International Journal on Advanced Science Engineering Information Technology

Vol.9 (2019) No. 4
ISSN: 2088-5334

Performance Evaluation of Power Efficient Mechanisms on Multimedia over LTE-A Networks

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***Abstract*— Power optimization is a critical challenge in multimedia services over cellular communication systems. Long Term Evolution-Advanced (LTE-A) has been developed for higher bandwidth access for accommodating today's heavy data applications to provide better performance. Idle mode permits cellular stations to manipulate power and sources with the aid of limiting its activity for discrete periods and this eliminates the lively requirement for handover and other ordinary operations. Also, provides a periodical method for the cell station for pending downlink traffic directed to the cellular station and as a result gets rid network handover traffic from basically inactive cellular stations. Discontinuous Reception (DRX) has been carried out to decrease the power intake of the consumer device, and transmission of big quantity of data. At data transfer, mobile device and the network phases negotiation occur. During other times, the device turns its receiver off and enters a low power state. Thereby similarly assisting numerous services and big quantities of information transmissions. This study prepossession of a massive quantity of data. Also proposes the two-power optimization modes idle mode and DRX mode parameters to achieve maximum possible power saving with the higher quality of multimedia services. Furthermore, the effectiveness of using DRX short cycles and DRX long cycles on multimedia services and the overall performance. Using OPNET Simulator 17.5, it concluded that DRX mechanism is preferred to operate compared with the Idle mechanism, also resulted that the DRX long cycles are a very good choice for all multimedia services and the overall network performance.**

***Keywords*— power saving; discontinuous reception (DRX); latency; LTE-Advanced; OPNET Modeler 17.5.**

I. INTRODUCTION

This study focuses on the Long-Term Evolution-Advanced (LTE-A) because it was initially designed to cope with the recently growing data traffic, particularly with the proliferation of smartphones and mobile applications. That is to say, the Long-Term Evolution-Advanced (LTE-A) was found out to be highly significant in supporting the LTE systems, attaining higher rates of data with less power consumption. In this context, the goal of LTE-A is to enhance the 1Gbps peak data rate in the downlink (DL), as well as presenting the LTE abilities. Thus, we could attain higher rates of data by following a higher transmission bandwidth with carrier aggregation, a higher-order modulation, more developed coding techniques, and multiple antenna schemes. In this sense, we were able to benefit from the idea of power optimization for curbing unwanted energy waste and extending the mobile battery life [1]. In 2013, Koc, Ali T., et al. developed a systematic model to evaluate power-saving accomplished and IDLEness brought about by DRX operation. Using OPNET, the outcomes demonstrated that the proposed tradeoff scheme is enormously effective in retaining a concord between strength saving and latency [1]. Also, in 2014, Koc, Ali T., et al. developed another model for appraising power-saving accomplished together with delay resulting from DRX system over the LTE network for dynamic and background portable traffic. The outcomes likewise demonstrate that DRX short cycles are exceptionally viable in decreasing delay for traffic, using desirable shorter inactivity timer for background traffic to enhance power saving. Then, on the other hand, proposed a mechanism to replace DRX layout in the light of traffic on UE, 3GPP in release eleven. DRX configuration switching will increase the power saving extensively with none significant growth in latency of lively traffic [2].

Furthermore, in 2015, Mushtaq, M. Sajid, et al. proposed a new downlink planning scheme, called quality-aware DRX (Q-DRX) Scheme, for long term evaluation (LTE) structures that no longer just enhance the quality of service (QoS). The proposed Q-DRX Scheme successfully restricted the packets postpone and packets loss by thinking about the important thing parameters of QoS with affordable assets distributed a few of the UEs perform an excessive fulfillment level [3].

On the other hand, in 2016, Tseng, Chih-Cheng, et al. presented an investigation on the DRX mechanism over the LTE network, which utilizes a blended DRX short and long cycles. Theoretical results showed that the estimations of the parameters in DRX were fluctuated to investigate their consequences for performance [4]. In 2017, Ramazanali, Hawar, et al. presented an IDLE mode DRX mechanism version is proposed, additionally allowing assessment of closely associated mechanisms which include paging and tracking area update (TAU). The version can be utilized by extending the analysis to cowl paging and TAU mechanisms in our future work. It could additionally be stepped forward through growing the info of linked state, which includes the release to the IDLE state and the connection established order to go into the connected state [5].

Moreover, in 2017, Bhattacharyya, Budhaditya, and Singh examined the premise of traffic intensity the UE in ON state will choose whether to get the packets in similar states or change to dynamic state if there should arise an occurrence of high traffic to limit the delay. The results have been compared with the existing DRX model. The results proved the efficiency of MDRX, and better outcomes had been achieved. Even an adaptive mechanism is introduced to keep the MDRX states unchanged while the traffic intensity changes [6]. Finally, in 2018, Mukesh Kumar Maheshwari et al. introduced and analyzed a new licensed-Assisted get entry to DRX mechanism (LAA-DRX) over LTE networks. Using the four-state semi-Markov model, shown the probabilistic estimation of energy-saving and awaken latency related to the proposed LAA-DRX procedure. Simulation results, by way of the usage of actual wi-fi trace, point out that evaluating to present LTE DRX system, the proposed LAA-DRX can achieve almost 4% higher power savings and up to 58% reduction in resource usage [7].

According to the above-mentioned previous studies, the novelty of this case study that not all previous studies addressed the influence of using the DRX mechanism compared to the IDLE mechanism on the various types of multimedia and the overall network performance. In addition, the effect of DRX mechanisms short cycle timer and long cycle timer on the multimedia and the overall network performance under fading effects and signal attenuation due to the condition of user mobility. In this framework, a simulation developed to discuss two fundamental parts that have been investigated: ***Section one*** includes a detailed comparison between the two power-saving mechanisms the IDLE mechanism and the DRX mechanism with the employment of various sorts of multimedia such as voice, video, and HTTP traffic. The use of very critical QoS performance matrices could identify the influence of each mechanism on the total network performance. ***Section two c***oncerns with the DRX mechanism and its timer modes; as there are several choices regarding the implementation of the DRX mechanism's short cycle timer and long cycle timer; that is to say, throughout study and analysis, the impact of each choice shall be interpreted on the multimedia, also the impact on the total network performance. A comparison assessment conducted to speak about the point of quality where we are utilizing over LTE-A network that has various benefits for empowering us to improve the ability of packet access. It also could increase the speed of multimedia access with higher rates of Signal to Noise Ratio (SNR) and giving lower values of Bit Error Rate (BER). In turn, the packet loss during transmission will be reduced, as well as the improvement of the overall network performance whatever the number of subscribers and system over-burdening. The rest of this paper further addresses the power optimization material and methods used in section two. Then section three includes the simulation results and general discussion. Finally, section four includes the conclusion and suggestion for future work.

II. Materials and Methods

A. Implementation of IDLE and DRX Mechanism

In the IDLE mode, UE may be unknown for eNodeB but is obvious for the network and can communicate with the network when it notices any incoming call and has an IP address. In this mode, the mobility management can be conducted through the UE by cells election and re-selection once the handover is needed or a better connection is possible. The network can never control UE's movement in this state; UE automatically chooses another cell as its moves. If UE enters any other location area, when getting information from the base station, the UE informs the network about any other tracking area it enters. The UE can never transmit or receive any data in this state. It merely monitors the paging and broadcast channel to maintain the connectivity as clear in figure1 [8].

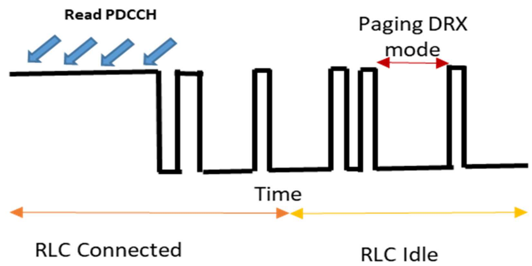


Fig.1 UE Utilization using the IDLE mechanism

UE moves from IDLE mode to the connected mode when RRC signaling connection is established. The IDLE mechanism saves the overall power of both the UE and the network as this period avoids unnecessary signaling and communication. Since the UE has limited power, the characteristic of LTE-A raises user's devices lifetime. Connected Mode is the state where the eNode B and the connected network are familiar with UE. Moreover, the radio must be active as the data are being communicated. The network does the mobility administration in this state and it can be centered on handover. In the "Connected Mode", UE keeps UE transmitter and receiver always ON i.e.

the UE's radio must be at the ON state as obvious from figure 2 [9].

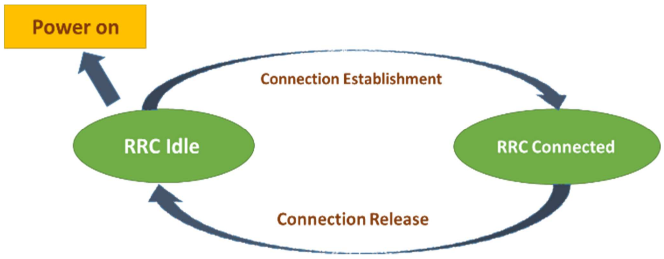


Fig.2 UE's IDLE and CONNECTED states

B. DRX Mechanism

Discontinuous receiving (DRX) is considered as a key power saving mechanism in LTE-A. Due to the fact DRX sustains battery power of the user's device commonly on account of the ability upward push in latency, an optimization is wanted to locate the quality tradeoff between latency and power saving. The LTE-A specification has followed DRX on the link degree to keep power and extend the battery life of the UE, as shown in figure 3[10].

