

Various Techniques for Scheduling in LTE-A Review

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Abstract: LTE (Long Term Evolution) is discovered in parallel to 4G network that has been evolved from an earlier 3GPP system known as the UMTS- Universal Mobile Telecommunication System. Mobile phones and various data terminals use LTE as a standard for wireless communication of high-speed data. LTE gives very high speed data rate to their user which helps them to 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, firstly LTE and its architecture has been discussed. After that various scheduling techniques has been discussed.

I. Introduction

LTE (Long Term Evolution) is used to provide very high data rate to its users. To fulfill the requirement of downloading speed, LTE uses resource blocks which are allocated to users according to their need [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].

Scheduling and resource allocation has become an essential component for high-speed wireless data systems. In these systems, the active users and the allocation of physical layer resources among them are dynamically adapted based on the users' current channel conditions and quality of service (QoS) requirements. Many of the scheduling algorithms considered can be viewed as "gradient-based" algorithms, which select the transmission rate vector that maximizes the projection onto the gradient of the system's total utility [5]. The utility is a function of each user's throughput and is used to quantify fairness and other QoS considerations.

A. OFDMA

OFDMA is an extension of the OFDM transmission scheme by allowing multiple users to access. That is what, allowing for simultaneous frequency-separated transmissions to / from multiple mobile terminals. In OFDM the user data is transmitted in parallel across multiple orthogonal narrowband subcarriers. Each subcarrier only transports a part of the whole transmission. The orthogonal subcarriers are generated with IFFT (Inverse Fast Fourier Transform) processing, [6] The number of subcarriers depends on the available bandwidth. In LTE, they range from less than one hundred to more than one thousand. OFDM meets the LTE requirement for spectrum flexibility and enables cost-efficient solutions for very wide carriers with high peak rates. The basic LTE downlink physical resource can be seen as a time-frequency grid. Basically To overcome the effect of multi path fading problem available in UMTS [7], LTE uses Orthogonal Frequency Division Multiplexing (OFDM) for the downlink - that is, from the base station to the terminal to transmit the data over many narrow band carriers of 180 KHz each instead of spreading one signal over the complete 5MHz carrier bandwidth. OFDM uses a large number of narrow sub-carriers for multi-carrier transmission to carry data.

II. Architecture of LTE system

The frame structure for the downlink transmission of LTE is shown in Figure 1. Each radio frame is divided into ten 1ms sub frames.

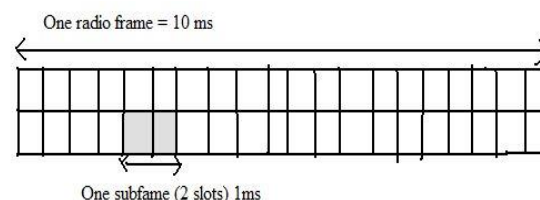


Figure 1: LTE frame structure

Each sub frame is split into two 0.5ms slots. There are seven and six OFDM symbols in each slot for the normal and extended cyclic prefix configurations, respectively. In the frequency domain, resources are grouped into units of 12 subcarriers (thus occupying total of 180 KHz). One resource block is defined as one unit of 12 subcarriers for duration of one slot [25].

III. Related Work

Hung-Chin Jang et al. (2013) in the paper titled “**QoS-Constrained Resource Allocation Scheduling for LTE Network**” proposed a QoS-constrained resource allocation scheduling for uplink SC-FDMA. 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. In the second stage, it uses a frequency domain scheduler to prioritize UE services based on channel quality. In the third stage, it limits the times of modulation downgrade in RBs allocation to enhance system throughput.

M. H. Habaebi (2013) in the paper titled “**Comparison between Scheduling techniques in long term evolution**” works on system traffic scheduling by providing resources to users in the well- organized manner. LTE is having very high speed data rate with the help of which user can access the internet through their mobiles. There are three types of scheduling algorithms such as: Round Robin, best Channel Quality Indicator (CQI) and Proportional Fair (PF) schedulers. The performance of these scheduling algorithms on the downlink was calculated in terms of throughput and Block error rate using a MATLAB. The best CQI algorithm shows better performance in terms of throughput than the other algorithm.

