An Opportunistic Exponential EDF Packet Scheduling for Multimedia Traffic in LTE Networks

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***Abstract*—In this paper, we propose a downlink scheduling discipline based on the Earliest Deadline First (EDF) discipline for multimedia traffic in LTE networks, that exploits multi-user diversity and can provide QoS guarantees. We call this new scheduling the Exponential Earliest Deadline First (EXP-EDF) discipline. The EXP-EDF scheduler chooses to schedule the user whose Head of Line (HOL) packet has the earliest expiration time and the best channel conditions. Simulation results show that the proposed scheduling can provide good performance for use with multimedia traffic.**

***Index Terms*—LTE, packet scheduling, multimedia traffic, Quality of Service.**

I. Introduction

LTE is the evolution of mobile technology standardized by the 3GPP (3rd Generation Partnership Project) [1], which is based primarily on Orthogonal Frequency Division Multiplexing (OFDM) and Multiple Input Multiple Output (MIMO) techniques, enabling significant improvements in radio resource allocation and the adjustment of the links. LTE will enable the use of services and applications that require a high data rate, such as multimedia applications, ensuring the Quality of Service (QoS) requirements of these applications.

Resource allocation mechanisms have proven to be one of the main challenges for LTE systems. These mechanisms are responsible for defining how resources are distributed among the different users. A good allocation of resources results in greater bandwidth economy and a better balancing of the system. The MAC layer, located in the base station, named evolved NodeB (eNodeB), is responsible for the dynamic allocation of physical resources for the downlink and uplink transport channels.

When it comes to real-time multimedia traffic, video streaming and voice applications require QoS requirements to be provided by the communication network. The packet loss ratio must be within acceptable levels. These losses are mainly caused by the dropping of packets that exceed the delay limits of the applications. The Earliest Deadline First (EDF) [2] is a scheduler especially suitable for real-time traffic. It can satisfy the deadline delays that these applications require. However, EDF is not directly applied in wireless networks because it does not consider the characteristics of the wireless channel. Given this, some authors have proposed adjustments to the EDF to adapt it to mobile networks, among which we can mention the following works [3] [4] [5] [6].

II. The Proposed Scheduling Discipline

Considering the QoS requirements of multimedia applications and features of the EDF scheduling discipline, this paper proposes a downlink scheduling discipline based on the EDF discipline for multimedia traffic that exploits multi-user diversity and can provide QoS guarantees. This is a channel-aware EDF discipline where the scheduler chooses to schedule the user whose Head of Line (HOL) packet has the earliest expiration time and the best channel conditions, and consequently the highest transmission rate, of all users. We call this new scheduling the Exponential Earliest Deadline First (EXP-EDF) discipline. The packets of users are scheduled according to the equation below:

$$j = \arg\max \exp\left(\frac{r_i(t) * D_{HOL,i}}{d_i - D_{HOL,i}}\right) * \frac{1}{\overline{R_i}(t-1)} \qquad (1)$$

Where d_i is a delay threshold for the ith user. $D_{HOL,i}$ is the Head of Line Delay, i.e. delay of the first packet to be transmitted by the ith user. $r_i(t)$ is the actual rate that could be used for transmission by the ith user at time t, which reflects the current channel state of the user's channel. $\overline{R^i}(t-1)$ is the mean rate supported or previously offered to the ith user.

III. Simulation Results

The proposed scheduler was evaluated in simulations, comparing its performance with other scheduling disciplines, such as the Proportional Fair (PF) [7] and the Modified Largest Weighted Delay First (M-LWDF) [8], using the LTE-Sim simulator [9]. For this, we considered a scenario composed of 19 cells with a radius equal to 0.5 km, considering clusters composed by four cells and intercellular interference. In the central cell, there are a variable number of UEs in the range [10 - 40], moving at a speed of 3 km/h. Each UE receives at the same time one video flow, one VoIP flow and one best effort flow. In this paper the results were presented only for the video flow.

First, we evaluated the Packet Loss Ratio (PLR), considering the variation of the number of simultaneous users in the central cell. The maximum delay allowed for packets was set to 100 *ms*. Packets with delays greater than this value were dropped. Figure 1 shows the results for the PLR for the schedulers EXP-EDF, PF and M-LWDF for video traffic. The EXP-EDF scheduler obtained a better performance for PLR when compared with the other schedulers.

Figure 2 shows the results in terms of throughput achieved by the video flows. It is observed that the EXP-EDF maintains a higher throughput compared to other schedulers when increasing the number of users.

Another important metric to be evaluated is the fairness index. This is a measure that should be taken into account to ensure a minimum performance, even for users experiencing channel conditions that are not so favorable. Fairness index has been computed using Jain's fairness index method [10]. Table I shows that the proposed scheduler can maintain a high level of fairness index.

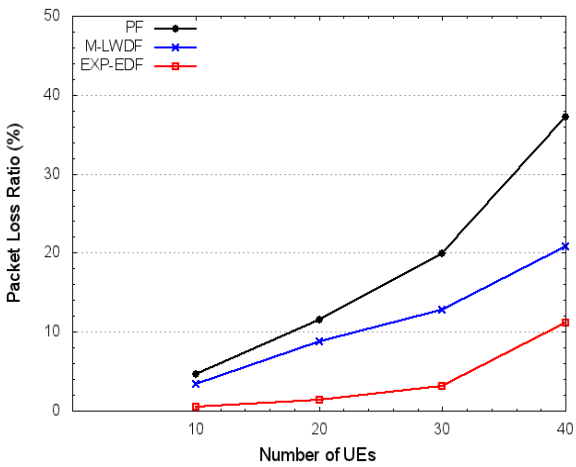

Fig. 1. Packet Loss Ratio of video flows.

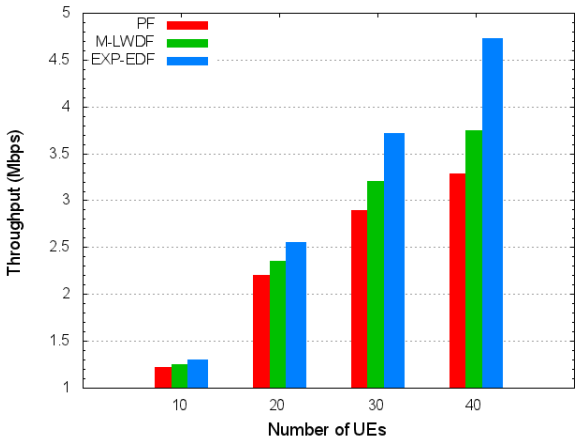

Fig. 2. Aggregate throughput of video flows.

TABLE I. FAIRNESS INDEX VALUE OF VIDEO FLOWS.

Number of UEs	PF	M-LWDF	EXP-EDF
10	0.97888	0.98579	0.99974
20	0.94781	0.96882	0.99645
30	0.91889	0.94673	0.98448
40	0.88679	0.91801	0.96266

IV. CONCLUSIONS

In this paper we considered the problem of packet scheduling for real-time multimedia traffic in downlink LTE networks. For this, a proposal was presented for a scheduling discipline called EXP-EDF. Considering the scenarios presented and evaluated metrics, the proposed scheduler outperformed the PF and M-LWDF schedulers. The EXP-EDF was also suitable for use with multimedia traffic, since it was able to maintain the QoS requirements, such as PLR and throughput, within acceptable limits. It also had a good fairness index.

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