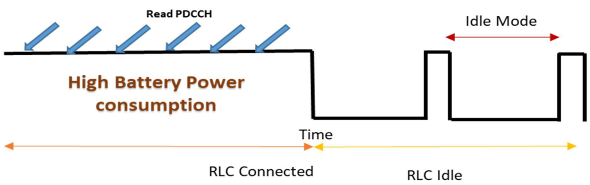


Fig.3 UE Utilization using DRX mechanism

In LTE-A networks, the DRX mechanism can look at Radio resource control (RRC) states between the UE and the eNodeB (3GPP, 2012). The RRC has various states in which the DRX mechanism can be worked, i.e., RRC_IDLE and RRC_Connected. Inside the RRC_IDLE state, the UE does no longer have a lively link with the eNodeB however; it is far registered within the network with a unique identifier. In the meantime, the eNodeB can page the UE for various purposes (e.g., location updating), and the UE could not have lively links with the eNodeB however, this is sometimes registered in the network with distinct identifiers. Meanwhile, the eNodeB may additionally page the UE due to different reasons (e.g., location updating), and the UE may additionally initiate requests of uplink channels through the establishment of an RRC_ Connected state for receiving and transmitting data.

In the RRC_ Connected state, the DRX mode is easily enabled during IDLE periods between the packet arrivals. Inside the absence of information packet for the UE, the nit may additionally pass into the DRX mode. The LTE-A's DRX mechanism, the sleep/wake-up scheduling for any of UE receiver, may also occasionally be defined as in phrases of the periods (ON-period, inactivity and Sleep period) as shown in Figure 6 below. Next figures (4, 5) illustrate other sorts of multimedia patterns traffic transmitted through employing DRX mechanism over LTE-A it can be noticed that ON state in addition to OFF states, i.e., packet activity for specific times and the non-activity [10].

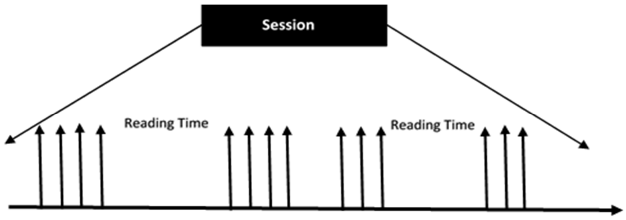


Fig.4 HTTP pattern

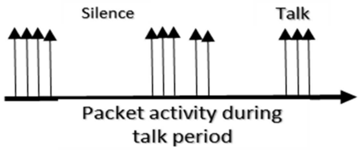


Fig.5 Voice and Video traffic pattern

Figure 6, shows the presence of several states in DRX, i.e. inactivity timer (T_i), ON duration timer (T_{ON}), Long sleep cycle (T_{LC}), Short sleep cycle (T_{SC}) and short cycle timer (N_{SC}). The inactivity timer is set to monitor PDCCH. There can be multiple short sleep cycles to delay the arrival of long sleep cycles by assigning the value to N_{sc} before moving towards the S4 state. The DRX state timer is comparatively less than the RRC _inactivity for the IDLE state so that it does not go to the IDLE state in between DRX modes. Instead of Uplink, the focal point of this research paper shall be on the analysis of Downlink Traffic. The values of the LTE-A's DRX parameter are considered [11]:

- ON-Duration (T): The consumer stays within the lively state and listens to the PDCCH on time. If any information packet is scheduled for this user then it starts its state of no activity Timer (t_i), in any other case, it keeps its DRX cycle by way of switching again to the sleep interval either light Sleep or Deep Sleep.
- Inactivity Timer (T_i): This timer prolongs the UE's lively mode even after ON-duration has expired. During ON-duration if a packet is listened to via PDCCH, the UE begins its T_i and gets information packets. During T_i, if any other PDCCH packet arrives, the inactiveness time restarts itself to obtain extra incoming information packets. While T_i expires, the DRX cycle begins with a sleep interval.
- Sleep Interval: it is the period for the duration of which the UE makes use of low power in case of DRX light Sleep T_{DS} duration or no power in case of DRX Deep Sleep T_{DL} duration. In the case of Deep Sleep mode, the length of the sleep interval is longer than light Sleep mode.

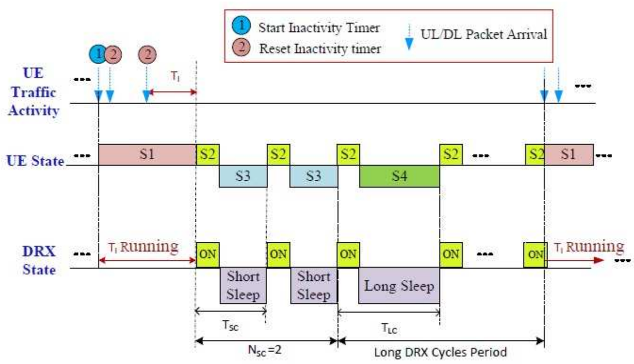


Fig.6 DRX mechanism (Quoted from [12])

C. Proposed Algorithm

The proposed system illustrated in Fig. 7 explains our systematic phases of the power saving mechanism selection that occur in the cellular network based totally on various parameters such as (1) Cellular user connection; (2) QoS metrics; (3) Video streaming information; (4) Variation of bandwidth; (5) Fading effects and (6) Coverage and mobility. These factors are affecting at once on the accumulated response measured. Our framework divided into two parts, as shown in figure 7. The proposed algorithm consists of three power-saving phases firstly the base station will check if the mobile user met the conditions of power-saving concerning the other parameters mentioned above. This phase is called the power saving entry. Then, the second phase will be corresponding to the choice or selection between the two mechanisms of the power saving used in this case study. If the mobile user will select the IDLE mechanism or will select the DRX mechanism and if the mobile user will select the DRX mechanism, the user will select the long cycles or the short cycles. Finally, the third phase which corresponding with the power saving process exit.

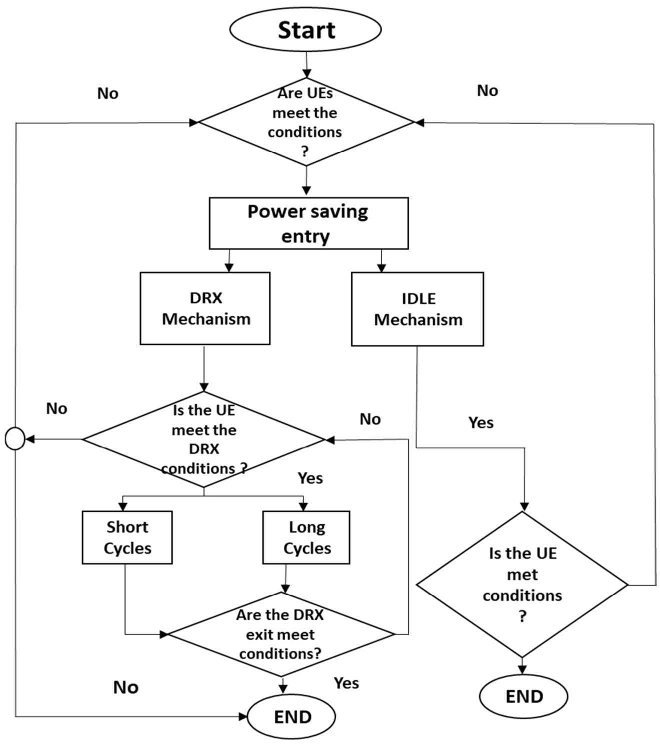


Fig.7 The Proposed Algorithm

D. QoS Performance Metrics

1) End to End Delay: Packet delay, DE2E, is calculated using the following equation (1,2) [13]-[16]:

$$d_{E2E} = N\left[d_{trans} + d_{prop} + d_{proc} + d_{queue}\right] \quad (1)$$

where : (I) d_{end}-$_{end}$= end-to-end delay; (II) d_{trans}= transmission delay; (III) d_{prop}= propagation delay; (IV) d_{proc}= processing delay; and (V) d_{queue}= Queuing delay.

$$N = Number\ of\ Links\ (Number\ of\ Routers - 1) \quad (2)$$

in which N is the quantity of network components among the portable station in addition to application server, d_{proc} is the processing postpone at given network, d_{queue} is offered the queuing postpone at any given network element, d_{trans} is supposed the transmission time of a package on a given connection between two network additives and d_{propa} is the propagation put off over a given network interface. delay or latency might be described as the time taken with the aid of the packets to attain from source to destination. However, the end-to-end delay greater than 500ms is taken into consideration unacceptable.

