MODELING AND PERFORMANCE EVALUATION OF PACKET SCHEDULING IN UPLINK 3GPP LTE SYSTEMS

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Abstract

The radios must be distributed in the best way possible to provide higher quality of service (QoS) to users. A main component of Long-Term Evolution (LTE) processing is the packet scheduler, which includes all time and frequency support in active flows. We evaluate in this article three different scheduling algorithms in the uplink transmission path for the mixed forms of traffic flows for the Single Carrier Frequency Division Multiple Access (SC-FDMA). We apply metrics which allow fast evaluation of performance measures such as throughput, Packet Loss Ratio (PLR), Fairness Index (FI) and Spectral Efficiency (SE) by using the LTE-Sim open source simulator. The main contribution of this paper is to determine the appropriate uplink scheduling algorithm for VOIP and video traffics in 3GPP LTE.

Keywords: SC-FDMA; QoS; LTE; Scheduling algorithms; Resource allocation; Uplink direction, throughput, fairness, Packet loss ratio, Spectral Efficiency.

I. Introduction

Today, the mobile broadband grows in very fast way. The long term evaluation is the technique used to establish a mobile network for high capacity. LTE in general is termed as 3G sometimes. The factors such as the high capacity and low latency makes it really effective in the radio connectivity system. There are various method used for the uplink and transfer of the signals from the base station. Some of the commonly known method for the process of sending signal to achieve the success are Single Carrier Frequency Division Multiple Access (SC-FDMA) and Orthogonal Frequency Division Carrier Multiple Access (OFDMA) [XII]. In general while an
LTE is applied a pre-coded OFDM variant called SC-FDMA is implemented. The reduced PAPR will have a good effect on battery power usage and will allow a smaller amplifier. Furthermore, an amplifier is needed. Unlike OFDMA in which each subcarrier transports unique data, the SC-FDMA spreads data across multiple subcarrier. Then, this makes the receiver more complex so the SC-FDMA technique is inconvenient for the downlink direction. However, it retains most advantages of Orthogonal Frequency Division Multiple Access (OFDMA) [XIX], [X]. To support various demands of multimedia resources in real time, QoS specifications must be ensured and PLR reduced by preserving them within the necessary implementation threshold. Moreover, multi-user scheduling is considered a key function of LTE networks since it allocates available radio resources to active users to fulfill their QoS requirements [XXIII], [VI]. We also recently proposed packet optimization algorithms to uplink LTE cellular networks with multimedia services [VI],[XX] and [XIV]. Three primary scheduling strategies are available which can optimize one of the above-mentioned goals: Maximum Throughput (MT), Round Robin (RR) and First Maximum Expansion (FME) scheduler. The LTE networks are recorded in a practical simulated multi cell environment [XX] to have performance metrics compared, including average system performance, Packet Loss Ratio (PRR), the Fairness Index (FI) and spectral efficiency. Section II gives an overview of the allocation of resources for the SC-FDMA. This article is structured as follows. Firstly, we have recently suggested kit programmers that include schedulers to be tested in our research for the uplink LTE framework. We will explain our simulation framework in depth in Section IV and draw conclusions from simulation. Finally, in Section V, we make conclusion.

II. Resource Allocation in SC-FDMA

For each user in the SC-FDMA a contiguous allocation needs of the Resource Blocks (RBs) to maximize the PAPR. This, in comparison to OFDMA [XIV-I], though, decreases the independence of resource allocation dramatically and proves to be an obstacle to design scheduling algorithms [XVI]. Nonetheless, a review of all feasible RB's distributions with contiguity paradigms is necessary to achieve the optimal solution of the resource distribution problem for SC-FDMA. In opposite to downlink scheduling algorithms, in uplink scheduling the RBs allocated to a certain user must be contiguous. This is done so that the low PAPR effects of the SC-FDMA scheme are maximized. This is more efficient than specifying for each RB if it is allocated [IV]. In LTE system, each frame consists of 10 sub sub-frames, each is divided into two slots as shown in figure 1.
In LTE system, the Resource Element [III] is considered as the smallest modulation structure which is of 15 kHz subcarrier by one symbol and assembled into Resource Blocks (RB). The dimensions of RB are as those of subcarrier by symbols. As a result, twelve consecutive subcarriers in the frequency domain and six or seven symbols in the time domain form each resource block. The number of symbols differs according to the Cyclic Prefix (CP). The Resource Block contains seven symbols when a standard CP is used. The Resource Block has six symbols when an expanded CP is used. The use of prolonged one means that the duration is greater than the standard CP length [VIII]. In order to maximize throughput and improve Quality of Service (QoS) requirements (for example for voice calls), some kind of scheduling decisions are made by the eNode-B [XVII], [XI].

