which is due to mobility. We see lots of data points that correspond to collisions except at FDD 3 there is no interference. UE_mobile SNR is Low and this causes packet drops in the first and second scenarios. We also see that drops are more in the first scenario with full overlap. HARQ retransmissions on the uplink direction. We see that UE_fixed receives the uplink traffic without any drops. HARQ performance is required due to the random motion of packets between the 2 cells.

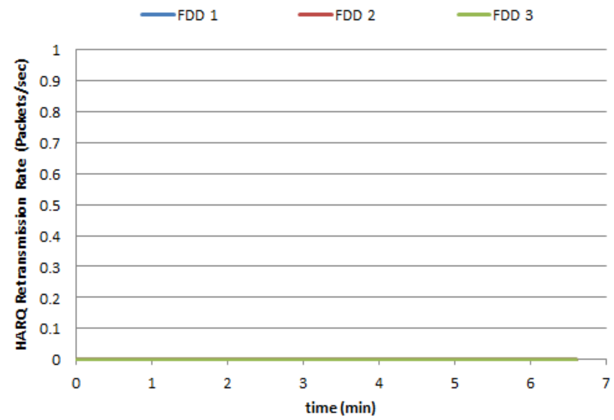

Fig. 10. UL HARQ Retransmission Rate for Fixed UE

5.2 HARQ Performance

5.2.1 Network Topology and Simulation Parameters

The network that shown in figure 11 including the following parameters: (I) 2 cells configured with 3 MHz FDD PHY Profile; (II) UE_Ethernet_Gateway is connected to eNodeB_1 and UE_mobile is connected to eNodeB_2; (III) UE_Ethernet_Gateway is 1500 meters away from eNodeB_1; and (IV) UE_mobile is following a trajectory towards north. At t = 230s, UE_mobile is 1500 meters away from eNodeB_2. The scenarios of simulation are listed in table 4.

TABLE.4

STATE OF SCENARIOS FOR HARQ PERFORMANCE

No. of Scenario	State of Scenario
Scenario7	Dropped Packet Rate
Scenario8	Transmission Rate
Scenario9	Retransmission Rate
Scenario10	DL SNR [UE_Ethernet_Gateway]
Scenario11	DL SNR [UE_mobile]

- **UE Ethernet Gateway Configuration**

The attribute "LTE" Advertised IP Address List on UE Ethernet Gateway specifies the list of host IP addresses that will be advertised by this UE router. This is required for downlink traffic to reach the nodes behind this UE router. This information is passed to the EPC node during the attachment procedure. Note that this feature is available only in UE Ethernet Gateway node model. In this scenario, the IP Address of Ethernet Workstation (192.0.6.1) is advertised. For uplink traffic, static routing is required in the UE router as discussed in table 5:

TABLE 5

STATIC ROUTING FOR UL

Destination Address	Next Hop
192.0.3.1 (Server)	192.0.7.1 (EPC Router)

For downlink traffic, static routing is also required in Gateway and IP Cloud nodes until the traffic reaches the EPC node as discussed in table 6:

TABLE 6

STATIC ROUTING FOR DL

Destination Address	Next Hop
192.0.6.1 (Ethernet Workstation)	192.0.7.1 (EPC Router)

- **Traffic Configuration**

UE mobile and Ethernet Workstation have 1200 kbps of downlink IP flows. This load, including the HARQ retransmissions, is saturating the downlink channel. Note that, without interference, the channel capacity is able to carry all of this traffic as shown in figure 11.

