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# Qos-Aware Scheduling With Complete Sharing Algorithms in Long Term Evolution (Lte)

**Oloruntegbe A.B [1] and Kuboye B.M [2]**

Computer Science Department, Federal University of Technology Akure, Ondo State, Nigeria,
*ayoblossom2@gmail.com, bmkuboye@futa.edu.ng*
**Corresponding Author's Email:** *ayoblossom2@gmail.com*

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## ABSTRACT

*As more and more Internet users become accustomed to broadband connectivity wherever they are and wherever they go, the deployment of 3G GSM mobile broadband has become a reality. The Internet generation has become more interested in multimedia applications such as multimedia online games (MMOGs), mobile TV and online content which has prompted 3GPP to work on LTE. The goal of this work is to create an LTE scheduling system that supports QOS using sophisticated sharing algorithms. This work started with a literature review in the area of Quality of Service (QOS) and scheduling algorithms used in LTE. The QOS Aware Professional Fair (QAPF) scheduling mechanism is extended in this work. This account for media movement between non-real-time users and starred base stations that are in the network but are not yet available for a fair share or traffic resource. To minimize congestion, calls transferred to new base stations are expected to be supported without interruption and are prioritized over new calls. In addition, the system uses a global sharing schedule to partition radio blocks between RT and NRT to ensure fair non-real-time (NRT) allocation. By fairly distributing the available resource blocks, Non-GBR (NRT) users get their fair share and an applicable fairness rule is created for the users. As a result, the QOS of real-time voice and data users is improved compared to QAPF. In addition, NRT users also get satisfactory results compared to QAPF situation.*

## 1.0 INTRODUCTION

Mobile broadband has become a reality in recent years as more and more Internet users become accustomed to ubiquitous broadband access. Multimedia applications such as mobile TV, multimedia online games (MMOGs), and content streaming through social media have attracted more attention from users and motivated 3GPP to work on LTE and LTE-advanced. LTE, an end-to-end All-IP mobile application, has become the response to provide better applications and services to mobile users (Harri Holma and Antti Toskala 2012). However, the improvements that LTE offers (e.g., increased capacity due to increased data throughput) and the continuous growth of applications that require high bandwidth as the technology advances, are continuously increasing the demand for mobile data traffic. Challenges for mobile operators which are: growth in demand for mobile bandwidth, increase in capacity and data throughput which is difficult to manage. Also as technology advances, the number of applications that require high bandwidth continues to increase. This research is set out to design QoS-Aware scheduling with complete sharing algorithms and simulate and evaluate the developed algorithm.

### 1. Related Work

Chauhan et al (2019) proposed the use of femtocells to provide superior internal voice communication, improved network capacity, and high data coverage in LTE-A. Crosstalk is a big problem in femtocell networks. Crosstalk is the interference between femtocell base stations and microcell base stations in the network architecture. In all heterogeneous LTE-A networks using femtocells, the use of femtocells can increase throughput while reducing crosstalk. The limitation is the high level of interference.

Sánchez et al (2014) discussed the study of LTE-Advanced HetNet in a realistic setting. The limitation of this work was how to distribute resources (time and frequency) among different types of nodes in the best way to avoid coverage gaps and load balancing between nodes.

Ronoh et al. (2012) Load balancing in heterogeneous LTE-A networks, they analyze the impact of QoS on how to distribute available radio resources to different users, taking into account specific principles regarding user prioritization compared to LTE. The limitation is that interference avoidance or mitigation techniques need to be implemented.

Assefa et al (2016) Random Linear network coding (RLNC) has emerged as a promising solution for reliable media delivery over mobile cellular networks. In addition, we deploy Application Layer-RLNC (AL-RLNC) on top of the existing Hybrid Automatic Repeat Request (HARQ) in 4G Long Term Evolution (LTE) networks. We consider a simple implementation scenario consisting of user equipment, eNode-B and remote host. The results also show that AL-RLNC improves throughput and coverage at the expense of higher packet latency. In addition, we compare the performance using AL-RLNC with that using advanced antenna technologies in LTE Multiple-Input Multiple-Output (MIMO) systems.

