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Scheduling Algorithms of Resource Allocation in LTE system

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Abstract: LTE (Long Term Evolution) systems involve the allocation of resources in a manner to benefit the user by providing high data rate to the users. In resource allocation there is a major role of scheduling which has become an essential component for high- speed wireless data systems. This allocation of resources is done according to the need and priority of the user. LTE uses OFDM (orthogonal frequency division multiplexing) for downlink transmission. In resource allocation algorithms in OFDM of LTE systems, the allocation of the radio resource has to be in the units of Scheduling Block (SB) and there exists the need for all SBs of each user to use the same Modulation and Coding Scheme (MCS) leading to the degradation of performance. In this paper we will discuss about various scheduling algorithms and the QoS guaranteed resource block allocation algorithm to overcome the constraints of MCS and to fulfil the requirement of Quality of Services (QoS).

Keywords: Resource allocation, LTE, Scheduling, Types of scheduling, Priority algorithm.

I. INTRODUCTION

LTE (Long Term Evolution) marketed as 4G LTE that has evolved from an earlier 3GPP system known as the Universal Mobile Telecommunication System. LTE is a standard for wireless communication of high-speed data for mobile phones and data terminals. LTE is having very high speed data rate with the help of which user can access the internet through their mobiles and results in high data throughput. LTE is self organized network [1].

LTE aims to provide higher data rate, packet optimised radio access, low latency and flexible bandwidth deployment.LTE uses Orthogonal Frequency Division Multiplexing (OFDM) for the downlink - that is, from base station to the terminal to transmit the data over many narrow band carriers each of 180 KHz instead of spreading one signal over the complete 5MHz career bandwidth. OFDMA basic principle is to divide the broad spectrum into multiple narrow bands and transmit information on this narrow channel in parallel. OFDM meets the LTE requirement for spectrum flexibility and enables cost-efficient solutions for very wide carriers with high peak rates. Orthogonal frequency-division multiplexing (OFDM), is a frequency-division multiplexing (FDM) scheme used as a digital multi-carrier modulation method [2].

OFDMA can support flexible radio resource management. LTE uses a pre-coded version of OFDM called Single Carrier Frequency Division Multiple Access (SC-FDMA) in the uplink [4].

LTE broadband wireless data networks feature OFDMA based downlink transmission schemes and MIMO techniques which tell particular choice of transmission rank, pre code matrix, modulation and coding scheme(MCS). As LTE is a MIMO (multiple inputs and multiple outputs) based technology, it can have two or more transmit antennae and in order to avoid reference signals from the same cell interfering with each other, different antennae are used to transmitting reference signal at different time and frequency. LTE supports fractional frequency reuse [5, 6].

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In real LTE system, the MCS adopted by each user should be decided by the worst SB allocated to it. resource block (RB) assignment and modulation-and-coding scheme (MCS) selection to maximize downlink throughput of long-term evolution (LTE) systems[3], where all RB's assigned to same user must use the same MCS in any given transmission time interval (TTI).

A. OFDMA

OFDMA is an extension of the OFDM transmission scheme by allowing multiple no of users. That is, allowing for frequency-separated transmissions to / from multiple mobile terminals simultaneous. In OFDM the user data is transmitted in parallel across multiple orthogonal narrow subcarriers. Each subcarrier transports a small part of the whole transmission. The orthogonal subcarriers are generated with Inverse Fast Fourier Transform (IFFT) processing [7].The number of subcarriers depends only on the available bandwidth. In LTE, range lies 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.[5] The basic LTE downlink physical resource can be seen as a time-frequency grid. Basically To overcome the effect of multiple path fading problems available in UMTS, LTE uses OFDM for the downlink - that is, from the base station to the terminal to transmit the data over many narrow band careers of 180 KHz each instead of spreading one signal over the complete 5MHz career bandwidth. OFDM uses a large number of narrow sub-carriers for multi-carrier transmission to carry data.