2) Packet Delay Variation: PDV is described as the variation in packet delay inside a given media at the mobile user station and always measured in msec. Eq.3 describes PDV for multimedia streaming procedure with ideal ranges <50 msec [17]-[19].

$$PDV = |(R_{XA}) - (T_{XA}) - (R_{XB}) - (T_{XB})| = |(T_{XB}) - (T_{XA}) - (R_{XB}) - (R_{XA})| \quad (3)$$

3) Average throughput: Throughput is the degree of the number of packets successfully handled in the network. Also, is the rate of the fruitful message transmitted over a correspondence channel. The information of these messages have a place that might be delivered over a physical or logical connection, or it can go through a specific network node. The numerical value of throughput, which estimated in packets/sec, must be high. Otherwise, it is going to affect each service class described the average throughput is defined as follows in equation (4) [20]-[22].

$$Throughput = Data\ [frames]\ /\ Time\ [s] \quad (4)$$

4) Packet Loss Ratio: PLR is the undermined/lost or too much-delayed packets partitioned by the aggregate quantity of packets predicted on the mobile client station. The PLR for the entire packet sent and received as follows [23]-[26]:

$$PLR = \frac{Lost_{packets}}{Sent_{packets}} * 100 \quad (5)$$

5) Mean Opinion Score: MOS gives a numerical degree of the quality of voice and video in the cellular networks, MOS values extending from 1 to 5: where 1 is the highly terrible quality, and 5 is the quality excellent. In our simulation, MOS is computed through a non-line are mapping from R-factor, as is demonstrated below [27]-[29].

$$MOS = \frac{\sum_{n=0}^{N} R_n}{N} \quad (6)$$

Where R are the individual ratings for a given stimulus by N subjects.

6) Signal-to-Noise Ratio: SNR is the percentage among the power for the original signal and the power for undesirable signal "noise". Also, it is a primary parameter for the sight and sound transmission services. SNR as its miles usually measured the overall sensitivity performance on the destination. The ideal values for the SNR for signals are about above 25 dB for multimedia services, as mentioned in equation 7. Where: P is referring to the incoming signal strength of interest, I is the indicating of the other interfering signals in the network, and N is related to the noise [30]-[32].

$$SNR(x) = P/(I + N) \quad (7)$$

7) Bit Error Rate: The bit error rate is characterized as the proportion between total numbers of errors to the aggregate number of transmitted bits. BER is sometimes evaluated as the aggregate QoS and performance for the system, including the source, destination, and the control channel between the two network elements. If the channel between the source and destination is at a decent state with higher SNR, at this point the BER will be little and can be understood the best quality and services as the video and voice signals are in the best case as mentioned in equation 8 [33]-[36].

$$BER = Errors/Total\ Number\ of\ Bits \quad (8)$$

8) Physical Downlink Shared Channel versus Physical Uplink Shared Channel Utilization: There are utilization statistics available for PDSCH and PUSCH, which gives the rate use of each channel. The PDSCH is the downlink channel that conveys all client information and all flagging message on the other hand PUSCH is the fundamental uplink channel and utilized to convey the UL-SCH (Uplink Shared Channel) transport channel [37]-[40].

III. Results and Discussion

Two identical network topologies were created in this study. Firstly, network topology consists of two scenarios for comparing between the IDLE and DRX mechanisms. Secondly, the scenario that differentiates three modes, i.e., without using DRX and the other two DRX modes (Short interval mode and Long interval mode). The modeling of scenarios was performed using the OPNET simulator 17.5 (release 8).

A. *First Simulation Parameters and Network Topology*

First network topology consists of two scenarios; two areas are operated at each scenario area (0) for the IDLE mode and area (1) for the DRX mode. Two mobile application users are used, the first user rotates around DRX area 1 in the first scenario, and on the other hand, the second user rotates around IDLE area (0) the second scenario at the same time. In both scenarios, the network consists of seven eNodeBs, parameterized, according to Table I, II, III, and IV. Concerning mobility, two Mobile users, and structure also includes elements EPC (Evolved Packet Core) and gateway that will communicate with the three-application server, shown in figure 8. By using OPNET 17.5 simulator, the two power optimization modes compared. The simulation run time = 490 seconds. Three types of data used (Voice, Video and HTTP), performance matrices such as (End to End delay, Packet delay variation, MOS and Traffic sent received) used in Voice and Video traffic, Object and Page response time for HTTP Traffic, SNR, BER, PUSCH, PDSCH, Throughput, Downlink and Uplink Packet drop for LTE-A network

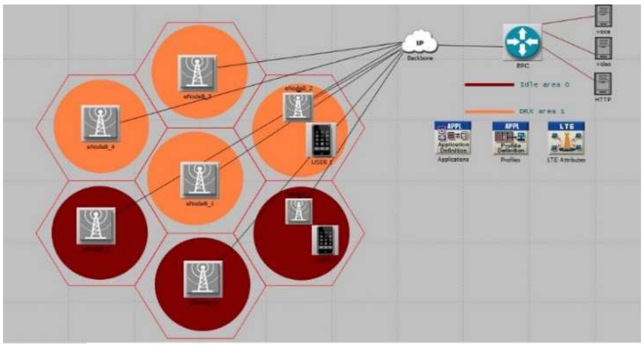


Fig.8 Network Topology for IDLE and DRX mechanisms

TABLE I
VOICE PARAMETERS

Attributes	Value
Application Silence Length (s)	Exponentially distributed, mean 0.65
Talk Spurt Length (s)	Exponentially distributed, mean 0.352
Type of Service	Best effort (0)
De-Compression Delay (s)	0.02
Encoder Scheme	GSM FR
Voice frame per packet	1

TABLE II
VIDEO PARAMETERS

Attributes	Value
Frame interarrival time information	15 frame/sec
Frame size information(bytes)	128*240 pixels
Type of Service	Best effort

TABLE III
CONFIGURATION OF THE LTE-A NETWORK

Antennas Parameter	Value
Transmission Power	26 dBm
SC-FDMA (UL) Frequency	1710 MHz
Hybrid OFDMA (DL) Frequency	2110 MHz
Bandwidth	Downlink70MHz – Uplink 40MHz
Gain Antenna	17 dBi
Antenna Height	40m
Radius Coverage	20 Km
Propagation Model	Urban
Duration of simulation	490s

TABLE IV
DRX PARAMETERS

Attributes	Value
DRX Capability	Enabled
Use cell parameters	Enabled
On duration timer (sub frames)	10,40 ms
Short DRX cycle timer (sub frames)	20
Use a short DRX cycle	Enabled
Inactivity timer (sub frames)	40
Retransmission timer(sub frames)	4
Long DRX cycle multiplication factor	4

B. *First Simulation Results*

1) *Case-1: Voice*

- *MOS and Packet delay variation.* Shown in figure 9, it is a huge variation in the voice quality (MOS), by using DRX mechanism, the MOS value = 4.5 then there is degradation down to 3.6 at the end of the simulation, so these values have a very good influence on voice quality. On the other hand, it is approximately equal 1.25 by using the IDLE mechanism, so the quality of traffic by using DRX mechanism is better. Moreover, packet delay variation as shown in figures (10) that verify 0.2ms in case of DRX mechanism considered as a lower value and support fast access for the service and 1.6ms for IDLE mechanism.

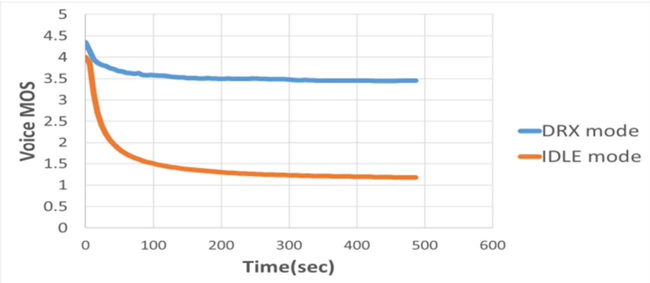


Fig.9 MOS over IDLE and DRX mechanism

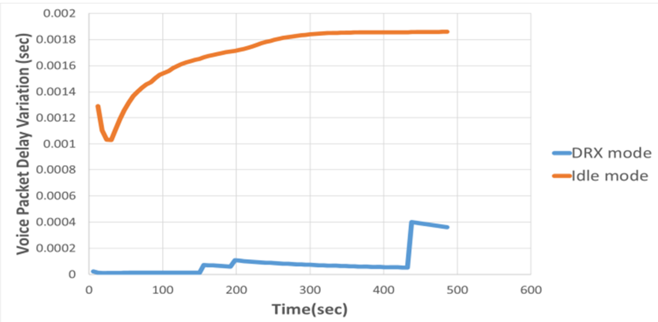


Fig.10 PDV over IDLE and DRX mechanisms

- *Itter and End to End delay (sec).* As shown in figure (11), End to End delay values satisfy lower values about 0.14 sec in case of DRX mechanism and 0.19 sec in the case of IDLE mechanism enabled respectively, on the other hand as shown in figure (12), voice jitter by using DRX mode values is near to zero compared with 2.5 msec using IDLE mechanism.

