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An Effective Scheduling Algorithm for MIMO Systems in Long Term Evolution Networks

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Abstract

Background: Long Term Evolution (LTE) represents an emerging and competent innovation for giving an internet access. LTE standard paves way towards the fourth generation networks, which is intended to deliver high speed data as well as multimedia services. **Statistical Analysis:** In LTE system Radio Resource Management (RRM) plays a very crucial role in managing limited radio resources to enhance the data rate. The paper focuses in addressing the challenges in downlink scheduling and provides a solution for the users to achieve higher spectral efficiency and throughput. In LTE systems' fading of a channel is a serious issue for signal degradation and the fading effect is minimized by a choice of time and space domain techniques. The overall performance of the algorithms is calculated in terms of the throughput and SNR where the resource distribution is analyzed and evaluated for every individual user %. **Findings:** Hence a novel scheduling algorithm is developed for Multiple Input Multiple Output (MIMO) systems, where as Alamouti scheme is used to reduce fading, for utilization of channel effectively and also transmit diversity is achieved without increase in bandwidth in LTE systems. The simulation results demonstrate that the developed scheduling algorithm provides effective throughput and fairness compared to some of the existing scheduling algorithms in LTE networks.

Keywords: Channel Quality Indicator (CQI), Multiple Input Multiple Output (MIMO), Orthogonal Frequency Division Multiple Access (OFDMA), Transmission Time Interval (TTI), User Equipment (UE)

1. Introduction

As interest in cooking, the recipes of several cuisines are opened and shared online. The recipes vary from traditional food of many countries to fusion food combined elements of different culinary traditions. In many recipes, how can we classify similar recipes? For example, Korean foods, 'steamed chicken' and 'streamed short-ribs', are different in the main ingredient, but these are included in the same food types. Because the cuisine style and the taste is similar. On the other hand, 'pork ribs' and 'pork ball' are same in the main ingredient, but these are recognized as different food types. Can we distinguish what recipe is easy or difficult to cook and what recipe is for Korean food that we don't know or haven't experienced?

The Third Generation Partnership Project (3GPP) developed an identical Long Term Evolution (LTE) System Architecture which is a version of Release-8 to build a framework for 4G. The technology came into existence with the ongoing demand of services such as internet browsing, video streaming and video telephony with constraints on bandwidth requirements. LTE is an IP packet based system which supports high data rates, low latency, increased capacity and coverage. To accomplish these objectives, LTE employs numerous technologies which include Orthogonal Frequency Division Multiple Access (OFDMA), Multiple Input Multiple Output (MIMO), and Single Carrier Frequency Division Multiple Access (SC-FDMA) schemes. Basically LTE uses wireless channel SC-FDMA for uplink and OFDMA for downlink which

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operates both in Frequency Division Duplexing (FDD) and Time Division Duplexing (TDD) modes. In Round Robin (RR)5 scheduling algorithm, the UEs are assigned resources in random fashion, without considering the channel state. The Best CQI algorithm allocates available resources to the UE which is having highest value of CQI on RB during each TTI. RR offers fairness to all the users, but less competent with respect to throughput as it does not consider channel variations whereas Best CQI algorithm is competent in terms of throughput but not fair for all the users. The probability of allocation of RB's to the users at the edge of the cell is very less and they starve for resources which are not adequate. The proposed algorithm for the fair scheduling is based on which RB allotment is done to all UEs in a TTI by selecting users one after another starting from the one with the highest CQI factor.

The organization of the paper is as follows. Section 2 describes the LTE structure. Section 3 describes the existing work. Section 4 proposes the solution to overcome the draw backs of the existing algorithms. Simulation results are observed in section 5 and the paper is concluded in section 6.

2. System Architecture

The key components include 8:

CRC insertion per transport block,

- Turbo coding channel.
- Rate matching with bit selection.
- Bit-level scrambling.
- Data modulation.
- Resource-element mapping.
- OFDMA signal generation.

2.1 CRC Insertion per Transport Block

To perform error detection 24 bit CRC is generated and it is added to each transport block.

2.2 Transport Channel Processing

It provides an interface between the MAC and the physical layers.