Yifeng (2009) proposed a congestion control solution for eNode-B. He designed an Active Queue Management (AQM) scheme to manage traffic in eNode-B. He recommended implementing AQM in eNode-B rather than in UE side because implementing AQM in UE side does not guarantee good performance. The goal of AQM is to control UE queue length, reduce end-to-end delay, and reduce the possibility of buffer overflow or underrun.

Niu et al. (2013) proposed an optimized scheduling approach that takes advantage of multi-user diversity by considering the instantaneous downlink conditions and QOS information of each user during resource allocation. They proposed a resource management approach for LTE downlink that fully exploits multi-user diversity. The QOS-Aware Proportional Fairing (QAPF) scheme is introduced (Myo and Mon, 2015, Myo et al., 2019). The proposed scheduler is said to be able to support QoS requirements of various service classes when its performance is evaluated using well-known schedulers, MLWDF and Ex/PF. The work is extended. The performance of the scheduler is analyzed by comparing it with the PF scheduler for non-real-time traffic and the Earliest Dead Line First scheduler for real-time traffic. The drawback of this scheduler is that it lacks fairness for NRT. This is because it does not schedule NRT until RT is scheduled, and if there are no available RBs left, NRT is reset. In addition, incoming calls with handovers are not considered by the scheduler.

The motivation for conducting this research is to improve on the previous work of (Myo and Mon, 2015, Myo et al, 2019). In this study, we will use a full distribution method to maintain fairness among various media in the network and complete the task by utilizing the current service. Therefore, the purpose of this study is to develop a QoS-aware scheduling algorithm and a full allocation algorithm.

## 2. RESEARCH METHODOLGY

This work extended the scheduling algorithm presented in QAPF to account for bearer that were present in the network but moved from one base station to another. To maintain uninterrupted calls, the call status transferred to the new base station is assumed to be uninterrupted and therefore should be given higher priority than new calls using guaranteed data rate (GBR) or non-GBR (NRT). In LTE, UEs using GBR are considered to operate in real time (RT) as they guarantee the specified data rate for the bearer. This reduces the satisfaction of ongoing calls as it guarantees continuous calls. Additionally, for the system to provide fair allocation for non-real time (NRT), the system should adopt a complete allocation schedule where radio blocks are shared between RT and NRT (Kuboye et al, 2016). A graphical representation of the general structure of the system scheduler is shown in Figure 1

### 2.1.1. Time Domain Scheduling (TDS)

The raw traffic data enters the system as a mixed traffic of GBR and nonGBR, traffic and is then transmitted to the Time Domain Schedule (TDS). This matches the IP traffic packets to their media types as shown in Table 1 (Monghal et al, 2008). The TDS then classifies them into GBR, which is considered as an RT call, and Non-GBR, which is considered as a non-real-time (NRT) call, as shown in Figure 1. 1. The TDS uses the Head of Line (HOL) delay to prioritize RT and NRT. The media priority list is generated by the TD scheduler. When creating a priority list, you must consider the quality of service (QoS) requirements of each media type. The primary factor in determining the priority of a weak media type in a GBR list is the start-of-line (HoL) latency. When constructing a priority matrix, media whose HoL delay exceeds the maximum delay budget are excluded.

The main factor for prioritizing the bears in GBR list is the head-of-line (HoL) delay. In generating the prioritization matrix, bearers which have HoL delay exceeding the maximum delay budget are excluded as shown in Equation 1 and 2.

*If maximum delay budget (Db) >HoL, then drop that bearer* 1

For the prioritization matrix, urgent bearers with closure delay up to the maximum delay are searched first.

*If maximum delay budget (Db) - HoL delay > minimum delay threshold, insert that bearer to the emergency list* 2

These extracted emergency bearers are sorted in descending order according to their delay. Once all emergency bearers have been prioritized, bearers whose delay below the minimum threshold will be prioritized by using their delay value. This shows that the bearers closing to expiration will obtained the higher priority. In this way, system spectrum efficiency can be saved.

