Performance Study of Round Robin and Proportional Fair Scheduling Algorithms by Emulation for Video Traffic in LTE Networks

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ABSTRACT
Video communication over mobile broadband is gaining popularity due to the increased demand for applications such as Video on Demand (VoD), IPTV, video conferencing etc. In order to support these video applications over mobile broadband, efficient video streaming within the limited bandwidth environment is essential. Further, Long Term Evolution (LTE) network incorporates advanced Radio Resource Management (RRM) mechanism such as scheduling to realize efficient video streaming over limited bandwidth arena. Scheduling does the task of dividing and allocating radio resources in order to maximize system throughput and enhance Quality of Experience (QoE) of the end user. Hence, in this paper an attempt has been made to evaluate the performance of Round Robin (RR) and Proportional Fair (PF) scheduling algorithms using EXata network emulator for real video traffic generated by Video LAN (VLC) media player. Packet Delivery Ratio (PDR) and throughput are considered as performance metrics for the emulation studies.

General Terms
Performance evaluation, LTE, Scheduling.

Keywords
LTE, QoS, Round Robin, Proportional Fair, Emulation.

1. INTRODUCTION
Video communication over mobile broadband has demanded Long Term Evolution (LTE) network venders to maintain high reliability, quality and low latency in limited bandwidth environment. These performance improvements are typically obtained through proper Radio Resource Management (RRM) functionalities such as scheduling. Scheduling aims at optimizing radio resource utilization over time and frequency domain in order to deliver the best possible user experience based on different criteria [1,2]. The two most commonly used scheduling algorithms based on throughput and user fairness in video communication are Round Robin (RR) and Proportional Fair (PF) scheduling algorithms. RR algorithm gives equal scheduling chance to each user in the cell, whereas PF scheduling algorithm assigns radio resource to user with highest instantaneous achievable data rate relative to its past average data rate [3].

Network emulation method provides an exact, high quality reproduction of real system behavior so that the emulated system is indistinguishable from the real system. Emulation is a cost-effective method for evaluating new network technologies before actual systems or networks are implemented. Further, emulation can be used to verify performance of net-centric systems and to set realistic expectations of the real system to be deployed [4]. Hence, in this paper an attempt has been made to evaluate the performance of RR and PF scheduling algorithms for real video traffic generated by Video LAN (VLC) media player using EXata network emulator considering Packet Delivery Ratio (PDR) and throughput as performance metrics.

The rest of the paper is organized as follows. Section 2 gives a brief overview of LTE. Emulation studies and results are given in section 3 and Section 4 concludes the paper.

2. OVERVIEW OF LTE
Third Generation Partnership Project (3GPP) LTE network targets a packet optimized system which provides higher data rate, lower delay with improved coverage and spectrum efficiency. In order to reach these performance targets, LTE adopts Orthogonal Frequency Division Multiple Access (OFDMA) based radio access network referred as Evolved-Universal Terrestrial Radio Access Network (E-UTRAN) and an all IP based core network referred as Evolved Packet Core (EPC). The E-UTRAN is responsible for the RRM mechanisms such as scheduling, call admission control, retransmission protocols, coding, power control, handover and various multi antenna schemes. It contains single type of network element called eNodeB (eNB), which act as the terminal point for all radio communications carried out by the User Equipment (UE). Whereas the EPC is responsible for mobility management, charging, authentication, setup of end-to-end connections. E-UTRAN and EPC are collectively referred as Evolved Packet System (EPS) which supports differentiated end to end Quality of Service (QoS) requirements of the end user [5].