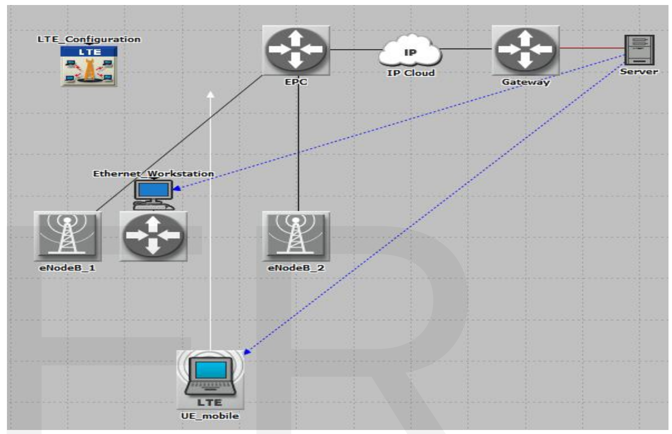

Fig. 11. Network Topology for HARQ Performance

5.2.2 Simulation Results and Discussion

- **UE Ethernet Gateway and Mobile (HARQ) in DL for LTE Systems**

Figures 12 and 13 that are shown below discuss the following parameters: (I) Dropped packet rates; (II) Retransmission Rate; and (III) Transmission rate. By the aid of IP packet routing and HARQ mechanism the total numbers of dropped packets are decreased and near to zero level in comparison with the system without that mechanism and also we can send more than 800 packets/sec for UE Ethernet Gateway and 700 packets/sec for UE Mobile Gateway with the aid of transmission and retransmission rates; so HARQ mechanism solve the random motion of packets between LTE cells by reducing the total number of packet losses at higher rates of transmission and retransmission states.

- **Signal to Noise Ratio**

The SNR for DL is shown below in figure 14 that discusses the effect of packet motion between cells under the effect of routing mechanisms for IP packets in Ethernet Gateway and UE Mobile Gateway. From the response of the DL SNR we can deduce that SNR for UE Mobile is lower compared to UE Workstation that

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can be solved by More HARQ retransmission for UE Mobile by comparing the response for UE Ethernet Gateway and UE mobile [around 600 packets/sec]. Due to higher number of retransmission at the saturation of DL channel; the UE Mobile is able to send all traffics without the interference and increasing SNR. Packets drops are decreased under the HARQ transmissions under the effect of LTE networks.

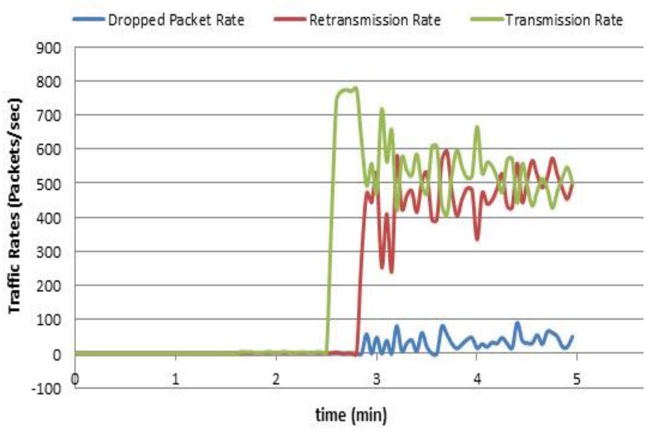

Fig. 12. UE Ethernet Gateway (HARQ)

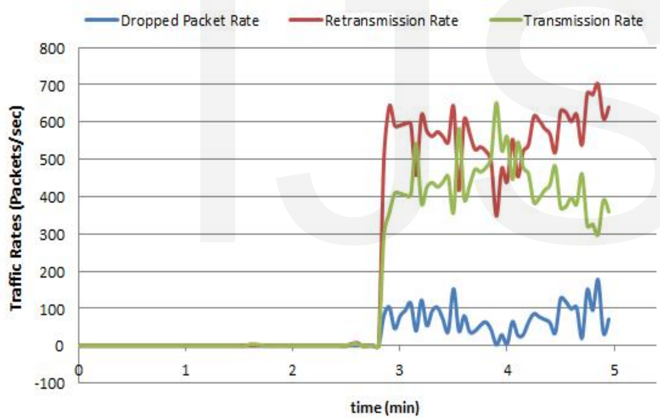

Fig. 13. UE Mobile Gateway (HARQ)