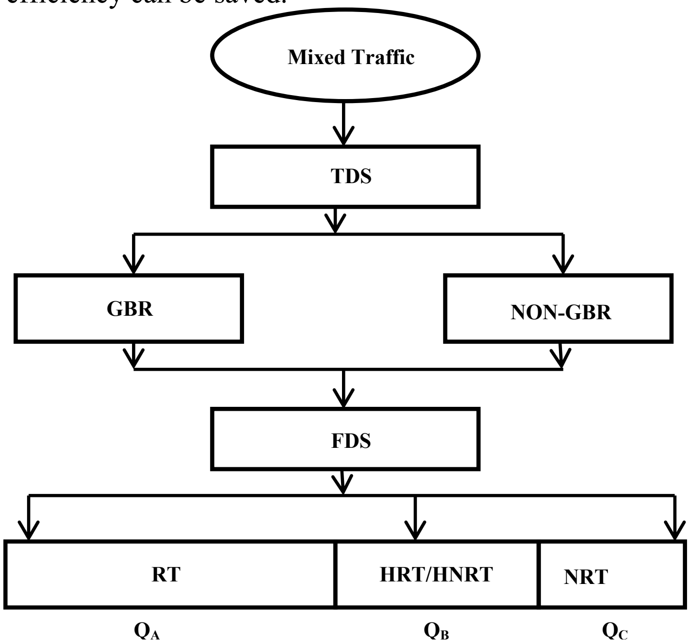


Figure 1: PRB general scheduler framework

The priority matrix of the nonGBR list is for best-attempt services such as file downloads, so it does not consider latency. Therefore, the generation of the priority matrix for nonGBR services is based on link status. The average channel capacity is used to consider fairness. In addition, the priority weight of the normalized CQI in Table 1 is used to distinguish priorities among non-real-time traffic. The priority calculation for bearer *i* at time *t*, *nonGBR* $Pi_{(t)}$ as shown in Equation 3.

$$\text{nonGBR } Pi_{(t)} = \arg\max[wi * ri/\text{-}ri] \qquad 3$$

Here, *wi* is the weight factor of bearer *i*, *ri* is the instantaneous throughput, and *–ri* is the average throughput of bearer *i*. The time-average throughput of user *k* is updated by the moving average as shown in Equation 4.

$$\text{-}ri(t)=(1-a)\text{-}ri(t-a)+ari(t) \qquad 4$$

*where, a=2/1+N* is scaling factor of *N* time period.

**TABLE 1: STANDARDIZED QOS CLASS IDENTIFIERS (QCIS) (Monghal et al, 2008)**

| QCI | BEARER TYPE | PRIORITY | PACKET DELAY BUDGET(MS) | PACKET ERROR LOSS RATE | EXAMPLE SERVICES |
|---|---|---|---|---|---|
| 1 | GBR | 2 | 100 | 10 | Conversational voice |
| 2 | | 4 | 150 | 10 | Conversational video (live streaming) |
| 3 | | 3 | 50 | 10 | Real time gaming |
| 4 | | 5 | 300 | 10 | Non-conversational video (buffered streaming) |
| 5 | Non- GBR | 1 | 100 | 10 | IMS Signaling |
| 6 | | 6 | 300 | 10 | Video (buffered streaming) TCP-based (e.g. WWW, e-mail, chat, ftp, p2p file, sharing, progressive video, e.t.c.) |
| 7 | | 7 | 100 | 10 | Voice, video (Live Streaming) Interactive Gaming |
| 8 | | 8 | 300 | 10 | Video (buffered streaming) TCP-based (e.g., WWW, e-mail, chat, ftp, p2p file, sharing, progressive video, and so on) |
| 9 | | 9 | 300 | 10 | |

## 3.1.2 Frequency Domain Scheduling (FDS)

The FD scheduler uses the classification and prioritization groups generated in the TDS to allocate resource blocks (PRBs) to media. During PRB allocation, the media to be offered in the next TTI is selected from the priority media list generated by the TDS. A Transmission Time Interval (TTI) is a unit of time in which an eNodeB schedules uplink (UL) and downlink (DL) data transmissions. A handoff call refers to a carrier that was online but has moved from one base station to another. Otherwise, to maintain continuity, it must accept a higher priority than a new call that is GBR (RT) or non-GBR (NRT). GBR is classified as real-time (RT) and non-GBR is classified as non-real-time (NRT). Therefore, it can reduce the sudden network connection interruption and improve the user satisfaction. In addition, the system adopts a complete allocation schedule that divides the radio block into three parts, QA, QB, and QC, and then assigns them to RT to ensure fair allocation for non-real-time (NRT) mode. , HRT, NRT, and HNRT are shown in the diagram in Figure 2. The complete allocation scheme has been proven to provide the highest system utilization among other channel allocation strategies (Moses et al, 2014).