Various applications such as conversational voice, conversational video, video streaming, Video on Demand (VoD), File Transfer Protocol (FTP), web browsing etc., have heterogeneous QoS requirements. For e.g., conversational video has stringent delay and jitter requirements while FTP requires a much lower packet loss rate. In order to support multiple QoS requirements, EPS has defined class-based bearer, where each bearer is assigned a scalar QoS Class Identifier (QCI) [6]. The standardized QCI characteristics for the bearer traffic between UE and the gateway are specified in terms of priority, packet delay budget, packet error loss rate and bearer type i.e., Guaranteed Bit Rate (GBR) or non- GBR. QCI is the primary parameter that controls bearer level packet forwarding treatment e.g., scheduling weights, admission thresholds and queue management thresholds. In LTE these values are valid to ensure that applications mapped to a QCI get the same QoS through the entire delivery over the EPS.

EPS incorporates advanced RRM mechanisms such as scheduling in order to deliver QoS effectively in the limited bandwidth environment. Scheduling algorithm is employed to select different users in time domain and different radio resources in frequency domain depending on the channel conditions and bandwidth requirements while ensuring fairness, stability and throughput optimality. The two most commonly used scheduling algorithms based on throughput and user fairness in video communication are RR and PF scheduling algorithms [3]. The RR scheduling algorithm maintains a constant delay between two transmissions to the same user. This is an advantage for modern voice and video communications which have strict delay requirements. However, the PF scheduling algorithm provides a good tradeoff between system throughput and fairness by selecting the user with highest instantaneous data rate relative to its past average data rate. However, in every block PF scheduler informs the UEs about their allotted slot positions of radio resources thus increasing scheduler complexity and overhead.