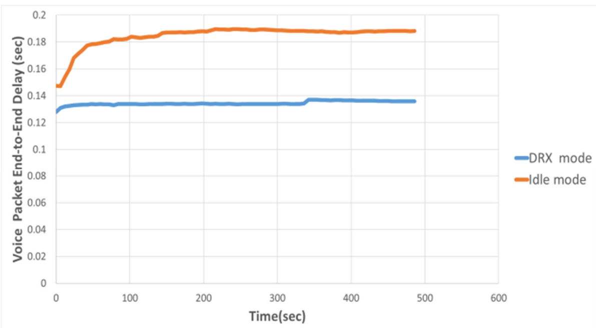


Fig.11 E2E over IDLE and DRX mechanisms

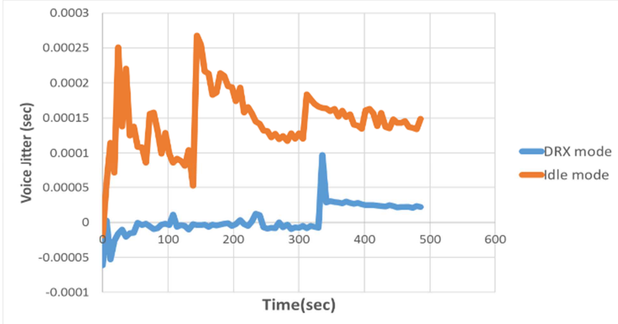


Fig.12 Jitter over IDLE and DRX mechanisms

- *Traffic Sent and Received (Packets/sec).* According to figure 13, traffic received using DRX mechanism is equal about 50 (packet/sec) same as traffic transmitted due to all previous results shown in figures (9,10,11,12), on the other hand, by using IDLE mechanism as shown in figure 13, there is a considerable packet drop in the traffic received. Moreover, we can calculate the PLR for the two mechanisms used; at second 200 the PLR values are equal 28% and 0.5% for IDLE and DRX mechanisms respectively.

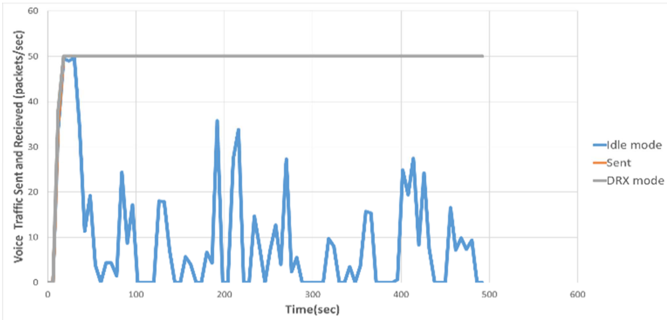


Fig.13 Traffic Sent, Received IDLE and DRX mechanisms (packet/sec)

2) *Case-2: Video streaming data*

- *End-to-End delay and packet delay variation.* As shown in figure (14), End-to-End delay values satisfy lower values approximately equals 4 seconds in case of DRX mechanism and 16 seconds in the case of IDLE mechanism enabled respectively. Additionally, the variation of packet delay satisfies lower values in case of DRX mechanisms compared with the IDLE mechanism. As shown in figure (15), that verify 10ms in case of DRX mechanism considered as a lower value and support fast access for the service and 40 msec for IDLE mechanism.

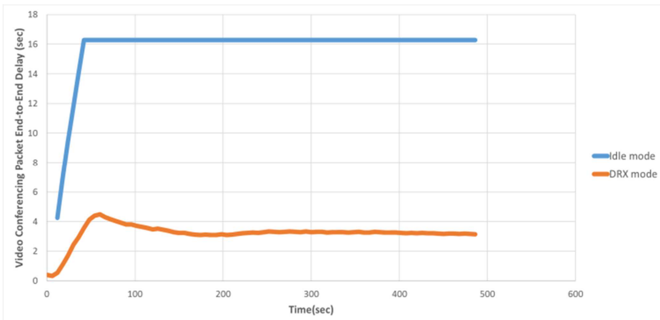


Fig.14 E2E Delay for IDLE and DRX mechanism

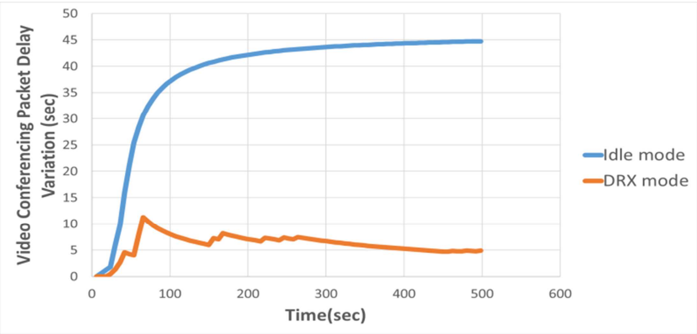


Fig.15 PDV Delay for IDLE and DRX mechanisms

- *Traffic Sent and Received (packets/sec).* As shown in figure 16, traffic received using DRX mechanism is equal about 10 (packet/sec) compared with 16 packets transmitted, on the other hand, by using IDLE mechanism there is also a huge packet drop in the traffic received. It is noticeable that is there a very high video packet dropped using the two modes. Moreover, the PLR for the two mechanisms could be accumulated, at second 200 the PLR values are equal 54% and 38% for IDLE and DRX mechanisms respectively.

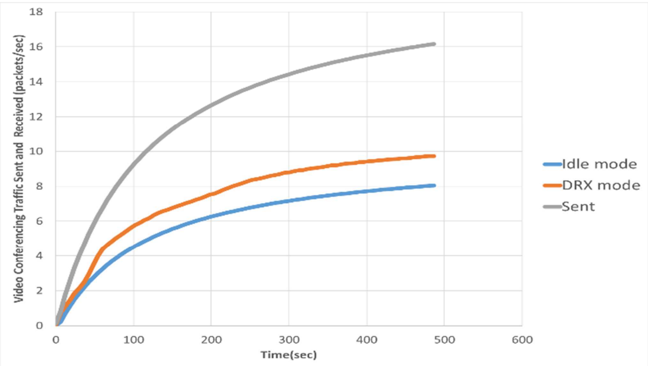


Fig.16 Traffic Sent and Received IDLE and DRX modes (packets/sec)

3) *Case-3: HTTP*

- *Download Response Time and Object Response Time (sec).* As shown in figure 17 and 18, IDLE mechanism has a higher delay response value approximately equals 2.762 seconds compared with the DRX mechanism, which equals 0.5 seconds, so due to higher delay values, there is a very bad effect on the quality of traffic received using the IDLE mechanism.

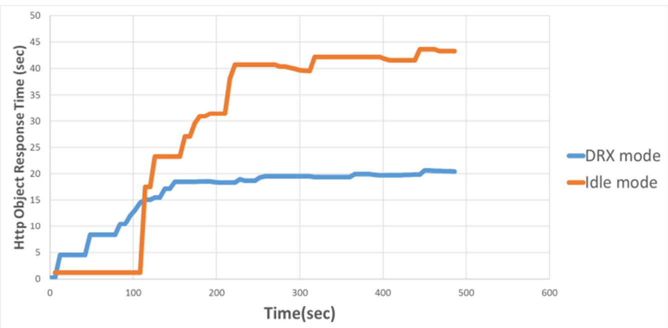


Fig.17 HTTP Page response time (sec)

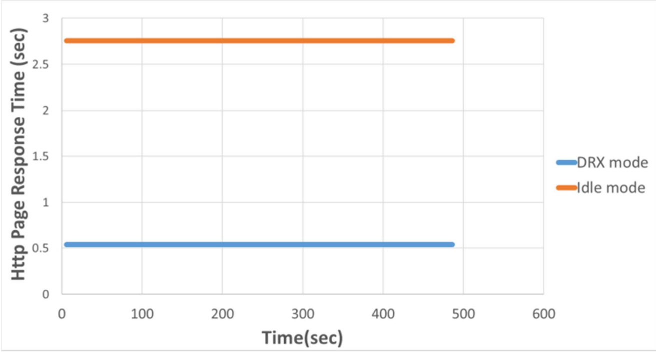


Fig.18 HTTP Object response time (sec)

- *Traffic Sent and Received (Packet/sec).* As shown in figure 19, due to higher response delays obtained, there is a very high data drop by using IDLE mechanism compared with DRX mechanism known that the traffic sent equals to 900 bytes/sec. Moreover, we can calculate the PLR for the two mechanisms, at second 200 the PLR values are equal 37.5% and 10% for IDLE and DRX mechanisms respectively.

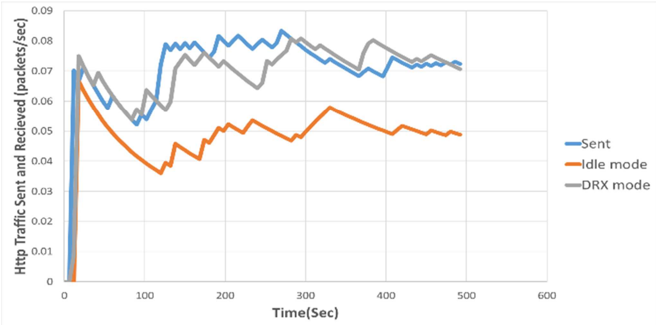


Fig.19 Traffic Sent, Received IDLE and DRX mechanisms packets/sec)

4) *Case-4: Network Performance*

- *SNR (dB).* According to figure 20, the maximum value of SNR is approximately equal to 70 dB by using DRX mechanism and 66 dB by using IDLE mechanism over LTE-A network. Therefore, the DRX mechanism is a good choice for the overall network SNR.