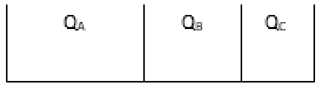


Figure 2. Complete Sharing Schemes

This scheme starts PRB allocation using the GBR bearer list, which is real-time traffic in QA and nonGBR in Qc, as shown in Figure 3. The PRB allocation follows the priority schedule of TDS in RT and NRT sections from highest to lowest. Due to the design difference in the technical scheduling algorithms, this priority resource block scheduling algorithm helps in managing congestion in LTE networks. RT/HRT occupies QA and QB sections if there are empty RBs to occupy. Otherwise, it is reset if there are no empty RBs and the RBs occupied by HNRT in QB are forcibly removed. RT can only replace HNRT at QB if there are no free RBs to occupy, since RT cannot replace HRT or RT as shown in Equation 6. HNRT can only replace NRT at QC if there are no free RBs in QB and QC, as shown in Equation 7.

$$RT = Q_A + Q_B \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 5$$

$$HRT = Q_A + Q_B, \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 6$$

$$HNRT = Q_B + Q_C \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 7$$

$$NRT = Q_C \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 8$$

Wherein priority,

$HRT > RT > HNRT > NRT$ and $RT = GBR$, $NRT = nonGBR$

This scheme provides a fair distribution of NRT resources, which can be completely exhausted if a radio block is not available, since there is a separate section for occupancy. The operational flow of this circuit is shown in the block diagrams in Figures 3 and 4. The block diagrams show the operation of GBR, which is considered separately as real-time (RT) calls and non-real-time (NRT) calls.

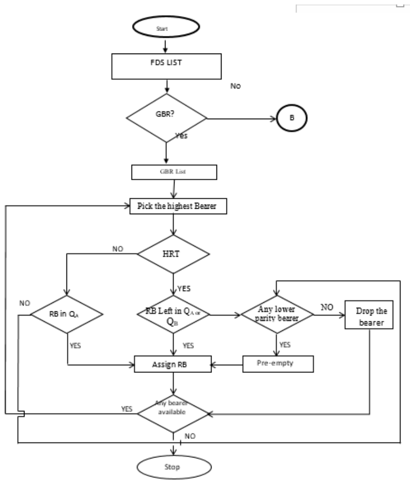


Figure 3: RT flowchart

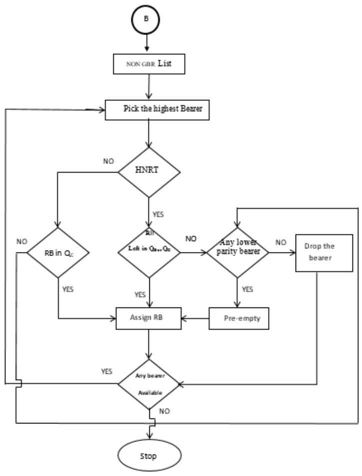


Figure 4: NRT flowchart

The implementation of the proposed system using LTESim, an open source simulator for LTE networks. The QoS-aware proportional fairness for RT and QoS-aware proportional fairness for NRT are compared with QAPF for evaluation purposes.

## 4.0 RESULT ANALYSIS

The performance analysis results of the proposed EQAPF (Enhanced Qos-aware Proportional Fair) are compared with QAPF (Qos-aware Proportional Fair) and EXP/PF(Exponential Proportional Fair), and the open source LTE Sim for LTE networks are as follows. This performance evaluation. Table 2 shows the simulation parameters.

