



Enhancement of Proportional Scheduling in LTE

Anu Mittal, Naveen Sharma

Department of Computer Science Engineering,

Swami Vivekanand Institute of Engineering & Technologies, Banur, Punjab, INDIA.

Abstract: *LTE (Long Term Evolution) is evolved in parallel to 4G network that has evolved from an earlier 3GPP system known as the Universal Mobile Telecommunication System (UMTS). LTE is a standard for wireless communication of high-speed data for mobile phones and data terminals. LTE provides very high speed data rate to its users with the help of which they can access the internet through their mobiles. LTE is self organized network. In this paper we have to focus on resource block scheduling in LTE system. In this paper, we propose a modification in a technique proposed by Na Guan to allocate resource blocks so that user's rate requirement can be fulfilled optimally and throughput of the system can be improved.*

I. Introduction

LTE (Long Term Evolution) is used to provide high data rate to its users. It uses resource blocks which are allocated to users according to their requirement of downloading speed [5]. A user got more resources will get greater speed. It supports OFDMA which divide broad spectrum into multiple narrow bands and these bands are used to send information in parallel. OFDMA can support flexible radio resource management. Radio resource allocations are studied in OFDMA. The three classical allocation algorithms are Round Robin (RR), Max C/I and Proportional Fair (PF) Scheduling [6].

Round Robin (RR) Scheduling Algorithms

In RR resources are allocated to each user for some time interval. First user can have resources for some time interval after which the resources are allocated to second user and so on. It is easy to implement RR algorithm but throughput of this algorithm is poor [1].

Maximum C/I Scheduling Algorithm

More is CQI value better is channel quality. So in this algorithm resources are chosen according to highest CQI value [2]. It provides excellent throughput but not fair. In this resources are assigned to the user according to the link quality [2, 3]. During scheduling the terminals which are located far away from the base station are not scheduled and nearby terminals are scheduled by sending CQI to the base station.

Proportional Fair (PF) Scheduling Algorithm

The most commonly used scheduling algorithm is proportional fair. In proportional fair resources are allocated according to priority of users [3]. It provides high throughput and thus is best option.

II. Related Work

Hung-Chin Jang et al. (2013) [11] proposed a resource allocation scheduling in which they used QoS-constrain. It is a three-stage approach to enhance resource allocation. In the first stage, it uses a time domain scheduler to differentiate UE services according to different QoS service requirements. It supports GBR bearer with stable RB resource allocation. As to non-GBR bearer service, it uses maximum bite rate (MBR) to ensure each UE may obtain a certain number of RBs to prevent UE from starvation. To prioritize UE services based on channel quality frequency domain scheduler was used.

M. H. Habaebi (2013) [12] provides resources to users in systematic manner in system traffic scheduling. LTE is possessing excessively high speed data rate using which users can access internet via means of their mobiles. Three categories of resource scheduling algorithms are: round robin, max CQI and proportional fair. To check performance of these algorithms throughput of system is compared.

Na Guan et.al (2013) [10] proposed a novel algorithm for multiple users in which minimum required SBs of each user is calculated in advance. Then he calculated priorities of each user and allocate SBs to users according to their priority. Firstly, user with maximum priority is allocated the SBs as per his requirement and then moves toward the next user with second maximum priority. The remaining SBs are allocated to first user. His simulation result shows comparatively better throughput than RR, Max CQI and PF algorithms.

Archana B. et.al. (2015) [13] studied about resource allocation in LTE system in which they focus on maximum usability of allocated resources. They analysed various schemes of resource allocation. They discussed the architecture of LTE and LTE radio frame. LTE protocol architecture consists of 3 layers: physical layer, medium access layer and radio resource control. They discussed the issues of resource allocation and provide the significant evolution of mobile communication.

III. Proposed Work

Table 1: Modulation techniques and coding techniques associated with it.

Modulation Technique	Coding Technique
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	$2/3, 3/4, 4/5$

A. Steps of Algorithm:

Step 1: Find average channel gain and minimum required SBs

a) *Finding average channel gain of each user*

To calculate average channel gain the total CQI which each user and get is calculated and then divided by number of non- zero SBs for that user.

Let average gain of a user k be avg_k then it will be calculated as:

$$avg_k = 1 / total\ SB \sum_{i=1}^n cqi[k, i], \text{ where } i \neq 0$$

b) *Calculate minimum required SB's*

$u[j].avgChannelGain = \text{sum} / \text{count};$

$\text{totalbits} = u[j].rateReq * 1000;$

$u[j].minSB = \text{totalbits} / (\text{subcarriers} * \text{OFDMAmodulation} * \text{timeslots} * u[j].\text{modulationTech} * u[j].\text{codingTech})$

Step 2 Prioritize Users

In LTE system users need to prioritised so that when we allocated resources, users with higher priority can get resources first. To prioritise we will sort users in descending order of priority.