6. Conclusion and Suggested Future Work

4G networks LTE has become a standard and level of measurements for a high quality of signal transmission and reception and is being used. The simulation results indicate that mobile LTE with HARQ retransmission rates can deliver sufficient flexible bandwidth while ensuring that high level of signal to noise ratio and lower level of packet losses as shown numerically in tables 7 up to 11; also, in figures 13 and 14. This paper presented OPNET simulated networks to show the effect of mobility on streaming data over 4G networks to realize good empirical values for these technologies. A multimedia streaming required a high level of quality to verify the fair access for all users. OPNET allows us to measure two major critical metrics such as: (I) Signal to Noise Ratio; and (II) Packet dropped during the transmission and reception processes. Simulation results show that HARQ performance increase the level of quality for both fixed and mobile UE's over LTE networks also LTE networks controls on streaming data flow with random motion the thing that deemed to be perfect issue. Future work includes more suitable models for quality of access for mobility on streaming data over mobile LTE networks at different types of network connections under the effect of different traffic loads and different paths between BSs and SSs and study different conditions for network to satisfy the best quality all the time of the service's access.

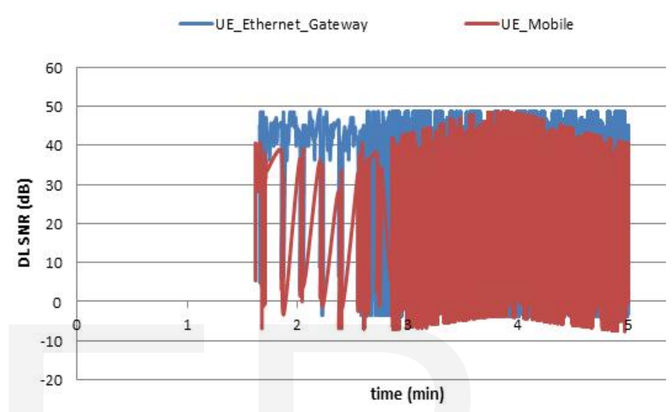

Fig. 14. SNR for DL

TABLE.7

SNR FOR FIXED AND MOBILE UE'S

State of Scenarios	Fixed UE's	Mobile UE's
FDD1 (1.925 GHZ)	20	19
FDD2 (2.115 GHZ)	30	22
FDD3 (2.12 GHZ)	35	30

TABLE.8

UL PHY PACKETS DROPS (PACKETS/SEC)

State of Scenarios	Fixed UE's	Mobile UE's
FDD1 (1.925 GHZ)	100	400
FDD2 (2.115 GHZ)	0	250
FDD3 (2.12 GHZ)	0	0

TABLE.9

UL HARQ RETRANSMISSION RATE

State of Scenarios	Fixed UE's	Mobile UE's
FDD1 (1.925 GHZ)	0	300
FDD2 (2.115 GHZ)	0	150
FDD3 (2.12 GHZ)	0	0

TABLE.10
TRAFFIC RATES (HARQ PERFORMANCE)

State of Scenarios	UE_Ethernet_Gate-way	Mobile Gate-way
Dropped Packet Rates	20	100
Retransmission Rates	500	600
Transmission Rates	750	650