**TABLE 2: SIMULATION PARAMETERS**

| **Parameters** | **Value** |
|---|---|
| Simulation Duration | 46 Sec |
| Number of users 1,2,3,4,5 | Number of users 1,2,3,4,5 |
| Cell radius 1 Km | Cell radius 1 Km |
| User speed 3 Km/h | User speed 3 Km/h |
| Frame Structure FDD | Frame Structure FDD |
| Bandwidth 10 MHz | Bandwidth 10 MHz |
| Transmission time interval $1(10^{-3}$ms) | Transmission time interval $1(10^{-3}$ms) |
| Maximum Delay $0.1(10^{-3}$ms) | Maximum Delay $0.1(10^{-3}$ms) |
| Minimum Delay $0.05(10^{-3}$ms) | Minimum Delay $0.05(10^{-3}$ms) |

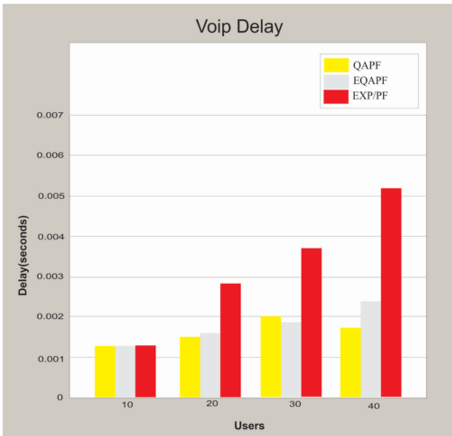


Figure 5: Average VoIP Delay Vs number of users

As shown in Figure 5 EQAPF has similar performance in delay with QAPF with a lesser user but increases as the users' increases. Compare to Ex/PF when the number of users is increased, it has higher performance in delay.

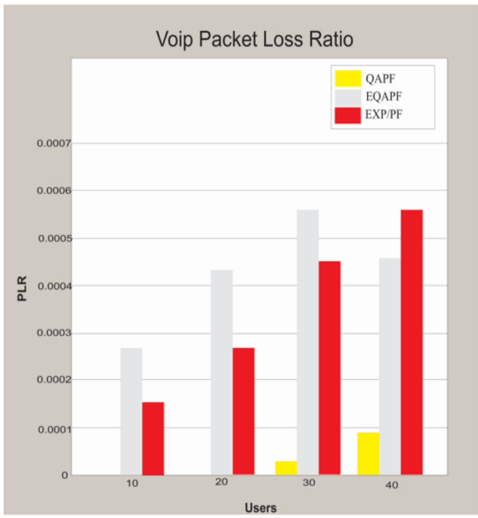


Figure 6: Average Packet Loss Rate (PLR) for VoIP users

Figure 6 shows that packet loss rate for QAPF has a lower packet loss rate than EQAPF and EX/PF. EQAPF has the highest PLR as the user increases to EX/PF but become lower at the highest user compare to EX/PF

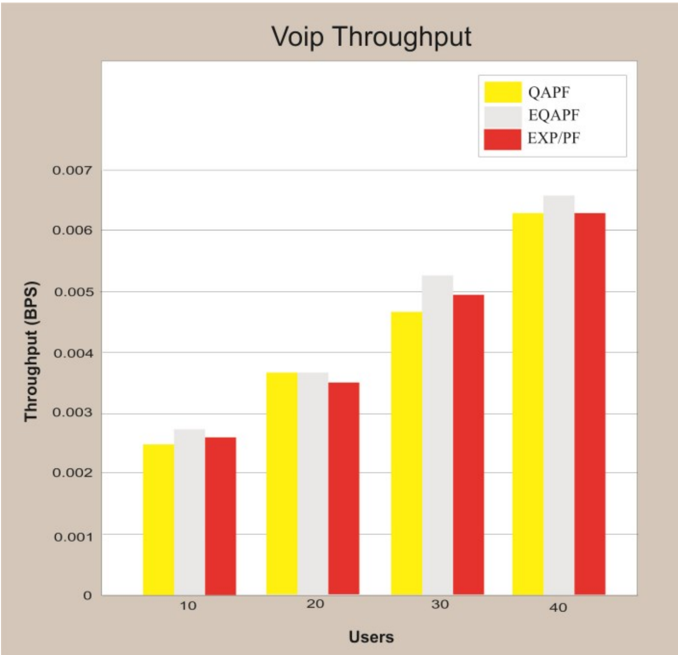


Figure 7:  VoiP Throughput vs Number of users

Figure 7 shows that the throughput performance for VoIP of EQAPF users is higher than that of QAPF and EX/PF. While QAPF and EX/PF has almost the same level of throughput as user increases.