B. Scheduling

Scheduling plays a great role in the resource allocation. Resources are allocated to the user according to their need and priority. LTE is simple and easy to use which is having higher privacy and security. It improved the speed and data rate. OFDM 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.[8] 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 and high 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. In frequency domain the resources are divided into N traffic channels which are a cluster of OFDM subcarriers. Whereas in the time domain the resources are divided into slots called frames and super frames. OFDM is used in other of systems like WLAN, WIMAX to broadcast technologies. [9]

C. Architecture of LTE system

In LTE, the transmission time is divided into sub frames of 1ms duration. In each sub frame, the available frequency band (typically 5-20MHz) is divided into a large number of orthogonal narrow-band subcarriers (or tones).Each sub frame consist of 2 time slots, each of 0.5 ms. One Resource block (RB) is 0.5ms and contains 12 subcarriers for each OFDM symbol in frequency domain. There are 7 symbols (normal cyclic prefix) per time slot in the time domain or 6 symbols in long cyclic prefix [10].

II. RELATED WORK

Hung-Chin Jang et al. (2013) proposed a QoS-constrained resource allocation scheduling for uplink SC-FDMA which is a three-stage approach used to enhance resource allocation. In the first stage, it time domain scheduler is used to differentiate UE services according to different QoS service requirements. In second stage, frequency domain scheduler is used to prioritize UE services based on channel quality. In third stage, to enhance system throughput it limits the times of modulation downgrade in RBs allocation.

M. H. Habaebi (2013) works on system traffic scheduling by providing resources to users in the well- organized manner. LTE provides very high speed data rate with the help of which user can access the internet through their mobiles and there are three types of scheduling algorithms such as: Round Robin (RR), 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 MATLAB. The best CQI algorithm shows better performance in terms of throughput than the other algorithm.

Honghai Zhang (2012) worked upon role of scheduling LTE downlink systems with the MIMO antennas. A New construct called transmission mode, which tells a particular choice of MIMO operational mode, 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. That gives a solution guaranteed to be within 1/2 of the respective Optima.

Na Guan et.al (2011) works on resource allocation for the downlink of LTE systems. With QoS guarantee, a novel multiuser resource allocation algorithm has been proposed, where the required number of SBs is firstly estimated for each user, then SBs are assigned to users according to their priorities. Simulation results show that our proposed algorithm significantly outperforms Max C/I, PF and RR algorithms in terms of satisfying users' QoS requirements, and provides a relatively high throughput as well.

III. Scheduling Algorithm

A. Round Robin (RR) Scheduling Algorithms

Round Robin is the simplest scheduling algorithm used by the CPU during execution of the process. Resources are allocated to each user without using channel condition [12]. 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 simplest, easy and good in fairness but its throughput is not good.

B. Maximum CQI Scheduling Algorithm

The highest value of CQI (channel quality indicator) means that the channel quality is good. It provides good throughput but not good in fairness. In this resources are assigned to the user according to the link quality. [11] 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.

C. Proportional Fair (PF) Scheduling Algorithm

The most commonly used scheduling algorithm is PF. PF results in good fairness and high throughput. Channel condition is calculated in this case 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. The scheduler can exercise Proportional Fair (PF) scheduling allocating more resources to a user with relatively better channel quality. [13] This offers high cell throughput as well as fairness satisfactorily.

D. Priority Algorithm

Priority Resourse Allocation Algorithm is carried out in two steps.

D.1. 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 $ƛ_K$ 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

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who's CQI values are not feedback by user k, their CQI initial state value is zero. But threshold value depends on different user that is dynamic. A high threshold can be assigned at the centre of every cell for the user at centre. 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

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

b) Estimated the number of SBs required by each userThe 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:

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

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

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

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

D.2. Allocation of SBs to each user

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, 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 :

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

b) Allocate SBs to each user

As i have defined user's priorities D.2) a), according to that SBs allocation is carried out on each user. Suppose one SBs is assigned to user according to step D.2) a) 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.

