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Downlink resource allocation algorithm: Quality of Service

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Abstract: The LTE technology has emerged one of the most fruitful technologies as it supports large number of applications including VOIP, video conferencing, file transfer, video streaming and web browsing. Scheduling of resources plays a vital role. This goal should be accomplished by providing, an optimal trade-off between spectral efficiency and fairness. In Downlink transmission of LTE system, the minimum allocation unit for user is source block (SB) and all SB's allocated to a user must have same modulation and coding technique (MCS). In this paper, we propose a scheduler that allocates resource block (SB) for different services in order to meet their QoS requirements. Proposed scheduler allocates SB's first for real time services by estimating no of SB's required and then allocates SB's to user according to their priorities.

I. INTRODUCTION

The growing demand for network services, such as VoIP, web browsing, video telephony, and video streaming, with constraints and bandwidth requirements, poses new challenges in the design of the future generation cellular networks. 3GPP 1 introduced the Long Term Evolution (LTE) specifications [1]. The scheduler is an important issue in the MAC layer for system performance. The scheduler in the MAC layer is the main factor that affects the system performance and the resource reusability. The main problem of RB allocation is to meet different service QoS requirements and maximize system throughput. The scheduler in LTE aims to maximize system performance. However, it may decrease the system performance for the latency or starvation of connections that have lower priority if the scheduler is only concerned with high throughput. To solve this problem, three basic algorithms have been proposed, Max C/I, Proportional Fair [2] (PF) and Round Robin (RR). In spite of Max C/I algorithm makes the highest system throughput, RR algorithm can guarantee service fairness, PF algorithm makes a trade-off between throughput and fairness. But these algorithms do not take QoS requirements for real time service into consideration. To guarantee the QoS requirements for real time service, several real time scheduling algorithms have been proposed. It can be seen that resource allocation algorithms of orthogonal frequency domain multiple access (OFDMA) are mainly limited to the level of subcarriers, and all the subcarriers allocated to one user can adopt different MCS technique. However in LTE, system resource should be allocated in SB's and all SB's allocated for a user must have same Transaction time (TTI) with single antenna configuration.

In this paper we propose a new approach which allocates appropriate number of SBs first to the real time service and then the remaining resources are allocated to non real time resources. This is mainly done to guarantee QoS. For both real time and non real time services resources are allocated by estimating the number of SB's required by each user according to rate requirement and then allocating the resources according to priority. Our goal is to strictly provide QoS for real time service, maximizing system throughput and fairness.

This paper is organized as follows: Section II contains Frame structure of LTE. Next, Section III is about the system model. Section IV. Explains the algorithm in section V. Contains the simulation results Section VI contains conclusion and the last section VII contains references.

II Frame structure of LTE

Radio resources are allocated into the time/frequency domain. In particular, in the time domain they are distributed every Transmission Time Interval (TTI), each one lasting 1 ms. The time is split in frames, each one composed of 10 consecutive TTIs. Furthermore, each TTI is made of two time slots with length 0.5 ms, corresponding to 7 OFDM

symbols in the default configuration with short cyclic prefix. In the frequency domain, instead, the total bandwidth is divided in sub-channels of 180 kHz, each one with 12 consecutive and equally spaced OFDM sub-carriers. Fig 1 below gives an overview about the LTE[3] frame structure. A time/frequency radio resource spanning over two time slots in the time domain and over one sub-channel in the frequency domain is called Resource Block (RB) and

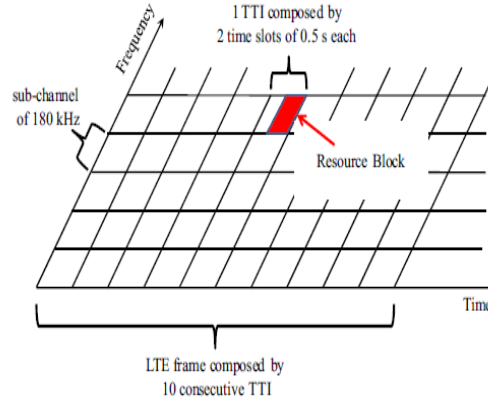


Figure 1. LTE Radio resource Grid.

corresponds to the smallest radio resource unit that can be assigned to an UE for data transmission. As the sub-channel size is fixed, the number of RBs varies according to the system bandwidth configuration (e.g., 25 and 50 RBs for system bandwidths of 5 and 10 MHz, respectively).