TABLE.11
SNR FOR FIXED AND MOBILE UE'S

State of Scenar-ios	UE_Ethernet_Gate-way	Mobile Gate-way
DL SNR	50	48

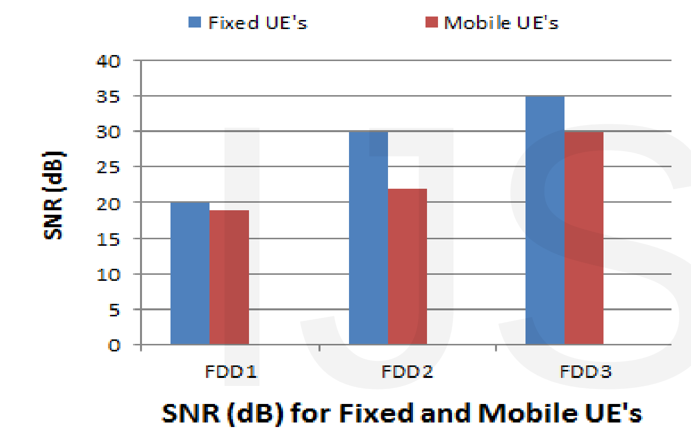

Fig. 15. SNR (dB) for Fixed and Mobile UE's

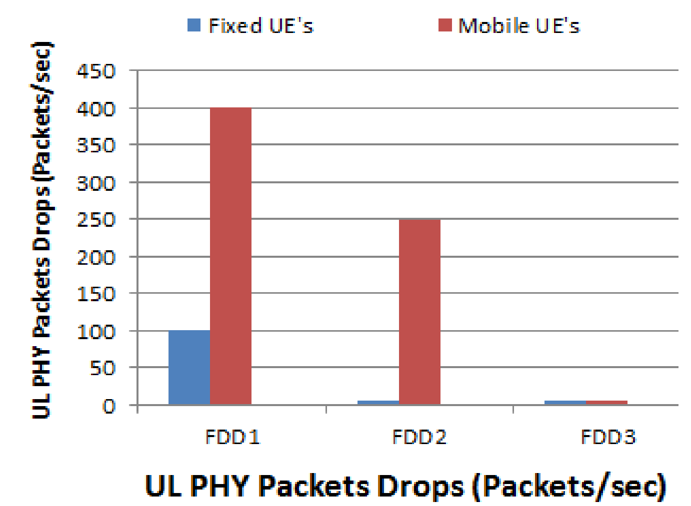

Fig. 16. UL PHY Packets Drops (Packets/sec)

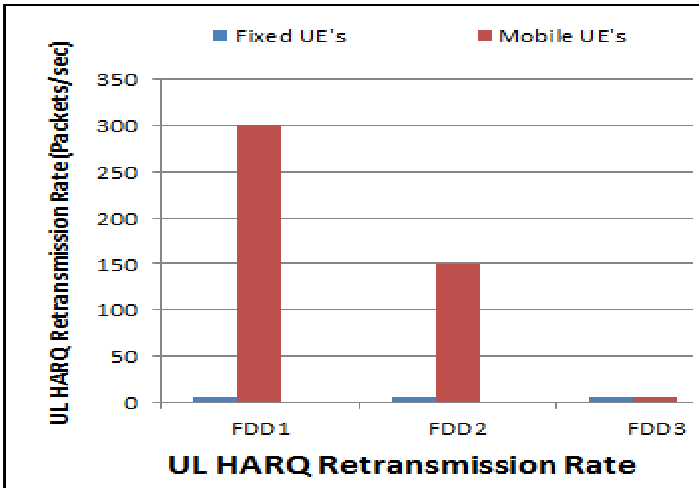

Fig. 17. UL HARQ Retransmission Rate

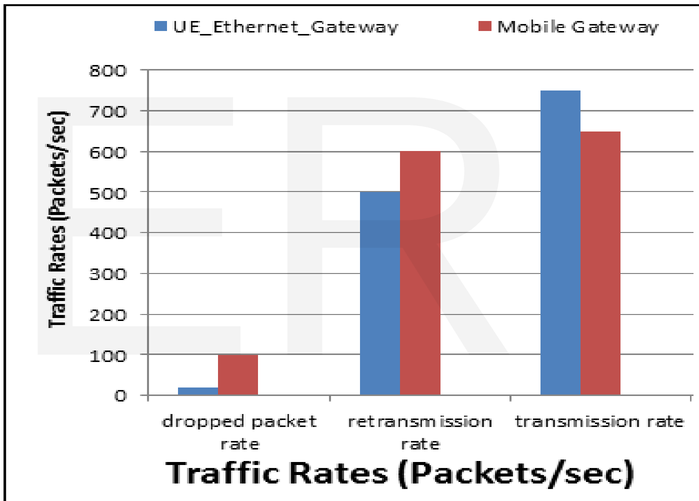

Fig. 18. Traffic Rates (Packets/sec)

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