Consider p as priority of users, prioritisation will be done on the following basis:

$$\text{If } avg_i > avg_k \text{ then } p_i > p_k$$

In case of two users have same average channel gain prioritisation will be done on the basis of rate requirement of user which will be as:

$$\text{If } rateReq_i < rateReq_k \text{ then } p_i > p_k$$

Step 3. Allocate SB's to users

To allocate SB's to user we will first start with user having higher priority then towards users with lower priority and so on. Each user will first allocated 1 SBs when each user will get SB then again start with user with higher priority to allocate SB. This allocation of SB will continue until either all users got minimum required SBs or all available SB got distributed. When all SBs got allocated then remaining SB's will be allocated to user with highest priority.

The algorithm to do this step is as follow:

Algorithm : Assign SBs to Users

Input: CQI matrix(cqimat) , list of users(users)

Output: List of users with allocated SBs

1. Set $AllUserSatisfied \leftarrow false$.
2. Set $TotalRemainingSB \leftarrow 0$.
3. Repeat while ($AllUserSatisfied \neq true \ \&\& \ TotalRemainingSB > 0$)
4. Repeat for i from 0 to TotalUsers
5. If $user_i.AllocatedSB < user_i.minSB \ \&\& \ TotalRemainingSB > 0$ then
6. Find SB such that it is not allocated to any user and has maximum CQI value in cqimat for user i
7. Allocate above found SB to user i
8. Set $user_i.allocatedSB \leftarrow user_i.allocatedSB + 1$.
9. Set $TotalRemainingSB \leftarrow TotalRemainingSB - 1$.
10. End If Else
11. End Loop
12. End Loop

Step 4. Calculate Allocated Data Rate to user

For each user the allocated data rate is calculated on basis of allocated SBs to each user. For user k allocated data rate will be calculated as:

$$\begin{aligned} user_k.filledRateReq &= user_k.AllocatedSBs \times subcarriers \times OFDMAmodulation \times timeslots \\ &\times user_k.modulationTech \times user_k.codingTech \end{aligned}$$

Step 5. Calculate throughput

Throughput is calculated of system. It is based on that each user's functionality depend on the slowest working SB. So it depends on minimum cqi value of SBs allocated to user.

$$Throughput = \sum_{i=1}^n \min cqi_i \times user_i.allocatedSB$$

Consider we have 2 users and 2 SBs. The CQI values for user 1 are 2 and 1 for each resource block and for that of user 2 are 1.5 and 0.5. Minimum required SBs for each user is 2 and user 1 has high priority than user 2. Then according to priority based algorithm user 1 will get both SBs and systems throughput will be $(2 * 1 + 0 * 0.5) = 2$. And with uniform allocation by priority technique each user will get one resource block user 1 will get SB with 2 CQI value and user 2 will get SB with 0.5 CQI value. Now the throughput will be $(1 * 2 + 1 * 0.5) = 2.5$. Hence, throughput is increasing with the uniform allocation by priority.

IV. Experimental Analysis

For our example we have took 4 users and 7 resource blocks. First we will show output using technique proposed by Na Gaun then by uniform allocation by priority. Figure 1 will show the output screens of technique by Na Gaun and Figure 2 will show the output screens of modified work. Channel Quality Index (CQI) matrix used for this example is shown in Table 2.

Table 2: CQI matrix for 4 users and 7 SBs

	SB1	SB2	SB3	SB4	SB5	SB6	SB7
User1	1	1.5	2	2.5	0.5	1	0.5
User 2	2.5	0.5	1	2	1.5	1.5	1
User 3	1.5	1	0.75	2	1.5	1.75	1.5
User 4	1.5	1	1.5	2	1	1.5	1

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Help
Current Directory: C:\Users\singal\Documents\MATLAB

Command Window
New to MATLAB? Watch this Video, see Demos, or read Getting Started.

Minimum required SBs for user1are -->4
Minimum required SBs for user2are -->3
Minimum required SBs for user3are -->5
Minimum required SBs for user4are -->2
Priorities of users in descending order are
1>>
4>>
2>>
3>>
CQI matrix after prioritising
1.0000 1.5000 2.0000 2.5000 0.5000 1.0000 0.5000
1.5000 1.0000 1.5000 2.0000 1.0000 1.5000 1.0000
2.5000 0.5000 1.0000 2.0000 1.5000 1.5000 1.0000
1.5000 1.0000 0.7500 2.0000 1.5000 1.7500 1.5000

Assigned SBs to user1are :SB1,SB2,SB3,SB4,
Assigned SBs to user4are :SB5,SB6,
Assigned SBs to user2are :SB7,
Assigned SBs to user3are :
Filled rate of user1is :
1.0752