2.3 Channel Coding

Turbo coding is used for coding in DL-SCH because of its reliable structure and ease of implementation.

2.4 Rate Matching

The exact sets of bits are extracted from the encoded bits which are transmitted to the transport block.

2.5 DL-SCH Processing

Resources for transmission of each transport block are referred in the physical channel.

2.6 Scrambling

Bit-level scrambling sequence is used for each transport channel to differentiate transmitted code words.

2.7 Data Modulation

In order to obtain complex modulated symbols from scrambled bits data modulation is used in downlink.

2.8 OFDMA Signal Generation

LTE networks employ OFDM for signal generation but the proposed work is implemented with OFDMA to make the network as a multi-user version.

An LTE structure as specified in Figure 1 is developed with MATLAB and the new scheduling algorithm is implemented in transport POSCH block which is explained further.

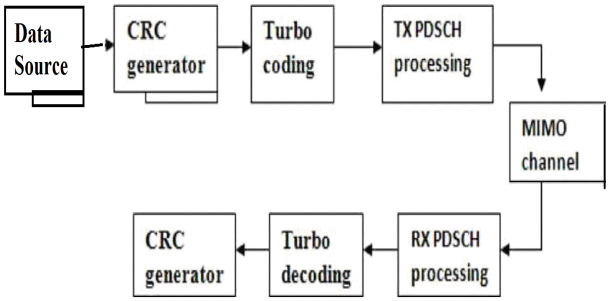

Figure 1 LTE System Architecture8.

3. Methods Existing

3.1 BEST CQI Algorithm

The scheduling scheme assigns RBs to UEs for those which are having fair link conditions. Each terminal sends CQI to the BS which is basically done in downlink. Then BS transmits CQI in the form of reference signal (pilot) back to the terminal. Such reference signal or downlink pilot is then used by UEs for the measurement of CQI6.

The users who are having higher CQI value are likely to be scheduled first because that particular user has better link conditions.

3.1.1 Drawbacks of Best CQI Algorithm

In the whole scheduling strategy, UEs which are located far away from the BS like users those are at the cell edges are unlikely to be scheduled. So the best CQI scheduling4 increases capacity of a cell at the cost of the fairness.

3.2 Round Robin Scheduling

In this scheduling approach UEs are assigned with resources without any priority. The primary advantage of RR scheduling is that the fairness is guaranteed to all the users. More over the implementation of RR algorithm involves less complexity.

3.2.1 Issues regarding RR Algorithm

The major disadvantage of the algorithm is the fact that it does not take into account of any user conditions, which leads to lower and unequal throughput.

3.3 Maximum Scheduling Algorithm

In this scheduling algorithm priority is assigned to the least expensive data measured in terms of consumed resources. The maximum scheduling algorithm maximizes the throughput, but the level of fairness is not stable among the users.

3.3.1 Issues Regarding MS Algorithm

Only few UE's are assigned resources and it would optimize the resource utilization in a given network, but it would not likely to maximize the profit for the network operator.

4. Proposed Work

In general, OFDM is a widely used access technique in LTE system. In order to make LTE as a multi user version, OFDMA is introduced for MIMO systems in this work. The major difference between OFDM and OFDMA is that, OFDMA has an ability to dynamically assign a subset of subcarriers for any individual users, thereby making OFDM as a multi user version. So OFDMA, adds true mobility which is the backbone for many promising technologies like LTE and WiMAX. In OFDM, only a single user can transmit over all the sub-carriers at a given time. But in order to sustain multiple users, OFDMA allows several UE's to transmit simultaneously on the different sub-carriers per OFDMA symbol.

The scheduler controls the allocation of shared time-frequency resources among users at each time instant. The scheduler is located in the base station and assigns downlink resources. The scheduler determines how the shared resources (time and frequencies) for each TTI (1 ms) should be allocated to the users for the reception of DL-SCH transmission. To achieve better throughput and fairness a new scheduling algorithm which exploits the advantages of Best CQI and the RR scheduling algorithms is proposed. In this work, total LTE frame is divided into 10 sub frames, each having 1 msec duration where each sub frame contains two slots having period of 0.5 msec duration. The Base Station (BS) compares CQI's from different UEs and selects the user which is having highest CQI10 where as in second time slot terminals are scheduled cyclically in return where the CQI factor is checked again. The users having high CQI in both the time slots are scheduled first. During the end of second slot period the process begins again, in this way a compromise between the fairness and throughput is achieved.