III SYSTEM MODEL

In downlink LTE system with N SB's where equal power is allocated to each SB. We assume that a base station serves K user and the minimum data rate is R_k Mbits/sec. One SB is N_s consecutive OFDMA symbols in time domain and N_{sc} consecutive subcarrier in frequency domain. Pilot and control signals also exist. $N_{sc}^{(d)}$ Out of N_{sc} subcarrier carry data signal $S \in (1, 2, 3, \dots, N_s)$, $N_{sc}^{(d)} \leq N_{sc}$, where $R_j^{(c)}$ is code rate associated with MCS and $j \in (1, 2, 3, \dots, j)$ where j is total no MCS supported by the transaction. M_j is the constellation size of the MCS j and T_s is the OFDMA symbol. The bit rate for an SB achieved using MCS is given by

$$r^{(j)} = \frac{R_j^{(c)} \log_2(M_j)}{T_s N_s} \sum_{S=1}^{N_c} N_{S'}^{(d)}(S)$$

The Channel Quality Indicator (CQI) is the feedback by the user to BS. It is defined by the coding and modulation technique. If we have K user in N th SB, the CQI matrix for N SB can be Expressed as $g_k = [g_{k,1}, g_{k,2}, \dots, g_{k,n}]^T$. K users CQI for N SB's can be given by $G = [g_1, g_2, \dots, g_K]^T$ and for user K maximum CQI can be obtained by $N^* = \arg \max_{n \in N} (g_{k,n})$ Considering the conditions: (1) Each SB can be allocated to one user. (2) All SB's allocated to user must have same MCS. (3) The bit rate of the SB should be greater than bit rate of the User

$$\sum_{n=1}^N p_{k,n} \sum_{j=1}^{q_{k,\max}(g_{k,n^*})} b_{k,j} r^{(j)}$$

Where $P_{k,n}$ means N^{th} SB is allocated to K^{th} user.

IV Resource Allocation Scheduler

In this paper we define suboptimal radio resource allocation algorithm. The resources are first allocated to the real time services and then to non-real time services. For both real time and non-real time services we calculate minimum no of resources required and then allocate SB's according to priorities. Steps For the algorithm are as follow:

Step1: Check user is using real time service or non real time services.

Step 2: For all the real time processes. Calculate no of minimum resources required. This is done in 2 Steps

- (a) Calculate each user average channel gain.
 - (b) Calculate minimum no of SB's required by each user.
- Step3. Allocate SB's to the Users. This is allocated 2 steps
- (a) Calculate User priorities. Priorities are allocated in following order
 - I. Highest priority is given to User having highest average channel gain and the users are defined in decreasing order.
 - II. If two user have same priority then check their minimum rate requirement. User with minimum rate requirement is given priority and users are defined in increasing order.
 - (b) Allocate the SB's to the User. SB allocation is done on user by user basis. Once the minimum requirement of all user are done. Rest of the resources are allocated to the non-real time services.

Step4. For non real time services calculate step 2 and Step3 (a) again.

Step 5. Allocate the SB's to the User using Non-real time services by first fulfilling the minimum requirement and allocating the remaining SB to the users using real time services.

IV Simulation Results

A. System parameters

Simulation parameters are listed in table 1. It is assumed that Each User is using only one service at a time and also the CQI condition is perfectly known to base station.