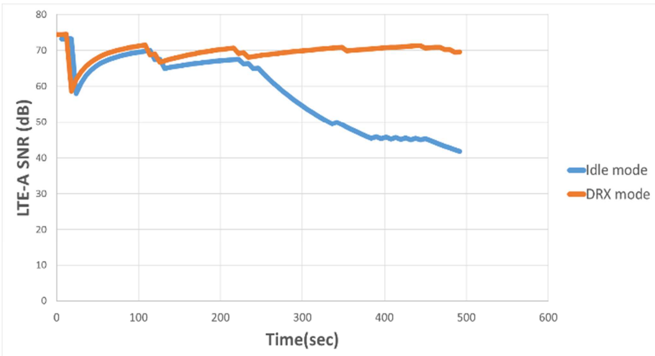


Fig.20 SNR for IDLE and DRX mechanisms (dB)

- *Uplink and Downlink Packet drop (packets /sec).* Figure 21 shown below, discussed the overall downlink packet drops due to the packet collisions in case of signal mobility by using the two mechanisms, in DRX mechanism equals 40 packets dropped.

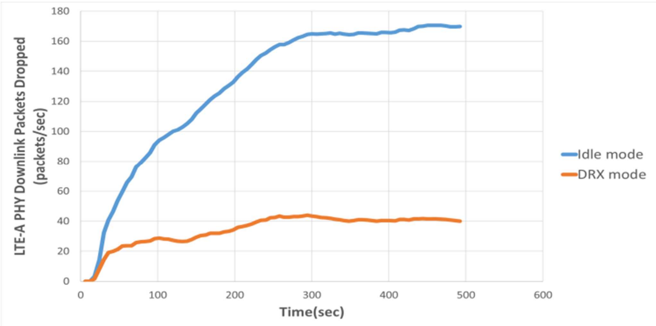


Fig.21 DL Packet drop IDLE and DRX mechanisms

On the other hand, by using IDLE mechanism packet dropped ratio increased up to 130 packets at second 200 and then increasing to 175 packets dropped at the end of the simulation. Additionally, figure 20 describes the ratio of uplink packet dropped due to transmission, as shown at second 200 equals 90 packets dropped and 60 packets by using IDLE and DRX mechanisms respectively shown in figure 22.

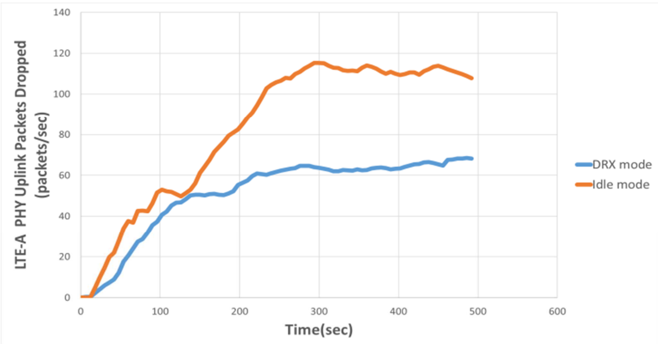


Fig.22 UL Packet drop IDLE and DRX mechanisms

- *Throughput (packets/sec).* As shown in figure 23, by using DRX mechanism has a better overall network throughput is approximately near to 175 (packets/sec) at second 200 then increasing to 220 (packets/sec) at the end of the simulation, on the other hand, IDLE mechanism satisfied lower throughput values reflect on the quality of multimedia.

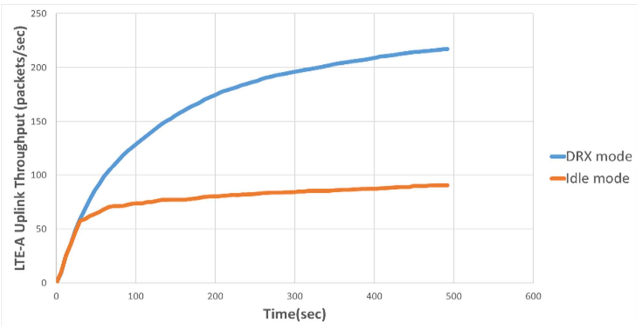


Fig.23 Throughput for IDLE and DRX modes (packets /sec)

- *BLER over Uplink and Downlink.* For the simulated system, as shown in figures 24, 25, the accumulated Uplink and Downlink values of BER using DRX mechanism satisfied lower values compared with the IDLE mechanism. Which also has a great influence on the multimedia quality.

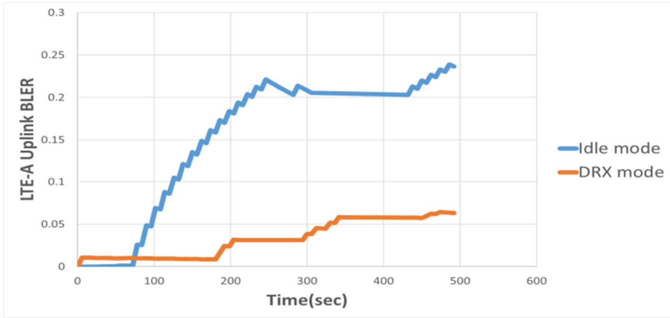


Fig.24 UL BLER for IDLE and DRX mechanisms

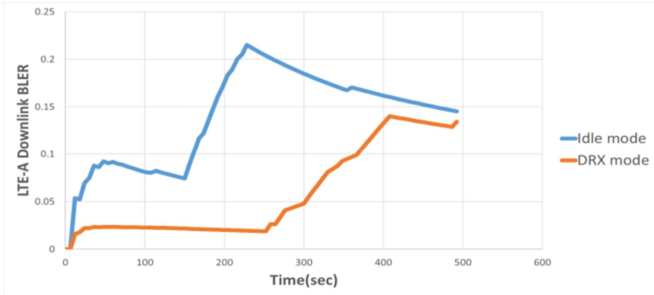


Fig.25 DL BLER for IDLE and DRX mechanisms

C. *Second Simulation Parameters and Network Topology*

Three scenarios are implemented; three areas are operated at each scenario area three for the DRX disabled mode, area (2) for the DRX mechanism short cycle mode and area (1) for the DRX mechanism long cycle mode. Three mobile application users are used; the first user rotates around the area (3) where DRX disabled in the first scenario. On the other hand, the second user rotates around the area (2) where Short cycle DRX (10 msec) in the second scenario and the third user rotates around the area (1) where Long cycle (40 msec) DRX in the third scenario at the same time. The simulation run time =490 seconds, in the three scenarios the three modes differentiated. The network consists of three eNodeBs, parameterized, according to Table I, II, III, and IV. Concerning mobility, three Mobile users, and structure also includes elements EPC (Evolved Packet Core) and gateway that will communicate with the Four-application server, as shown in figure 26. Three types of data used (Voice, Video, and HTTP), performance matrices such as (End to End delay, Packet delay variation, MOS, and Traffic sent received) used in Voice and Video traffic, Object and Page response time for HTTP Traffic, SNR, BER, Throughput, PUSCH, PDSCH, Downlink and Uplink Packet drop for LTE-A network.

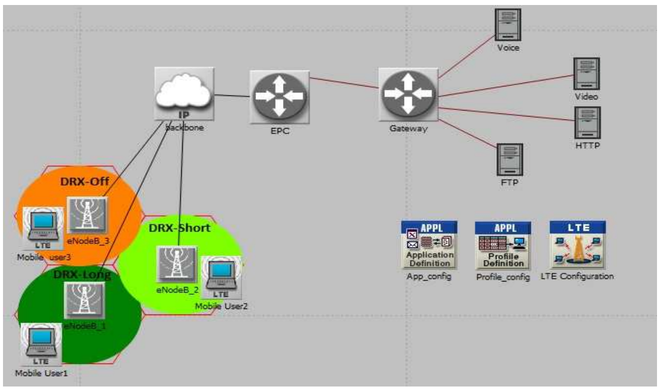


Fig.26 Network Topology for DRX modes

D. *Second Simulation Results*

1) *Case-1: Voice*

- *MOS and Packet delay variation.* Shown in figure 27, the voice quality (MOS) by using DRX long mode has the best MOS value, which equals 3.86. On the other hand, it approximately equals 3 by using the IDLE short mode and 2.6 without using DRX, so the quality of traffic by using DRX long mode is better due to higher MOS value. Additionally, the variation of packet delays satisfies lower values in case of DRX modes as shown in figure 28 verified 5ms in case of DRX long cycle considered as a lower value and support fast access for the service and the highest 20ms for no DRX mode.