Algorithm 1 New SCH algorithm for scheduling:

- Begin Implement LTE architecture.
- Do dividing LTE frame into 10 sub frames.
- While each sub frame of 1 msec TTI.
- Do dividing sub frame again into 2 slots having d5msec TTI.
- While compare CQI.
- If user with high CQIr Schedule first user in first slot period.
- Else.
- Schedule next user.
- If first slot is finished repeat same in second time slot.
- If in both time slots user has high CQI assign resource block to the user.
- Else.
- Repeat step 5 for first slot TTI.
- End if.
- End if.
- End if.
- End while.

Algorithm 2 ALAMOUTI scheme for Ml MO systems:

- Begin setting all parameters.
- While generate data.
- Splitting data in to two vectors.
- Do transmitted data QAM modulation.
- For 2 transmitter and 1 receiver case.
- Do half power is transmitted in each channel.
- Add noise and receive data.
- End for.
- End for.
- End while.

Algorithm 2 explains about alamouti scheme for two transmitter and one receiver case. At a given symbol period two signals are simultaneously transmitted from the two antennas. Further the combiner, combines the two signals which are sent to the maximum likelihood detector to achieve better transmit diversity in LTE systems.

5. Simulation Results

5.1 af Performance Analysis of Scheduling Algorithm

The overall performance of the algorithm is calculated in terms of the throughput and SNR where the resource distribution is analyzed and evaluated for every Individual user. Figure no. 2 and 3 explains the throughput performance of proposed algorithm in comparison with the existing algorithms for various bandwidths 1.4 MHZ and 3 MHZ involving 6, 1 5 number of UEs. From the simulation graphs it is noticeable that performance of proposed

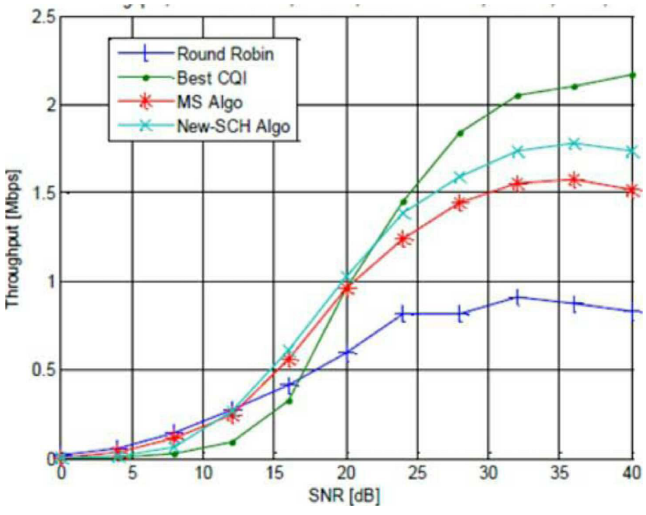

Figure 2. Cell throughput for 6 number of users at BW= 1.4 Mhz.

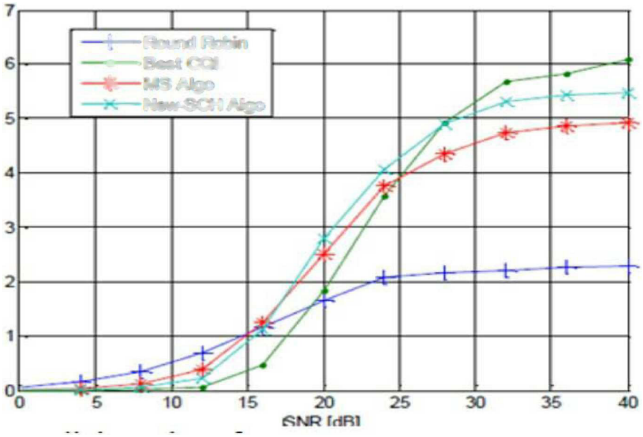

Figure 3. Cell throughput for 15 number of users at 3Mhz bandwidth.