No of SB's	No of User	No of SB's
	4	8
	6	12
	8	16
	10	20
	12	24
Total no of subcarrier	No of user	No of subcarrier
	4	84
	6	144
	8	192
	10	240
	12	284
Subframe length T	1ms	
Maximum doppler	30 Hz	
Channel model	6-ray Rayleigh channel	
Delay Spread	5us	
Minimum rate requirements	0.8, 1.8, 0.99, 0.6, .36, 1.1, 3.1, 0.5, 1.2, 2.1, 2.2, 0.7 Mbits/sec	
Modulation and Coding	QPSK: 1/3 1/2 2/3 3/4 4/5 16QAM 1/2, 2/3, 3/4, 4/5 64QAM 2/3, 3/4, 4/5 256QAM: 2/3, 3/4, 4/5	

Simulation parameters are listed in TABLE1

B. Average throughput

Average throughput of LTE system is calculated and is provided in figure 2. The graph clearly shows that the Modified Scheduler has better average throughput than Multiuser Resource allocation algorithm[4].

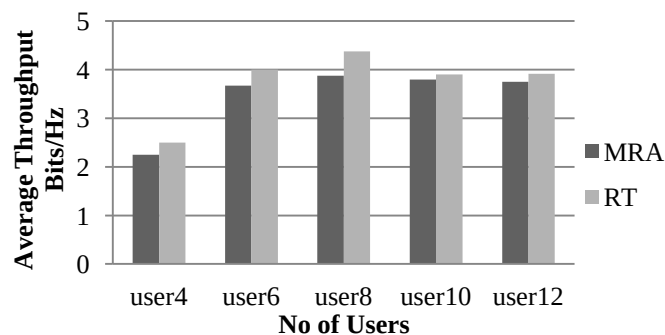


Figure2 Average system through-put

C. Minimum Requirement of users.

Minimum data rate requirements of the user is fulfilled in both the cases in both the algorithm but the remaining resources are allocated to all the users and not only to the user with highest priority. Various cases are taken. No of user varies from 4 to 12. Minimum rate requirement for various users are 0.8 Mbits/sec, 1.8 Mbits/sec, 0.99 Mbits/sec, 0.6 Mbits/sec, .36 Mbit/sec, 1.1 Mbit/sec, 3.1 Mbits/sec, 0.5 Mbits/sec, 1.2 Mbits/sec, 2.1 Mbits/sec, 2.2 Mbits/sec, 0.7 Mbits/sec using various modulation and coding techniques.

In case of 4 user

For 6 Users

Figure 3. Allotted User rate in Mbps by MRA

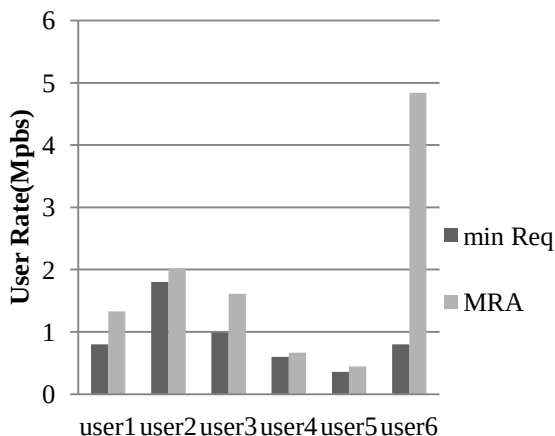
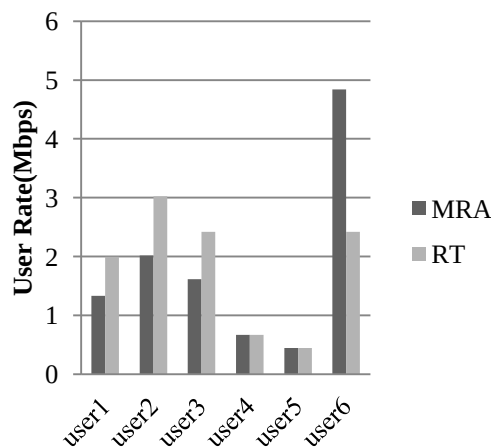