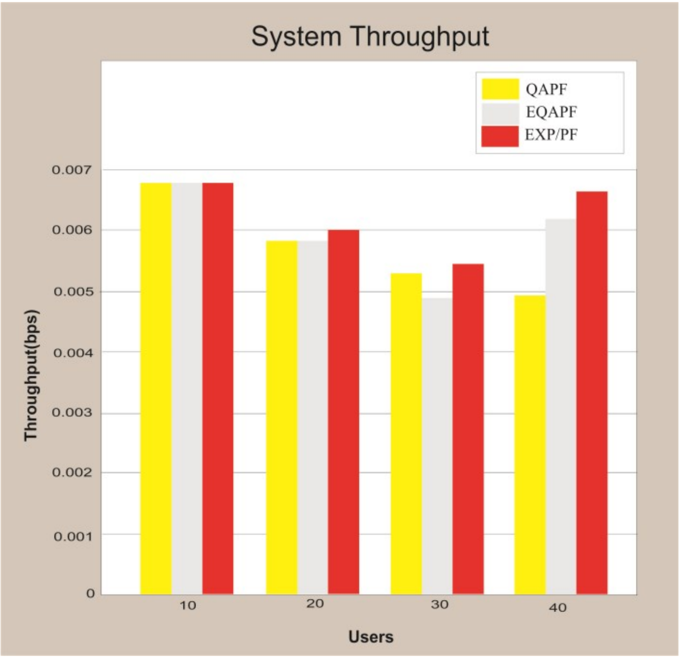


Figure 8: System Throughput vs Number of users

According to figure 8 overall system spectrum efficiency for three schedulers is high when the number of users is low. When the traffic load is high, system spectrum efficiency falls. Among them, QAPF can cause lower system throughput than others because users with low channel condition, but more waiting time are scheduled to guarantee the QoS requirements of GBR services.

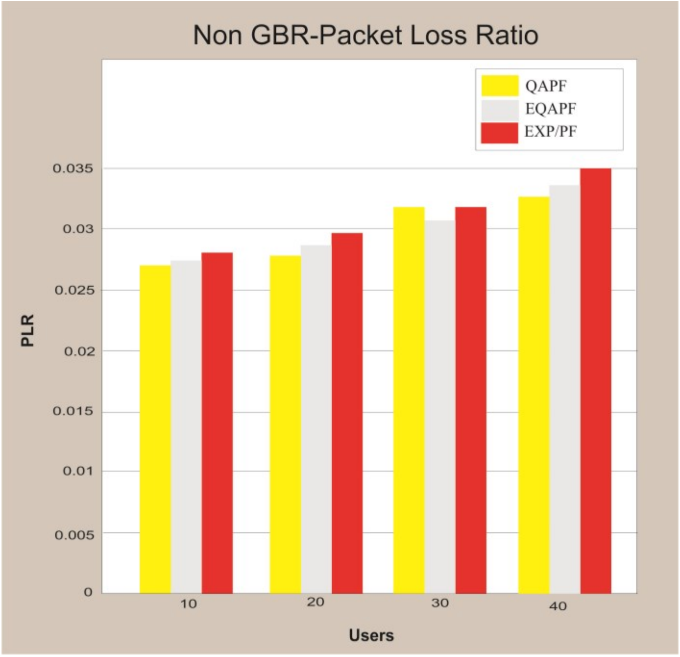


Figure 9: Packet Loss Ratio for nonGBR services Vs number of users

Figure 9 shows the average packet loss ratio of nonGBR services (Video streaming or Background traffic).When the users are increased, EQAPF has slightly higher performance in packet loss rate than QAPF while EP/PF has the highest performance in PLR when the users increases.