(New - SCH) algorithm is almost same even if number of users are increased from 6 to 15 which is observed from the Table 1.

From Figure 4 and 5 it is clear that Best CQI method offers better throughput performance, where as ft is least in case of RR method. The fairness among users in any algorithm is observed by the amount of variations in UE's throughput at different SNRs. The RR scheduling algorithm do not adopt according to the channel feedback where the CQI value is fixed and assumed that that channel conditions are same on each RB during the simulation. The throughput fluctuations are more among the users in case of Best CQI method which indicates less fairness. In the RR scheduling algorithm the fluctuations are comparatively less and offers better fairness. But in case of RR scheduling the throughput is low. Table no. 2 gives the observations for different users indicating less values of throughput for RR and high variations in users throughputs for Best CQI If New SCH throughput is observed, lesser fluctuations among users indicates capability to

Table 1. Throughput performance for different algorithms for different bandwidths

Algorithm	Throughput at 1.4 Mhz b/w	Throughput at 3 Mhz b/w
Round robin	0.5	1.8
Best CQI	0.9	1.9
MS algorithm	0.9	2.5
New-SCH algorithm	1	2.9

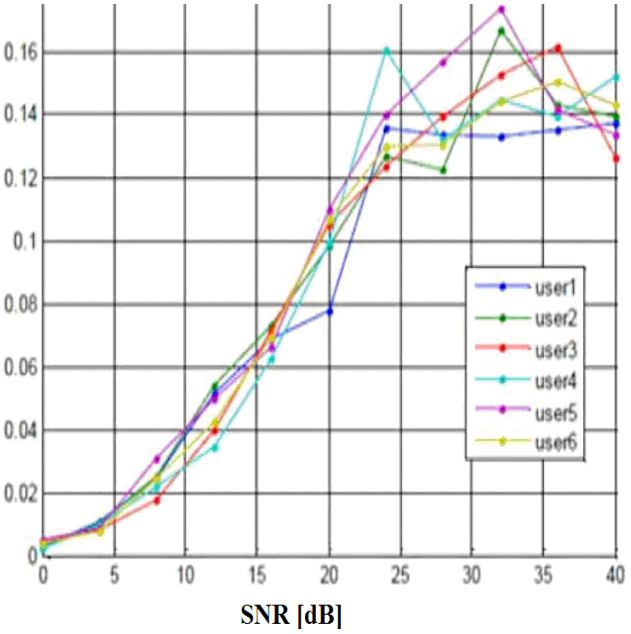

Figure 4. Round robin scheduling.

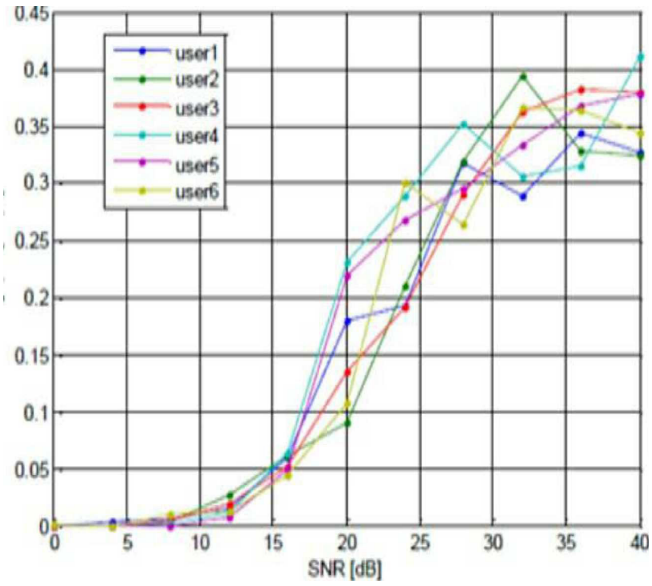

Figure 5. Best CQI scheduling.

allocate available RBs to all UEs in a fair manner. The implementation of the proposed SCH algorithm is considered for the single cell, multi-user scenario.