Figure 4 User 1, 2 and 3 are using real time services while user 4,5 and 6 are using non real time services



For 8 Users

Figure5. Allotted User rate in Mbps by MRA algorithm

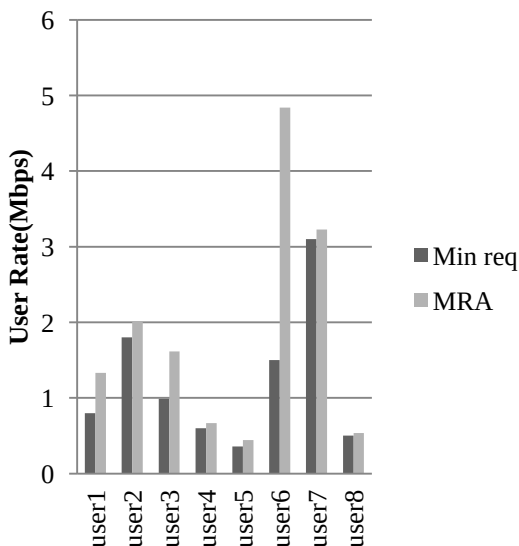
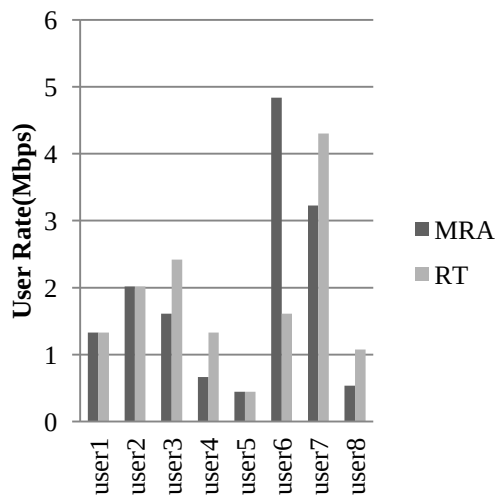


Figure 6 User 3,4,7 and 8 are using real time services while user 1,2,5and 6 are using non real time services



For 10 users

Fig .7 Allotted User rate in Mbps by MRA

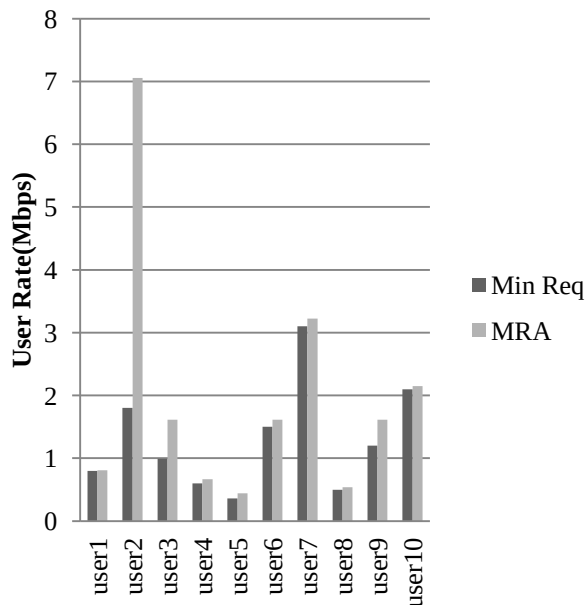
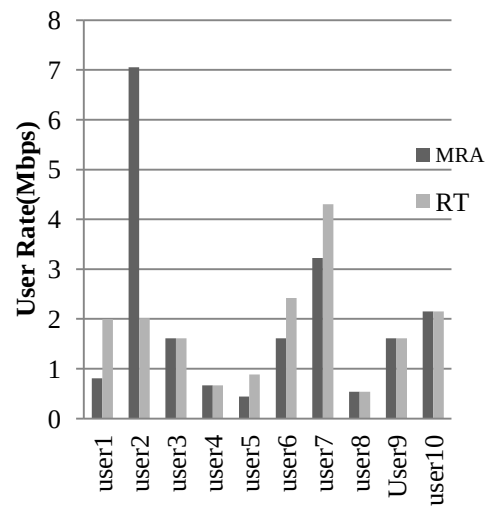