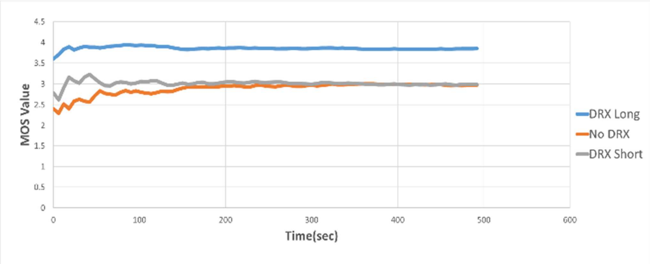


Fig.27 MOS over DRX modes

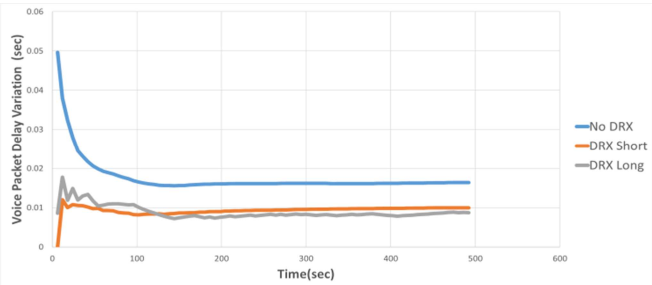


Fig.28 PDV over DRX modes

- *Jitter and End to End delay (sec)* Also, as shown in figure (29), E2E delay values satisfy lower values approximately equal 0.13 second in case of DRX long cycle mode and 0.176 sec in the case of DRX disabled mode respectively. On the other hand, as shown in figure 30, voice jitter by using DRX long mode values is about 0.00005sec compared with 0.0015sec using DRX disabled mode.

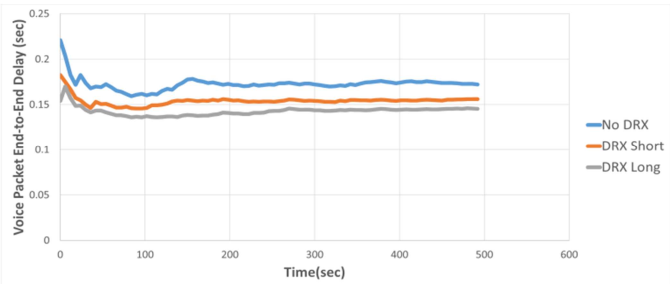


Fig.29 End to End over DRX modes

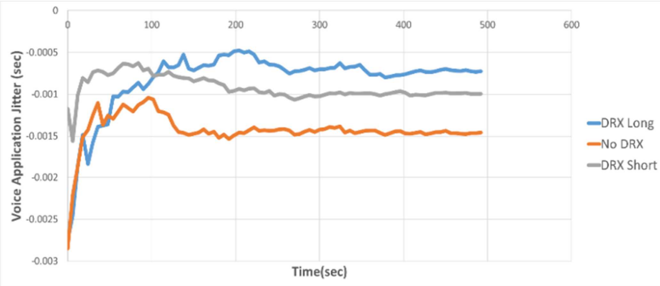


Fig.30 Jitter over DRX modes

- *Traffic Sent and Received (Packets/sec).* According to figure 31, due to previous delay values accumulated at second 200 traffic received by using DRX long interval mode will equal 144 (packet/sec), 140 (packet/sec) by using DRX short interval mode, on the other hand by using DRX disabled mode as shown in figure 31 ,there is a significant packet drop in the traffic received. Noticed that the traffic sent is 145 (packet/sec). Moreover, we can calculate the PLR for the three modes, at second 200 the PLR values are equal 0.7%, 3.5% and 80% for DRX long cycle, DRX short cycle, and no DRX modes respectively.

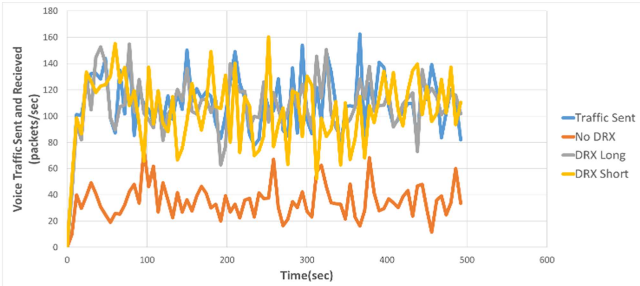


Fig.31 Traffic Sent and Received DRX modes (packet/sec)

2) *Case-2: Video streaming data*

- *End-to-End delay and packet delay variation.* As shown in figure (32), E2E delay values satisfy lower values about 0.05 sec in case of DRX long interval mode and 0.3 sec in the case of DRX disabled mode respectively. Additionally, the variation of packet delays satisfies lower values in case of DRX modes as shown in figure (33) that verify near to zero in case of DRX long interval mode considered as a lower value and support fast access for the service and 50 msec for DRX disabled.

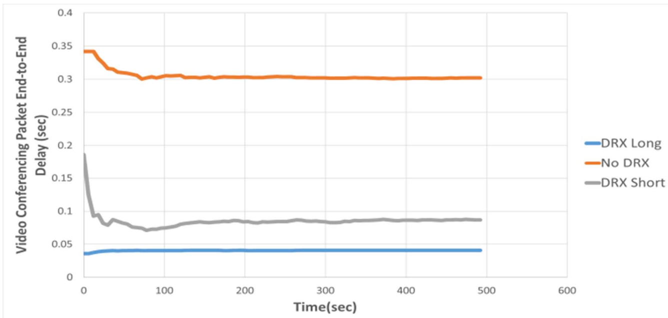


Fig.32 End to End Delay for DRX modes

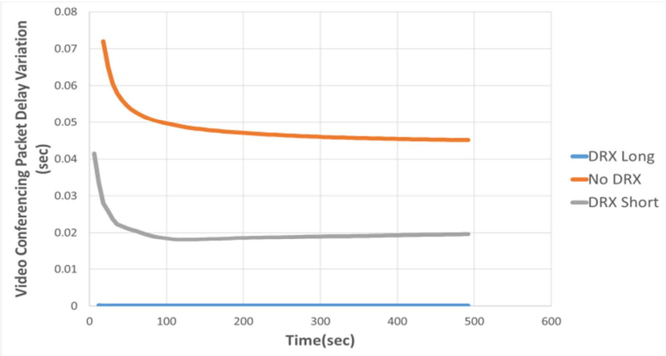


Fig.33 PDV Delay for DRX modes

- *Traffic Sent and Received (packets/sec).* As shown in figure 34, at second 300 traffic received using DRX long interval mode is equal about 15 (packet/sec) compared with 15 packets sent, on the other hand by using no DRX mode there is also a big packet drop in the traffic received. It is noticeable that the problem of a very high video packet dropped solved by using DRX long mode. Moreover, we can calculate the Packet Loss Ratio for the three modes, at second 300 the PLR values are equal 0.195%, 10% and 20% for DRX long cycle, DRX short cycle and no DRX modes respectively.

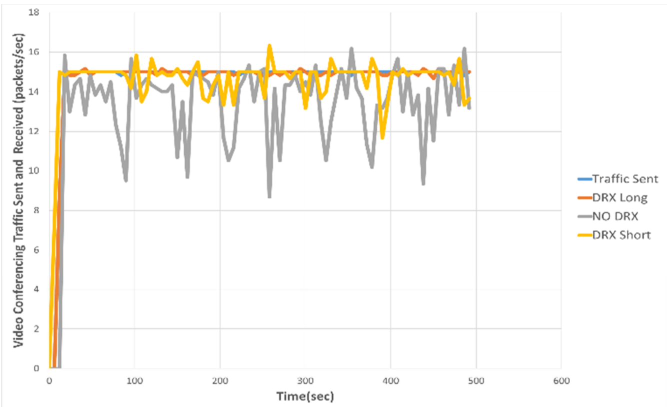


Fig.34 Traffic Sent and Received over DRX modes (packets/sec)

3) *Case-3: HTTP*

- *Page Response Time and Object Response Time (sec).* As shown in figure 35 and 36, respectively, DRX disabled mode has a higher delay response values up to 0.5 sec at page response time and 0.2sec at object response time compared with the other modes.