5.2 A Performance Analysis of Aiamouti Scheme

The below graph explains the channel utilization of Alamouti scheme for various number of transmitters and

Table 2. Throughput comparison Involving 6 users (20 db SNR)

Users	Throughput (MBPS) for RR algorithm	Throughput (MBP S) for Best CQI algorithm	Proposed New SCH algorithm throughput
User 1	0.08	0.18	0.16
User 2	0.1	0.09	0.14
User 3	0.12	0.14	0.18
User 4	0.1	0.23	0.14
User 5	0.12	0.2	0.18
User 6	0.1	0.1	0.17

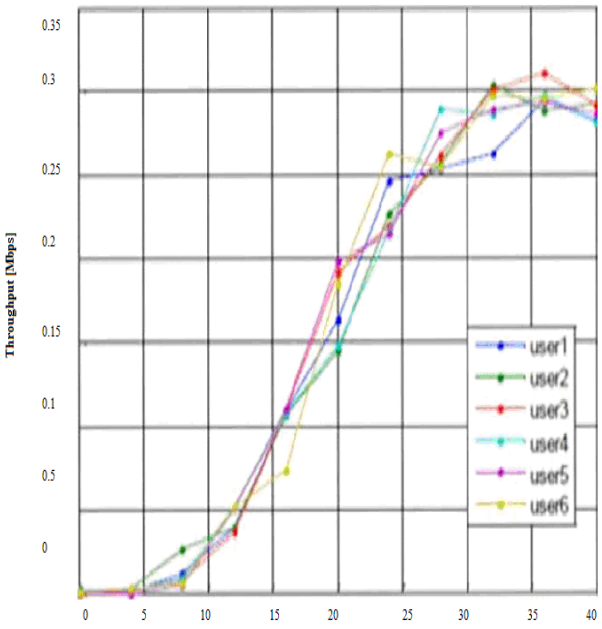

Figure 6. New SCH algorithm throughput performance.

receivers when the channel is affected by Rayleigh fading. Though the number of transmitters and receivers are increased, results show that the system achieves full diversity and outperform under lay transmissions without any need of increase in the bandwidth of the channel or

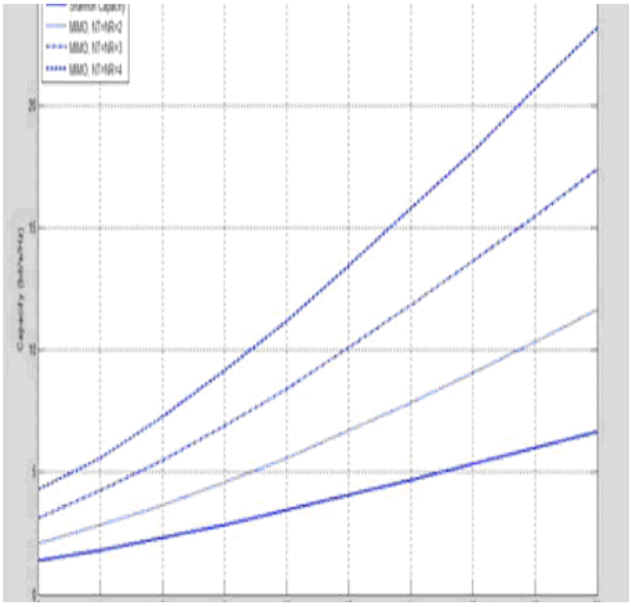

Figure 7. Alamouti scheme.

data rate. The Alamouti scheme radiates energy perfectly in isotropic manner because signals transmitted from the antennas have the same energy when they are projected in any direction. It has the best outage probability among all the schemes that radiate energy isotropically and also the signals are completely correlated resulting low SNR. The results show that the channel is utilized effectively for more number of users without increasing the bandwidth.

6. Conclusion

The proposed New-SCH algorithm is simulated and the results are compared with different scheduling algorithms. The performance is investigated at both cell-level as well as user level. The results explain that the proposed algorithm is a balance of throughput and fairness. Alamouti scheme is used to achieve best transmit diversity and for utilizing the channel effectively without increase in bandwidth in LTE systems.

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