Filled rate of user4is :
1.3306

Filled rate of user2is :
1.0080

Filled rate of user3is :
0

Throughput of system=7
>>
  
```

Figure 1: Output calculated by technique proposed by Na Gaun

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Command Window
New to MATLAB? Watch this Video, see Demos, or read Getting Started.

Minimum required SBs for user1are -->4
Minimum required SBs for user2are -->3
Minimum required SBs for user3are -->5
Minimum required SBs for user4are -->2
Priorities of users in descending order are
1>>
4>>
2>>
3>>
CQI matrix after prioritising
1.0000 1.5000 2.0000 2.5000 0.5000 1.0000 0.5000
1.5000 1.0000 1.5000 2.0000 1.0000 1.5000 1.0000
2.5000 0.5000 1.0000 2.0000 1.5000 1.5000 1.0000
1.5000 1.0000 0.7500 2.0000 1.5000 1.7500 1.5000

Assigned SBs to user1are :SB3,SB4,
Assigned SBs to user4are :SB1,SB2,
Assigned SBs to user2are :SB5,SB7,
Assigned SBs to user3are :SB6,
Filled rate of user1is :
0.5376

Filled rate of user4is :
1.3306

Filled rate of user2is :
1.9891

Filled rate of user3is :
0.7560

Throughput of system=9.75
>>
  
```

Figure 2: Output calculated by uniform allocation by priority

From above shown figures we find that there is great change in the throughput. The throughput of the technique proposed by Na Gaun is 7 and the throughput of the uniform allocation by priority is 9.75. Also all users are getting some resource blocks in uniform allocation by priority and only 3 users were able to get resources in technique proposed by Na Gaun.

V. Comparison

Comparison of technique proposed by Na Gaun and uniform allocation by prioritization is done by making comparison tables. The comparison is done on the basis of rate allocated to each user and throughput. Required rate and allocated rate of technique proposed by Na Gaun are shown in Table 3.

Table 3: Required rate and allocated rate in technique proposed by Na Gaun

	Rate Required	Rate Allocated
User 1	1.0234	1.0752
User 2	2.34	1.008
User 3	3.324	0
User 4	0.765	1.3306

Graphical representation of table 3 is shown in Figure 3.

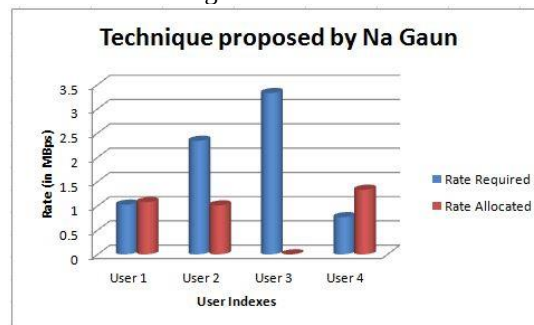


Figure 3: Graph of rate requirement and allocated rate using 4 users in technique proposed by Na Gaun

In above graph, is made from output of 4 users. In above graph two bars are shown for each user. It can be clearly seen that allocated rate is allocated only to 3 users out of 4. It means that only three users will be able to work.

Required rate and allocated rate of technique proposed method are shown in Table 4.

Table 4: Required rate and allocated rate in uniform allocation by priority technique

	Required rate	Allocated rate
User 1	1.0234	0.536
User 2	2.34	1.9891
User 3	3.324	0.756
User 4	0.765	1.3306

Graphical representation of table 4 is shown in Figure 4.

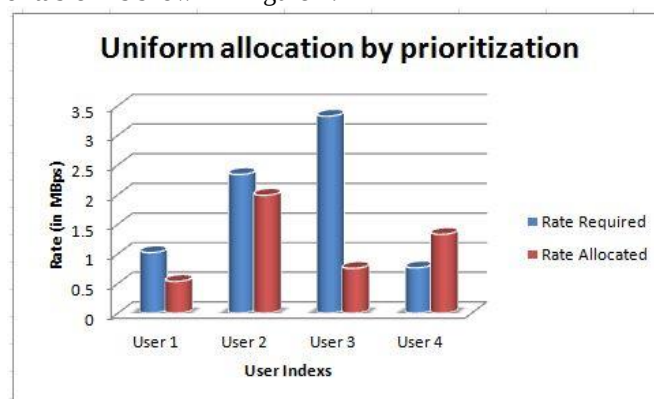


Figure 4: Graph of rate requirement using 4 users in uniform allocation by prioritization

In above graph, is made from output of 4 users from uniform allocation by priority. In above graph two bars are shown for each user. It can be clearly seen that allocated rate is allocated to each user. It means that each user will be able to work.

Throughput of technique proposed by Na Gaun and uniform allocation by priority of above example is calculated comparison of both is shown in Table 5.