Figure8 1,5,6,7 and 9 are using real time services while user 2,3,4,8 and 10 are using non real time services



For 12 users

Figure 9 Allotted User rate in Mbps by MRA algorithm

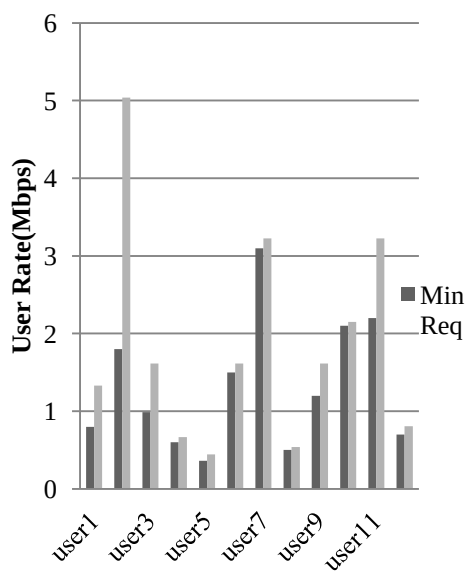
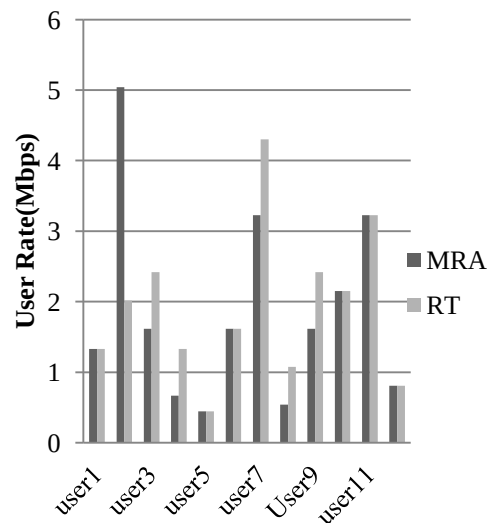


Figure 10 User 3,4,7,8,9, and 12 are using real time services while user 1,2,4,5,6 and 11 are using non real time services



In the above graphs it is clearly seen that after the minimum requirement of the users are fulfilled all the remaining resources are provided to the user with highest priority as in fig. 3 all the remaining resources are given to user 6 and after the modification are done in the real time algorithm the resources are provided to user 1,2 and 3 after all user's minimum requirement are fulfilled basically because Users 1,2,3 are using real time services and also have a higher priority. Similarly in fig 5 having 8 users, all the remaining resources are given to user 6, and after the modification are done in the real time algorithm the resources are provided to user 3, 4, 7 and 8. In fig 7 having 10 users, all the remaining resources are given to user 2 after the minimum requirement of the users are fulfilled, and after the modification are done in the real time algorithm the resources are provided to user 1,5,6,7 and 9. Similarly for fig 9. having 12 users, all the remaining resources are given to user 2 after the minimum requirement of the users are fulfilled, and after the modification are done in the real time algorithm the resources are provided to user 3,4,7,8 and 9 after minimum requirement of all users is fulfilled.

VI. Conclusions

The paper deals with downlink resource allocation algorithms. Two major Changes had been done to the existing Multiuser Resource allocation algorithm. The first one is that algorithm now works for real time and non real time services and secondly After minimum rate requirement of each user is fulfilled The remaining resources are assigned according to priority and not only to user with highest priority. Results show that new modified algorithm has better performance than existing algorithm.

VII References

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