Alam M. S et al.(2013) in the paper titled “**Relay Selection and Resource Allocation for Multi-User Cooperative OFDMA Networks**” works upon relay selection and resource allocation in a multi-user cooperative OFDMA-based uplink system that simultaneously supports GBR and AMBR traffic. They proposed a QoS aware optimal joint relay selection, power allocation and subcarrier assignment scheme under a total power constraint. To satisfy the individual users’ QoS requirements a joint optimization problem has been formulated for relay selection and resource allocation with the objective of maximizing the system throughput.

Phunchongharn P et al(2013) in the paper titled “**Resource Allocation For Device-To-Device Communications Underlying Lte-Advanced Networks**” presented an overview of D2D communications in LTE-Advanced cellular networks and discussed the related research issues. Resource allocation scheme for D2D communications under laying a cellular network is proposed. This joint resource block scheduling and power control scheme considers maximizing the spectrum utilization while addressing two crucial issues in D2D communications which are interference to cellular devices and QoS provisioning for the D2D links. They did performance appraisal to show that scheme can increase spectrum utilization by scheduling multiple D2D links to spatially reuse the same resource block.

Honghai Zhang (2012) in the paper titled “**MIMO Downlink Scheduling in LTE systems**” worked upon role of scheduling LTE downlink systems with Multiple Input and Multiple Output (MIMO) antennas. New construct called transmission mode, which tells a particular choice of MIMO operational mode, precoding matrix, transmission rank and the modulation and coding schemes (MCSs) of up to two codeword’s (one codeword is transport block of information bits) and then develop a unified low- greedy algorithm and the two variants of the algorithm: 1) for the backlogged traffic model and 2) for the finite queue traffic model. Concluded that gives a solution guaranteed to be within 1/2 of the respective Optima.

IV. Scheduling

Scheduling plays a great role in the resource allocation. The resources are allocated to the user according to their need and priority. LTE is easy to use which is having higher privacy and security. It improved the speed and data rate. OFDM means Orthogonal Frequency Division Multiplexing that is used by LTE for downlink transmission where OFDM divide the bandwidth into multiple narrower sub-carries and data is transmitted on these carries in parallel streams [3]. In OFDM the subcarrier is modulated with different modulation method like QPSK, QAM, 64QAM and the use of higher order modulation such like 16QAM and 64QAM provides the higher bandwidth utilization, higher data rate, within a particular bandwidth an OFDM symbol is obtained by adding different modulated subcarrier signals In downlink of an OFDMA the resources are divided in the frequency and time domains [24]. In the frequency domain the resources are divided into N traffic channels which are a cluster of OFDM subcarriers. Whereas in the time domain the time resources are divided into slots which is called as frames and super frames. OFDM is also used in other of systems like WLAN, WiMAX to broadcast technologies.

V. Resource Allocation

Resource allocation’s role is to dynamically assign available time-frequency resource blocks to different [13] UEs in an efficient way to provide good system performance. In LTE, channel-dependent scheduling is supported, and transmission is based on the shared channel structure where the radio resource is shared among different UEs. Therefore, with resource allocation *multiuser diversity* can be exploited by assigning resource blocks to the UEs with favorable channel qualities. Moreover, resource allocation in LTE is able to exploit the channel variations in both the time and frequency domain, which provides higher multiuser diversity gain than

HSPA that can only exploit the time-domain variation. Given a wide bandwidth in LTE, this property is beneficial especially for slow-time varying channels, such as in the scenario with low mobility, where taking advantage of channel selectivity in the time domain is difficult. With OFDMA,[6] the downlink resource allocation is characterized by the fact that each scheduled UE occupies a number of resource blocks while each resource block is assigned exclusively to one UE at any time. Physical resource blocks (PRBs) and virtual resource blocks (VRBs) are defined to support different kinds of resource allocation types. The VRB is introduced to support both block-wise transmission (localized) and transmission [10] on non-consecutive subcarriers (distributed) as a means to maximize frequency diversity. The LTE downlink supports three resource allocation types: type 0, 1, and 2. The downlink scheduling is performed at the eNode-B based on the channel quality information fed back from UEs, and then the downlink resource assignment information is sent to UEs on the PDCCH channel.

A. Resource Allocation Algorithms

In OFDM system the radio resource scheduling has been studied. Scheduling is the process of allocating resources to the user to get better throughput and to increase system efficiency. CQI is 5 bit information [11]. A higher CQI value indicates that the channel has a better channel quality and lower value indicate low better channel quality. 5-bit CQI value ranges from 0-30, a higher CQI gives transport-block size, a modulation scheme, and the number of channelization codes. There are various types of scheduling algorithm.