The Link Adaptation strategy in multi-user wireless environments is essential, as the adaptive modulation and code (AMC) scheme overcomes channel fluctuations. The scheduler entity plays an important role in allocating resources blocks to every time interval of transmission (TTI) dependent on the input situation obtained from UE as a Channel Quality Indicator (CQI). Each of the value for a CQI is a 1-15 index that is compatible with MCS and the amount of redundancy used [II]. This value is the most fitting one for a CQI. To order to determine the spectral efficiency of that UE [XXII] the equivalent bit rate per bandwidth is defined by 3GPP, as shown in Table 1.
Table 1: CQI TABLE [I].

| CQI | Modulation | Bits/Symbol | REs/PRB | N_RB | MCS | TBS   | Code Rate |
|-----|------------|-------------|---------|------|-----|-------|------------|
| 1   | QPSK       | 2           | 138     | 20   | 0   | 536   | 0.101449  |
| 2   | QPSK       | 2           | 138     | 20   | 0   | 536   | 0.101449  |
| 3   | QPSK       | 2           | 138     | 20   | 2   | 872   | 0.162319  |
| 4   | QPSK       | 2           | 138     | 20   | 5   | 1736  | 0.318841  |
| 5   | QPSK       | 2           | 138     | 20   | 7   | 2417  | 0.442210  |
| 6   | QPSK       | 2           | 138     | 20   | 9   | 3112  | 0.568116  |
| 7   | 16QAM      | 4           | 138     | 20   | 12  | 4008  | 0.365217  |
| 8   | 16QAM      | 4           | 138     | 20   | 14  | 5160  | 0.469565  |
| 9   | 16QAM      | 4           | 138     | 20   | 16  | 6200  | 0.563768  |
| 10  | 64QAM      | 6           | 138     | 20   | 20  | 7992  | 0.484058  |
| 11  | 64QAM      | 6           | 138     | 20   | 23  | 9912  | 0.600000  |
| 12  | 64QAM      | 6           | 138     | 20   | 25  | 11448 | 0.692754  |
| 13  | 64QAM      | 6           | 138     | 20   | 27  | 12576 | 0.760870  |
| 14  | 64QAM      | 6           | 138     | 20   | 28  | 14688 | 0.888406  |
| 15  | 64QAM      | 6           | 138     | 20   | 28  | 14688 | 0.888406  |

III. LTE Uplink Schedulers

The process of the uplink is more complicated over the process for downloading. The data at the beginning is sent from the interface of the user to the end node and this is in general called as the UE. Secondly, it is very difficult to predict radio resources number needed by the UE to exchange data with the base station [V], [VIII]. For the LTE uplink radio resource allocation and as an input, the scheduler has a UE-RB association matrix which is very interested for given better results that improve the system performances. The scheduler metric is arranged into a matrix \( M \), as shown in figure 2, of dimensions \( N \times N_{RB} \), where \( N \) is the number of UEs in the network, and \( N_{RB} \) represents the total number of RBs.

![Fig. 2: Channel Conditions Matrix](image)

For the above, there are three different scheduling schema are used. The simulation was done with the help of the following as RR, MT and the FME algorithm to acquire the results.

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Round Robin (RR) Scheduler

The scheduling algorithm RR is simple and easy to use. Thus, different systems use it very often. The UEs are assigned one after another in this scheduling system. That UE is planned for this without taking the CQI into account. The RR algorithm is a fair scheduling algorithm because for each UE, the fairness index of RB is the same. Nevertheless, RR scheduler gives all UE an equal chance to obtain RBs, the overall throughput is much lower than other scheduling algorithms because this scheduler does not take into accounts the channel conditions. In LTE, various UEs mixed services with different QoS requirements and it is very difficult to allow every UE to take up the same RBs for the same priority because it will decrease the resources efficiency. The flowchart regarding the working of this algorithm is shown in figure 3.