3. EMULATION STUDIES AND RESULTS

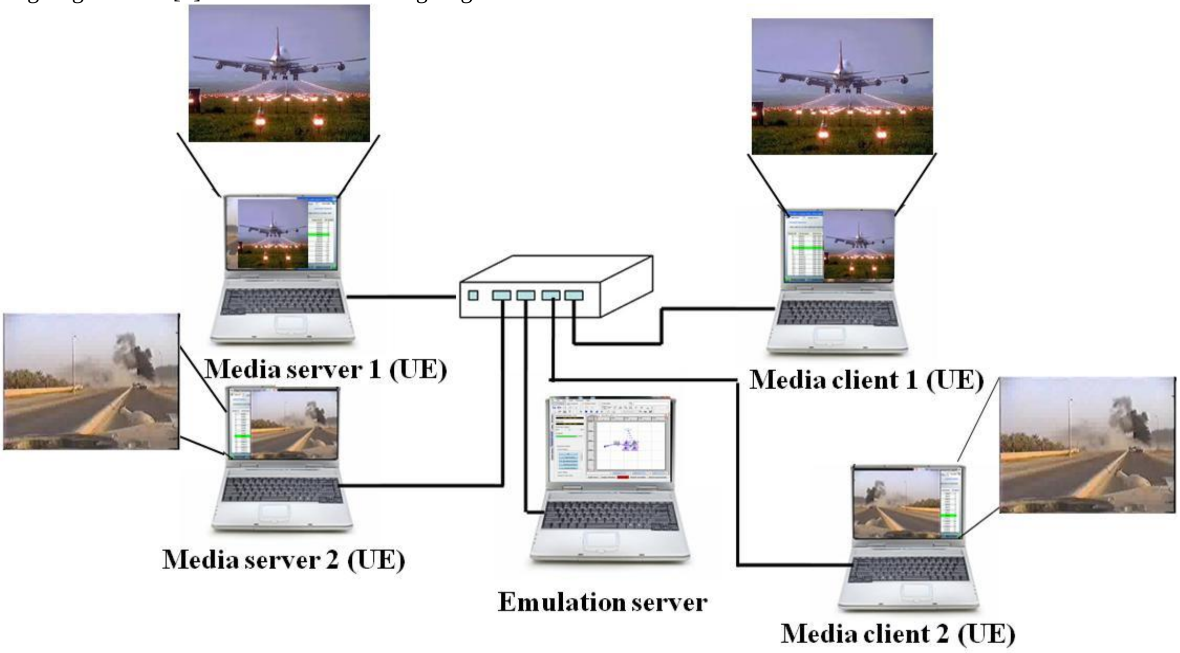

Fig 1: Test bed established for the emulation studies

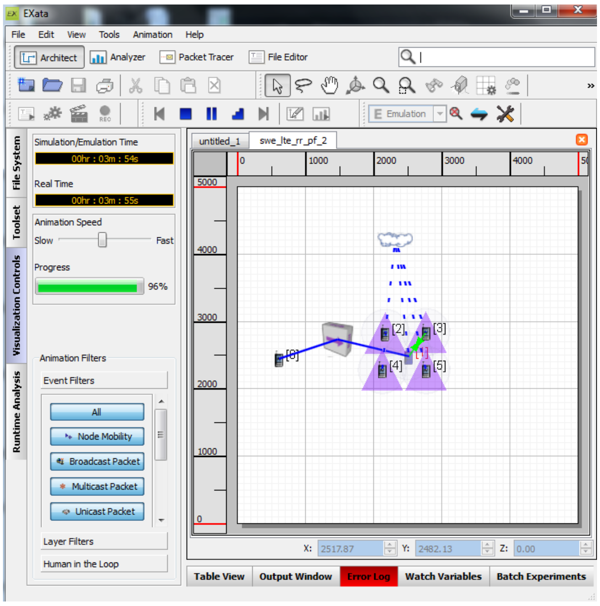

Fig 2: Snapshot of the scenario designed for emulation studies

Emulation studies has been carried out to evaluate the performance of Round Robin (RR) and Proportional Fair (PF) scheduling algorithms for real video traffic using EXata 4.1 network emulator [7]. Emulation test bed established consists of an emulation server and four computers interconnected using network router as shown in Figure 1. The connections between them are established using EXata connection manager. The scenario designed for emulation studies using EXata 4.1 network emulator consists of an eNB and four UEs as shown in Figure 2, where the UEs are mapped onto four real computers (Figure 1). Among these four computers two of them are configured as media servers and the other two as media clients. Each media server transmits mp4v encoded video file using VLC media player to the corresponding client (Figure 1). Packets are captured using Wireshark network protocol analyzer version 1.4.2 at both the media server and client for analysis of performance metrics considered [8,9]. The emulation parameters considered are listed in Table 1.

Table 1. Emulation parameters

Property		Value
Emulation-Time		4 minutes
Emulation-Area		5Km X 5Km
Propagation-Channel-Frequency		2.4GHz
Propagation-Model		Statistical
Pathloss-Model		Two ray
Shadowing-Model		Constant
Shadowing-Mean		4dB
Channel-Bandwidth		10MHz
Antenna-Model		Omni directional
eNB	MAC-Scheduler-Type	Round Robin / Proportional Fair
	PHY-Tx-Power	46dBm
	PHY-Num-Antennas (Tx X Rx)	2 X 2
	Antenna-Height	15m
	Antenna-Gain	14dB
	MAC-Tx-Mode	2 (SFBC)
UE	MAC-Scheduler-Type	Simple-Scheduler
	PHY-Tx-Power	23dBm
	PHY-Num-Antennas (Tx X Rx)	1 X 2
	Antenna-Height	1.5m
	Antenna-Gain	0.0dB

Emulation study is carried out for video codec bit rate of 16 Kbps with RR scheduling algorithm. Throughput and PDR are calculated by capturing packets at media servers and clients. Emulation studies are repeated for video codec bit rates: 32, 64, 128, 192, 256, 384, 512, 768, 1024 and 2048 Kbps [10].

Emulations studies are repeated with PF scheduling algorithm for various video codec bit rates as considered in emulation studies of RR scheduling algorithm.