Table 5: Throughput of previous and uniform allocation by priority

	Technique proposed by Na Gaun	Uniform allocation by priority
Throughput	7	9.5

Graphical representation of throughput shown in table 5 is shown in Figure 5.

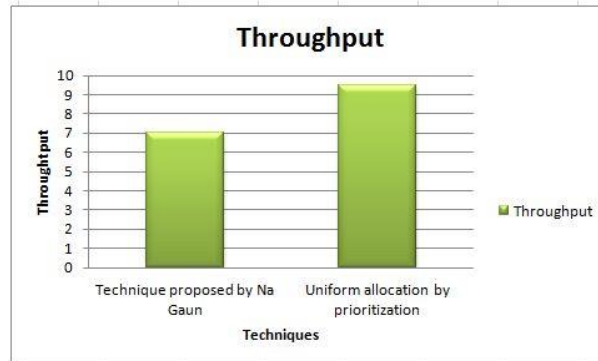


Figure 5: Throughput of technique proposed by Na Gaun and uniform allocation by priority

VI. Conclusion and future scope

We have proposed a modification in technique proposed by Na Gaun in which we have allocated resources to users such that each user gets one SB first. We took input of rate requirement of users and CQI matrix. Then minimum required SBs are calculated for each user and prioritization of users is done. On the basis of that prioritization available resource blocks are allocated to users and allocated rate of each user and throughput of system is calculated. In this we compared our results for 4 users: Comparisons of previous and uniform allocation by priority are shown in Tables 3 and 4 and graphs 3 and 4. It is clearly seen from these tables and graphs that in technique proposed by Na Gaun only 3 users out of 4 can work as resource blocks will be allocated only to 3 users. And in uniform allocation by priority all users can work. Thus, uniform allocation by priority is better in terms of allocated rate. It is also seen from Table 5 and Figure 5 that throughput of uniform allocation by priority is more than technique proposed by Na Gaun. Thus, uniform allocation by priority is also better in case of second parameter i.e. system throughput.

In future some more changes can be proposed to increase throughput of system.

References

- [1] Aderemi A. Atayero, "An Introduction to LTE". 3GPP LTE Encyclopedia. Retrieved December 3, 2010.
- [2] M. Faulkner, "Long Term Evolution (LTE): A Technical Overview". Motorola. Retrieved July 3, 2010.
- [3] GPP. UTRA-UTRAN long term evolution (LTE) and 3GPP system architecture evolution (SAE). <http://www.3gpp.org/article/lte>, 2010.
- [4] H. Zhang, N. Prasad, and S. Rangarajan, "MIMO downlink scheduling in LTE and LTE-Advanced systems", Technical report, NEC Labs America, June, 2011.
- [5] Mai Tran, David Halls, Andrew Nix, Angela Doufexi and Mark Beach, "Mobile WiMAX: MIMO Performance Analysis from a Quality of Service (QoS) Viewpoint", Centre for Communications Research, University of Bristol, Bristol, United Kingdom, 2009.
- [6] G. Lebrun, T. Ying and M. Faulkner, "MIMO transmission over a time-varying TDD channel using SVD", IEEE Electronics Letters Volume 37, Issue 22, October 2001.
- [7] Q. Bai, N. Passas, J. A. Nossek, "Scheduling and resource allocation in OFDM and FBMC systems: An interactive approach and performance comparison", 2010 European Wireless Conference, April 2010.
- [8] S. Shi, et al., "A Resource Scheduling Algorithm Based on User Grouping for LTE-Advanced System with Carrier Aggregation," in Computer Network and Multimedia Technology, 2009. CNMT 2009. International Symposium on, 2009, pp. 1-4.
- [9] Honghai Zhang, Narayan Prasad and Sampath Rangarajan "MIMO Downlink Scheduling in LTE systems" in 2012, IEEE.
- [10] Na Gaun, Lin Tian and Gang Sun "QoS Guaranteed Resource block allocation algorithm for LTE System", IEEE, 2011.
- [11] Hung-Chin Jang and Yun-Jun Lee, "QoS-Constrained Resource Allocation Scheduling for LTE Network", 2013 International Symposium on Wireless and Pervasive Computing (ISWPC), pp. 1-6, 2013.
- [12] M. H. Habaebi, J. Chebil, A.G. Al-Sakkaf and T. H. Dahawi, "Comparison between Scheduling techniques in long term evolution", IIUM Engineering Journal, Vol. 14, No. 1, 2013 Department of Electrical and Computer Engineering Malaysia. pp 66-75.
- [13] Archana B. and T.P. Surekha, "Resource Allocation in LTE: An Extensive Review on Methods, Challenges and Future Scope", Communications on Applied Electronics, vol 3 no 2, pp 12-22, 2015.