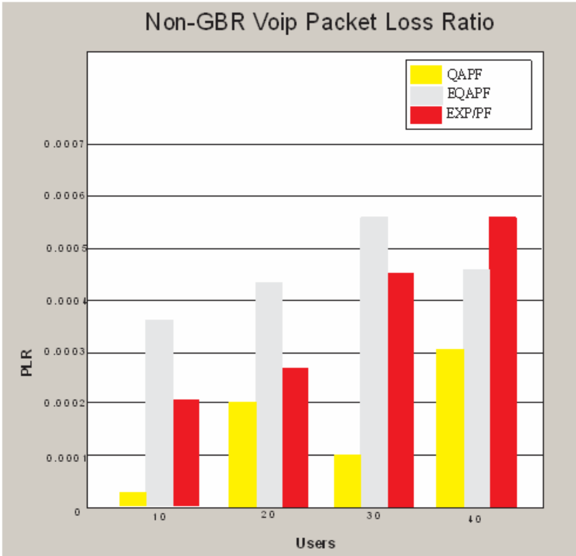


Figure 10: Non-GBR VOIP Packet Loss Ratio vs Number of users

Figure 10 shows that Non GBR VOIP packet loss ratio of QAPF is lower than EQAPF and EXP/PF. EQAPF has the highest PLR has user increases compare to EX/PF but EQAPF reduce when it get to the highest user.

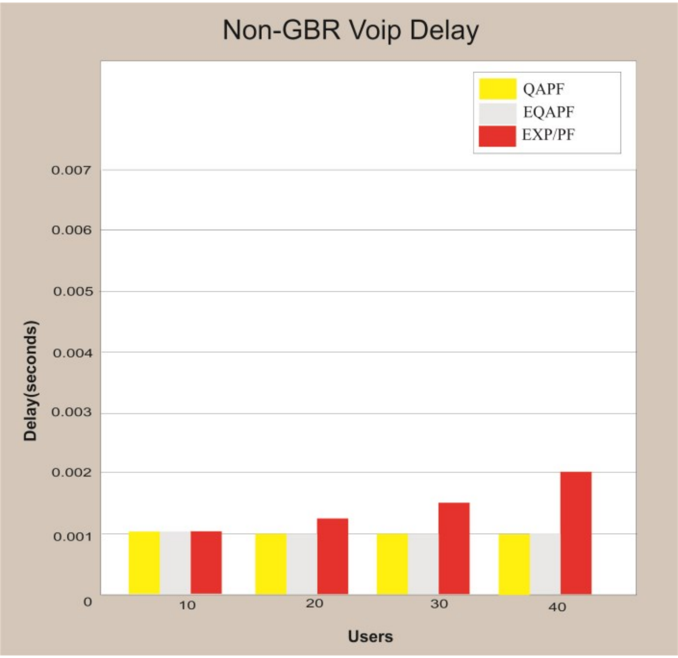


Figure 11: Non-GBR VoiP Delay vs Number of users

Figure 11 shows that non GBR voip delay of QAPF as a similar delay at each user level with EQAPF and they are at lower level as user increases compare to EX/PF.

**5.0 CONCLUSION**

In this paper, we propose a QOS-aware scheduling and full-sharing algorithm for LTE networks. If implemented, it will satisfy both the QOS requirements of GBR and nonGBR by considering the demand and importance of GBR class classified as RT while not allocating the allocated RBs to nonGBR classified as NRT. Upon completion of this study, the QAPF improvement through full-sharing scheme will be established to prevent HRT call drop and increase NRT call absorption in the system. The EQAPF has higher in performance delay for voice flow when it is compare with QAPF and EX/PF. It set lower average throughput and higher packet loss rate for voice flows, in comparison with EQAPF. The reason behind this is that QAPF drops the packets that violate the maximum delay budget.

The research established and actualized the Enhanced QOS-Aware Proportional Fair (EQAPF), proposed that the status of handoff calls into the new base station should have a higher priority over the new calls either GBR (RT) or NON–GBR (NR

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