Maximum Throughput (MT) Scheduler

The primary objective is to represent all the users who are involved however the first one is represented by the user with the maximum SINR. To order to preserve the Fairness of all users the functioning of this method is as follows: all participating users are listed in the following order according to their SINR. In a round-robin phase, resources are divided with the UE being supported first and second strongly by high SINR, and so on. The assisted user will only work if all users are presently served. The flowchart according to above algorithm is shown in figure 4.

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**Fig. 3:** Flow chart for Round Robin Algorithm

**Fig. 4:** Flow chart for Maximum Throughput Algorithm
First Maximum Expansion (FME) Scheduler

The channel-dependent matrix was implemented for FME scheduler [XIII]. The growth of the resource assignment a chosen EU is the main factor at the right and left sides of the RB [IX]. As each RB is used, the algorithm tests the cumulative metric and decides whether that limit is once again an UE to which the resource is actually allocated or whether that total is an EU other than it. If the RB is added to another UE, the consistency restrictions would be violated. If these things are valid, the RB shall receive an EU assignment Otherwise, the UE will be deemed as supported, and a new RB will be assigned to the currently chosen RB. The scheduler also reiterates the cycle of growth. In [VIII], the FME frequency is estimated to be O(NNRB). Figure 5 explains the flowchart of this algorithm.
Output assessment was carried out in a multicellular inter-cellular interference that transmits 50 per cent of video and 50 per cent of VoIP using the LTE-sim simulator [VI]. A hexagon configuration with a radius of 1 km is supposed to occur for the cell. Users are distributed uniformly between cells and travel continuously in the random direction, at a speed of 3 kmph. This video flow provides a trace-based application that sends realistic 128 kbps video track files packets [XVIII]. For an efficient voice flow based on the ON / OFF Markov chain. VoIP has been considered a G.729 voice stream with a bandwidth of 8.4 kbps. Paper explains in this section the simulation method for the assessment and the comparative analysis of the results of the three schedulers. The results of the measurements using the LTE simulator are then discussed [VI]. In this respect, we equate the first three schedulers in terms of achievement of results, PLR, fairness index and spectral efficiency for many clients. The results of the simulation assumption is presented before addressing the effects of the simulation. The parameters of the simulation used in this work are described in Table 2.
Many metrics were used in our research to get a better assessment of the simulation performance. Next, concentrating on the efficiency of schedulers such as Throughput, Packet Loss, Spectral Efficiency is important for a successful assessment of the QoS. Figure 6 shows the number of users in cell vs the PLR. In the comparative study, the RR algorithm was used as a guide for analyzing the other algorithms considered. In terms of data rate PLR it shows ideal efficiency.

![Fig. 6: Packet Loss Ratio.](image-url)
The performance of the cell can be managed with the parameters that are available. However in terms of the throughput the performance evaluation of the VOIP is more and it increases as the number of the users increases in the system. This is depicted in the Figure 7. Also it can be seen that the scheme will fail to meet the QoS need for video streaming service. Through growing number of users, The FME scheduler clearly has a better cell throughput than other scheduling algorithms for video flows.

FME shows a higher fairness index than MT algorithm for all classes of flows as shown in Figure 8. The Jains Fairness Index method is used [XVIII].

Effective use of the radio resource is an important goal to achieve. The spectral efficiency (SE) is called the indicator of success for the whole cell. For both cases, Figure 9 describes the results in SE terminology. The MT scheduler reaches the lowest SE with differing user numbers from 20 to 60 while the FME scheduler beats all other schemes.

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In this paper we estimated the efficiency in uplink direction of some algorithms for LTE networks. This paper had three schedulers introduced and they were merged into LTE-Sim. It is obtained that the RR scheduler allows spectral efficiency between users to take priority. In addition, there are various users in the system and to maximize the efficiency of the users without using PLR, the most efficient algorithm found is the FME. Since this algorithm makes it easy to create a balance between the machine PLR and the throughput of the system. The result also suggest that a FME scheduler with minimized PLR to optimize device throughput. The forthcoming work will concentrate on implementing schedulers in a 5 G uplink system based on a Semi Persistent Provisioning Strategy.

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