Round Robin (RR) Scheduling Algorithms

In RR the resources are allocated to each user without using channel condition [7]. Each user can use the resources in proper time interval. First user can use the resource for the given time interval after the completion of time then these resources is assigned to another user. The new user has placed at the end of waiting queue. The implementation of RR is easy and it result in poor throughput. This results in good fairness and it is the simplest algorithm.

Maximum C/I Scheduling Algorithm

The highest value of CQI means that the channel quality is good. It provides excellent throughput but not fair. In this resources are assigned to the user according to the link quality [15]. 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 PF. PF results in high cell throughput and fairness. In PF channel condition is calculated and then resources are allocated to user which is having the highest priority and further the allocation is done to next priority user. This allocation is continuing until all the resources are allocate to the user [12]. The scheduler can exercise Proportional Fair (PF) scheduling allocating more resources to a user with relatively better channel quality. This offers high cell throughput as well as fairness satisfactorily. Thus, Proportional Fair (PF) scheduling is the best option.

Priority Algorithm

Priority Resource Allocation Algorithm is carried out in two steps

A) Estimate of the number of SBs demand by each user

a) Calculate each user's average channel gain

Each user is deployed by one MCS for allocated SBs, the percentile channel condition is concerned instead of the channel state on each Sbs. In reduction process of feedback overhead, a feedback method based on CQI threshold λ_k for k is adopted. In every scheduling process the time interval, user only feeds back CQI values which I greater than threshold value. For the SBs who are CQI values are not feedback by user k, their CQI initial state value is zero [7]. But threshold value depends on different user that is dynamic. A high threshold can be assigned at the center of every cell for the user at center. For the user at every edge of every cell, low threshold value can be set.

Let g_k and α_k donate the k_{th} user's average channel gains. Then, the k_{th} user channel gain is given by

$$\bar{g}_k = \frac{1}{\alpha_k} \sum_{n=1}^{\alpha_k} g_{k,n}, \quad g_{k,n} \geq \lambda_k \quad \text{and} \quad \alpha_k \leq N$$

b) Estimated the number of SBs required by each user

The number of SBs each user need can be calculated on the ratio of user's minimum rate requirement to the user average channel gain.

Let N_k be number of SBs allocated to user K. N_k should proof the given conditions:

$$\frac{R_1}{\bar{g}_1} : \frac{R_2}{\bar{g}_2} : \dots : \frac{R_K}{\bar{g}_K} = \phi_1 : \phi_2 : \dots : \phi_K$$

$$\sum_{k=1}^K \phi_k = 1$$

$$N_1 : N_2 : \dots : N_k = \phi_1 : \phi_2 : \dots : \phi_K$$

which state that k is directly proportion to minimum data rate requirement, inversely to average channel gain. The number of SBs allocated for each user is

$$N_k = \lfloor N \phi_k \rfloor$$

where $\lfloor x \rfloor$ takes the greatest integer which may be equal to or less than x . But if N_k is equal to zero, then set N_k equal to one

B) Allocation of Sbs to each users

All SBs assigned to one user should have same MCS in LTE system. When the Sbs allocated to one user, should have different channel qualities in term of CQI, MCs for each user must be chosen according to the lowest CQI so that the data transmitted on each SB can correctly received. But there will be decrease in the user's data rate. So according to priority algorithm the user with lower data rate and good average channel condition should be assigned first [20], so that remaining SBs can be allocated to other users, so that user meet their rate requirements. Priority algorithm idea is as following

a) Arrange user in descending order by calculating user's priorities. The user's priorities can be calculated by following conditions :

if $\bar{g}_k > \bar{g}_i$ then $p_k > p_i$

if $\bar{g}_k = \bar{g}_i$ and $R_k < R_i$, then $p_k > p_i$

b) Allocate SBs to each user

As i have defined user's priorities a), according to that SBs allocation is carried out on each user. Suppose one SBs is assigned to user according to step b) the requirement rate is not be satisfied, so to satisfied the required data rate more SBs will be assigned to user . When all user data rate requirement have been satisfied and there are some remaining SBs, then that remaining SBs, will be assigned too user according to their priority.

VI. Conclusion

In this paper, we have studied about LTE and various algorithms to allocate resources. The study of various algorithms shows that priority algorithm provides better throughput. In future, more work can be done to efficiently allocate resources and to increase throughput of the system.

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