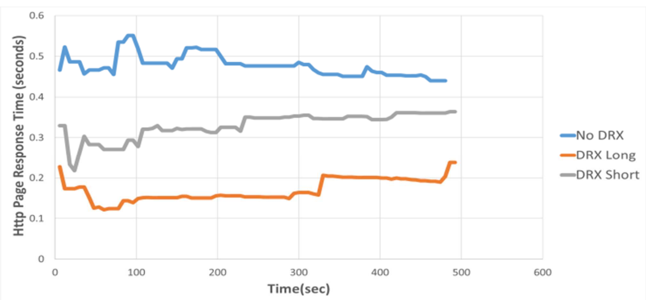


Fig.35 HTTP Page response time (sec)

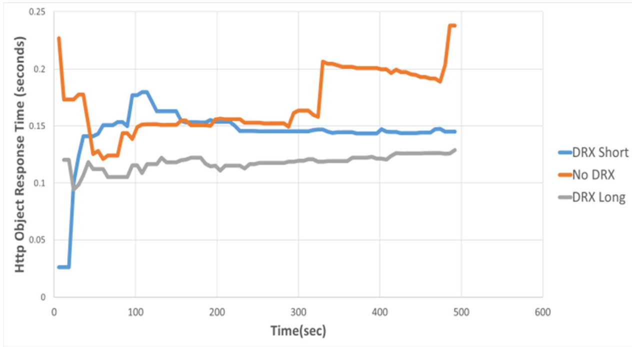


Fig.36 HTTP Object response time (sec)

- *Traffic Sent and Received (Packet/sec).* As shown figure 37, there is a packet drop at traffic received by using DRX mode due to higher object and page response delays compared with DRX long mode = 612 bytes known that the traffic sent is about up to 625 bytes/ sec. Moreover, we can calculate the Packet Loss Ratio for the three modes, at second 300 the PLR values are equal 2.08%, 4.9% and 18.3% for DRX long cycle, DRX short cycle, and no DRX modes respectively.

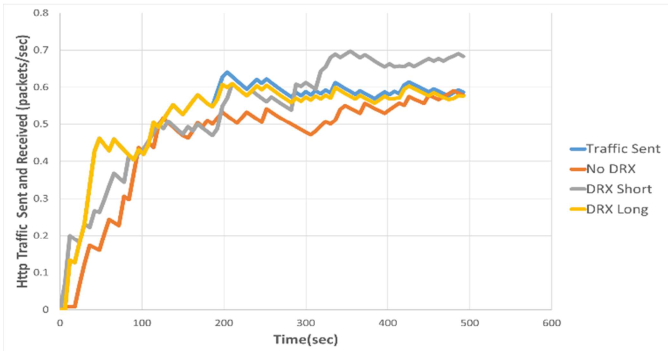


Fig.37 Traffic Sent and Received over DRX modes (packets/sec)

4) *Case-4: Network performance*

- *Uplink and Downlink SNR (dB).* The best acceptable values of the SNR for signals are approximately on the network uplink is equal up to 30 dB using DRX long cycle mode and degraded to 25 dB by disabling DRX mode. On the other hand, Downlink SNR= 25.5 dB by using DRX long mode and 20.25 dB by disabling DRX as shown in figure 38 and 39, respectively.

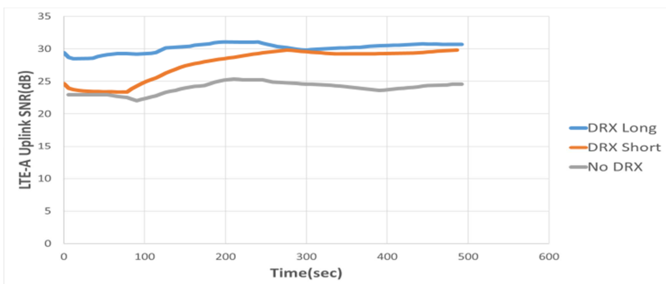


Fig.38 Uplink SNR for DRX modes (dB)

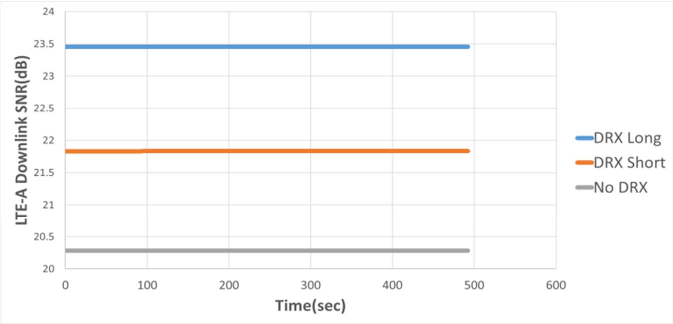


Fig.39 Downlink SNR for DRX modes (dB)

- *Uplink and Downlink Packet drop (packets /sec).* Figures 40 and 41 shown below are discussed the overall uplink and downlink packet drops due to the packet collisions in case of signal mobility by using the three modes over the LTE-A network. The third case in which DRX disabled is the highest packets dropped case equal 350 packets and 60 packets on uplink and downlink respectively at the end of the simulation and this impacts on the multimedia transmitted quality compared with DRX long and short modes.

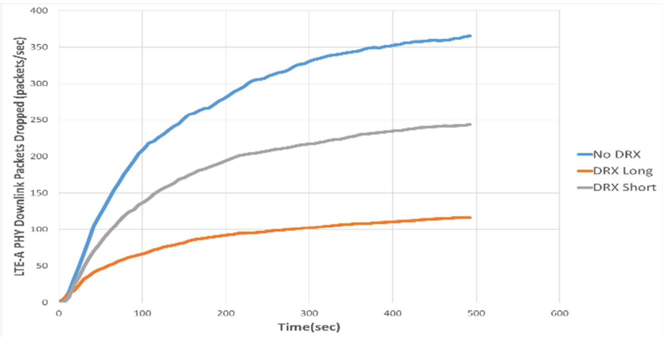


Fig.40 DL Packet drop over DRX modes

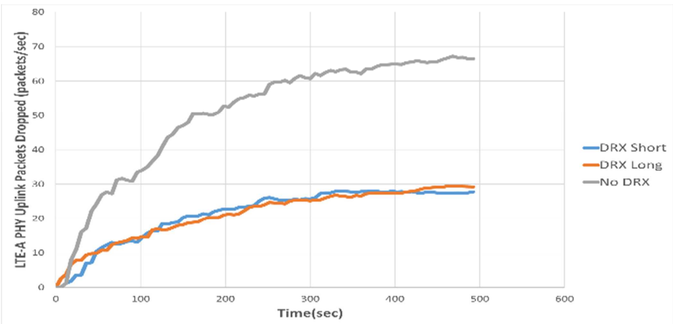


Fig.41 UL Packet drop over DRX modes

- *Throughput (Packet/sec).* As shown in figure 42, by using DRX long cycle mode has the best network throughput is about 650 (packets/sec) compared with the other modes. Therefore, it could be concluded that by choosing DRX long cycle is a very choice compared with other modes.

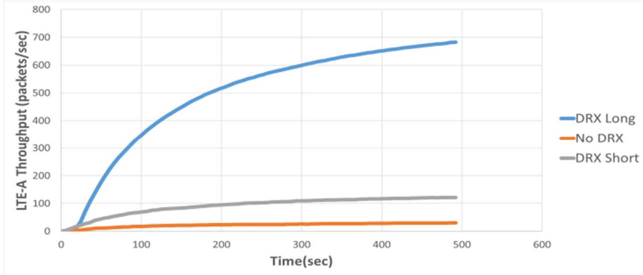


Fig.42 Throughput for DRX modes (packets /sec)

- *BLER over Uplink and Downlink*

From the simulated system, according to figures 43, 44, the accumulated Uplink and Downlink values of BER, using DRX long interval mode satisfied the lowest over Uplink and Downlink compared with other modes.

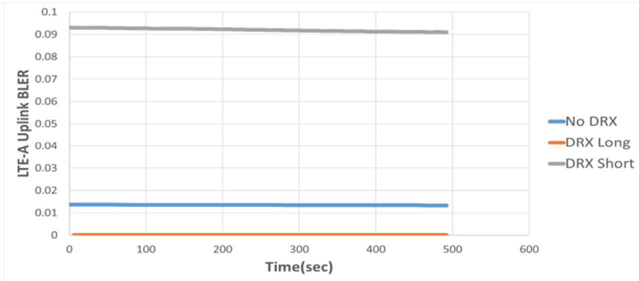


Fig.43 UL BLER for DRX modes

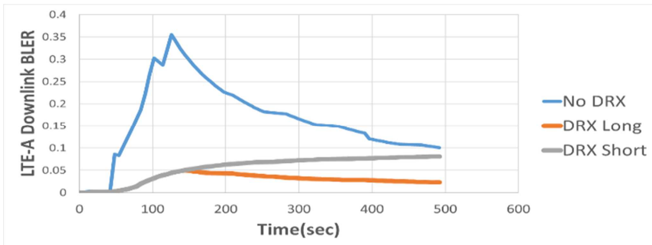


Fig.44 DL BLER for DRX modes

- *PDSCH and PUSCH Utilization*

As shown in figure 45, 46 the lowest utilization percentage for the downlink and uplink share channel respectively done by using DRX long cycle mode which equals 7% utilization at the end of simulation over the downlink channel. In addition, 15% utilization over the uplink channel compared with other cases, this low value of downlink and uplink channel utilization will have a great effect on the overall performance of the network.