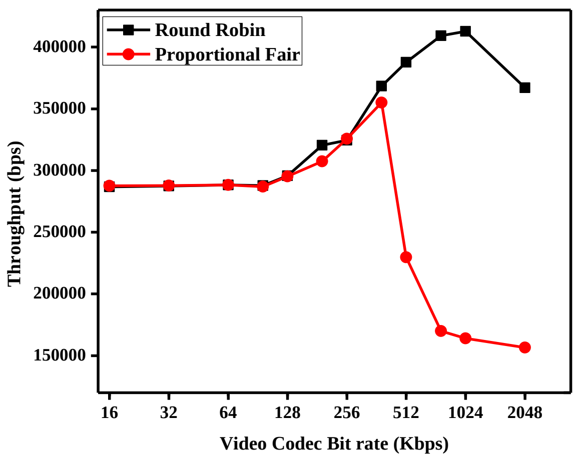

Fig 3: Average throughput performance for different video codec bit rates

Figure 3 shows the average throughput performance of RR and PF scheduling algorithms for different video codec bit rates. It is evident from Figure 3 that the throughput performance of RR and PF scheduling algorithms is similar for lower video codec bit rates (up to 384Kbps). At lower codec rates, the throughput performance of both RR and PF algorithms are affected due to higher transport and network protocol overheads [11]. It is also observed from Figure 3 that for higher video codec bit rates, throughput performance of RR is better than PF. Since RR scheduling algorithm has the advantage of assigning radio resources to the UEs in a predetermined manner [12]. Hence, throughput performance of RR is better compared to PF in case of streaming applications [13].

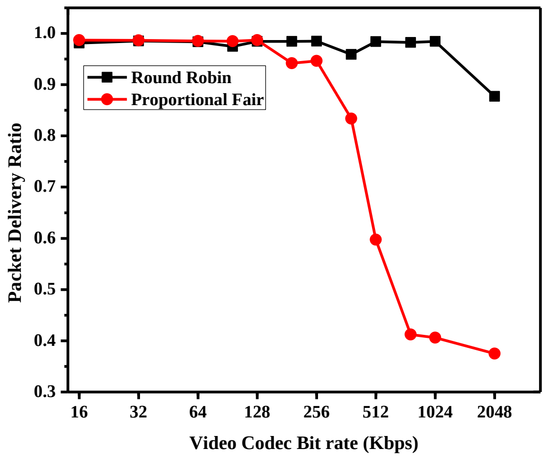

Fig 4: PDR at media client 1 for different video codec bit rates

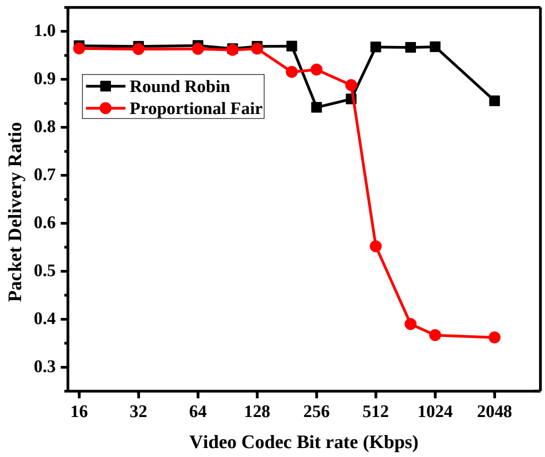

Fig 5: PDR at media client 2 for different video codec bit rates

Figure 4 and 5 illustrates the PDR for different video codec bit rates at media client 1 and 2 respectively. It is apparent from Figure 4 and 5 that PDR for both RR and PF are almost same for lower codec rates and is better for RR scheduling algorithm at higher codec rates. This is because RR scheduling algorithm assigns radio resources in a predetermined manner whereas PF scheduling algorithm has an additional overhead of calculating PF metric and allocating radio resources accordingly at every transmission time interval [12].

4. CONCLUSION

In this paper performance of RR and PF scheduling algorithms have been evaluated for real video traffic using EXata network emulator considering throughput and PDR as performance metrics. Throughput performance and packet delivery ratio for RR & PF scheduling algorithms are similar for lower codec rates while RR performs better compared to PF for higher codec rates. Hence RR scheduling algorithm performs better than PF for video streaming applications.

5. ACKNOWLEDGMENTS

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