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IV. RESULTS

The graph of throughput of Max C/I, PF, Purposed and RR algorithm versus the number of users

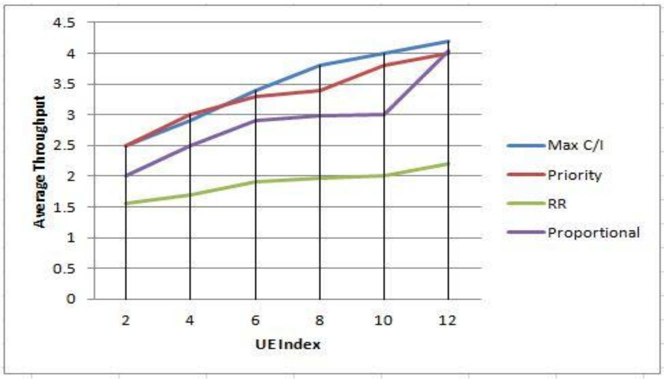

Fig. 1. Throughput of Max C/I, PF, Purposed and RR algorithm versus the number of users

The bar graph of the number of satisfied users in MAX C/I algorithm when total users are eight.

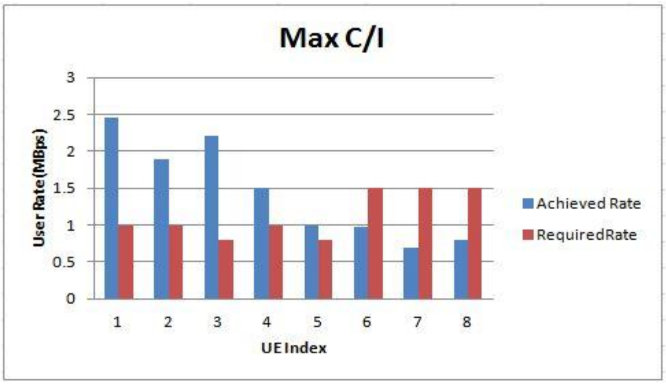

Fig. 2. Number of satisfied users in MAX C/I algorithm when total users are eight.

The bar graph of the number of satisfied users in RR algorithm when total users are eight

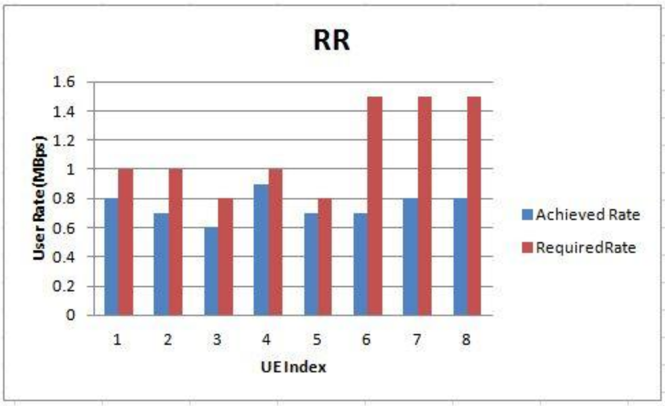

Fig. 3. Number of satisfied users in RR algorithm when total users are eight

The bar graph of the number of satisfied users in PF algorithm when total users are eight

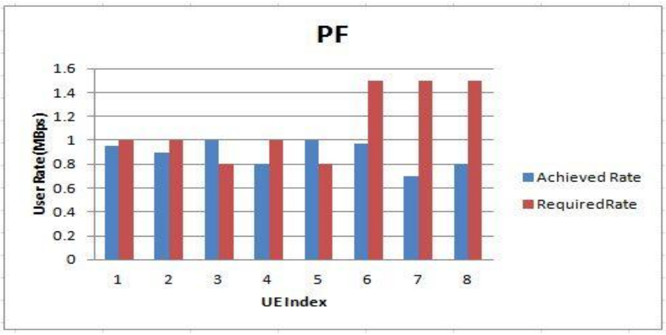

Fig. 4. Number of satisfied users in PF algorithm when total users are eight

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V. CONCLUSION

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

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