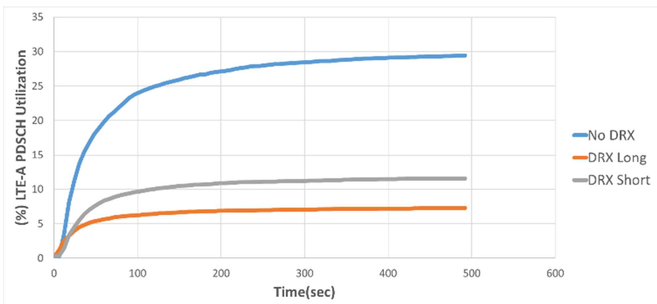


Fig.45 PDSCH Utilization for DRX modes

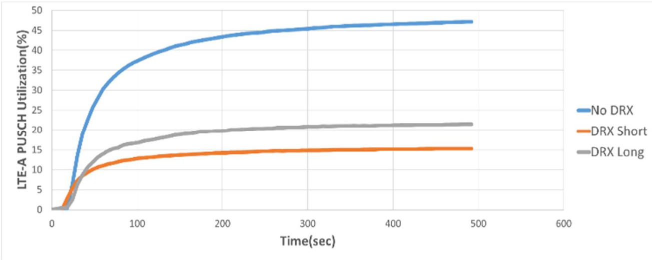
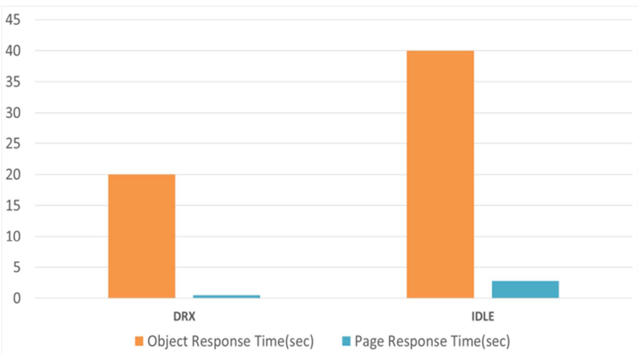


Fig.46 PUSCH Utilization for DRX modes

E. General Discussion

In this paper, we pointed out the necessity of power optimization; we compared between two power-saving mechanisms to maintain what is the preferred mechanism on multimedia and the overall network performance, then we examined the effect of using the short and long DRX cycles on the overall network performance and the multimedia. The analytical simulation results showed that DRX mechanism besides having a lower object and page response time; it also has a higher HTTP traffic received quality, so it is the preferred mode. Also, we can enhance the overall network performance and multimedia quality by using DRX long cycles as discussed in (I) figure 47 (a,b) and (II) figure 48. This study shows that there is a better MOS, lower End-to-End delay, lower jitter, packet delay variation, higher traffic quality, and lower PLR using DRX mechanism. Moreover besides, by using long cycles there is a great improvement to the overall network performance, voice and video quality discussed in (I) figure 49 (a, b) and (II) figure 50 (a, b). Additionally, this paper presented OPNET simulated networks to show the effect of using DRX mechanism on streaming data over LTE-A networks by realizing more real-time scenarios to verify good empirical values based on these technology's protocols.

A multimedia streaming required a high level of quality to verify the fair access for all users. More quality metrics have been investigated through the simulation of more reliable streaming data using OPNET 17 interface. Simulation results had shown that DRX mechanism increases the level of quality for overall network performance over LTE-A networks. Additionally, it realizes long cycle has a great effect on the overall network performance compared with the other proposed power mechanisms with overall efficiency (percentage) as mentioned in the followings data: (I) figure 51; and (II) figure 52.



(a)

(b)

Fig.47 HTTP two mechanisms Results

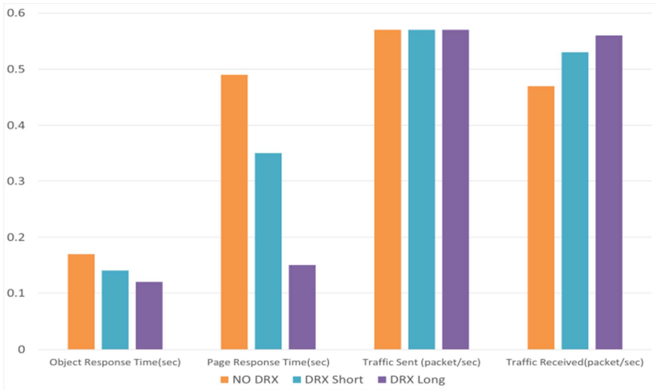
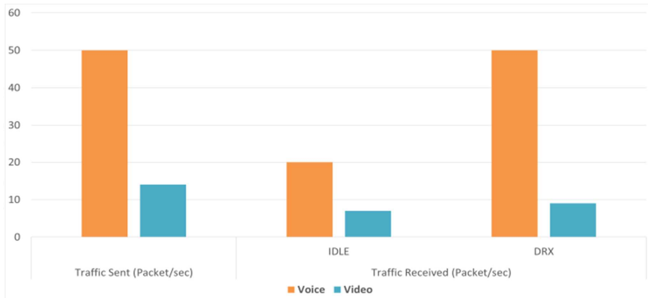
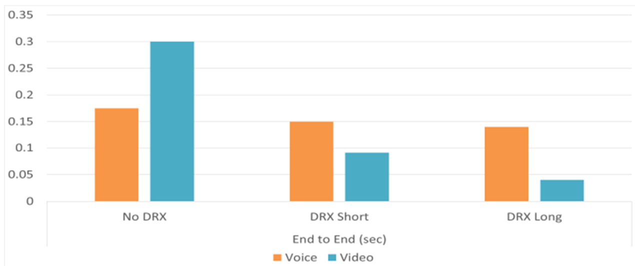


Fig.48 HTTP Three DRX modes Results

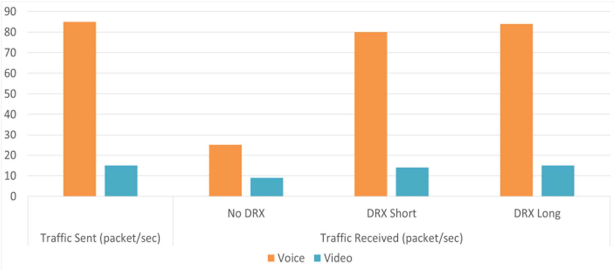


(a)

Fig.49 Video and Voice two mechanisms Results



(a)



(b)

Fig.50 Video and Voice Three DRX modes Results

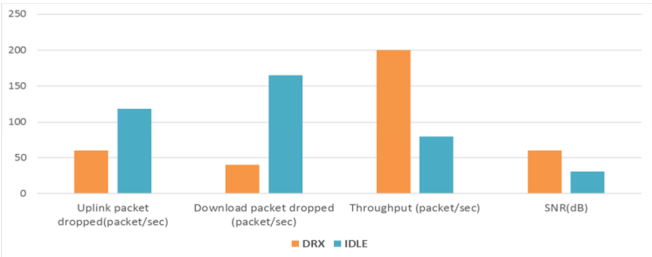


Fig.51 LTE-A Network two mechanisms Results

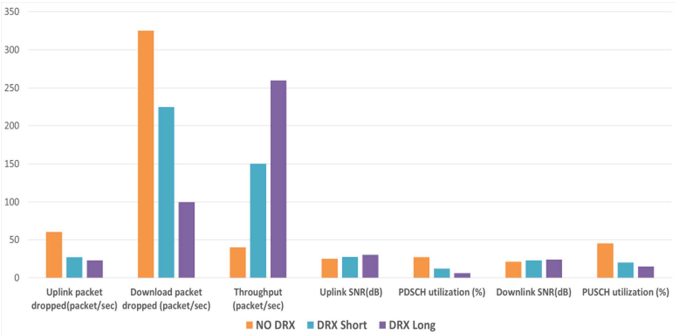


Fig.52 LTE-A Network three DRX mode Results

IV. Conclusion

Power saving mechanisms represents a highly practical problem in the transmission of packets for multimedia streams. In this case, this study focused on the point of QoS of multimedia streaming and the behavior of the overall performance of the LTE-A network under critical conditions such as mobility and fading effects. An accurate comparison of power-saving mechanisms by using OPNET simulated networks to show the effect of power-saving mechanisms over LTE-A networks on multimedia streaming to satisfy excellent empirical quality values on multimedia and the overall network performance has been presented. Several important critical parameters that have been utilized in the presented system for enhancing QoS for the multimedia streaming quality over LTE-A networks. In the use of DRX mechanism with long on duration cycles at an appropriate range of networks connections that realize :(I) Lower end-to-end delay at as mentioned in Fig. (44,45,47). (II) Higher MOS values this is meaning that the overall system performance may improve via 98% so all subscribers may want to get admission to such services each time everywhere. (III) Lower packet delay variations, as mentioned in Fig. (44,45,47). Moreover, (IV) Higher signal to noise power ratios as mentioned in Fig.49 and Fig.50 higher packets per seconds information throughput based totally on packets for information transmission with approximate zero packet loss ratio in comparison with the IDLE mechanism and DRX short cycle as mentioned in Fig.49 and Fig.50. That is to say, by using the DRX mechanism with long cycles, there is a great effect on the multimedia transmission quality and the overall network performance in comparison to IDLE mechanism. Future work includes more suitable power optimization mechanisms streaming data over mobile 5G networks at different types of network connections. Under the effect of different fading effects and different paths between BSs and SSs and studies different conditions for the network to satisfy the best quality all the time of the service's access.

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