Journal of Engineering and Applied Sciences 13 (6): 1376-1381, 2018
ISSN: 1816-949X

Downlink Scheduling in 5G Massive MIMO

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Abstract: In this study, we doing research on the downlink scheduling algorithms and methods on the fifth generation based on massive MIMO technology as known that the scheduling algorithm help to increase the system efficiency by improving the QoS parameters. Three major methods will be used in this study and a simulation for each was done using MATLAB 2016a, the Best Channel Quality Indicator (Best-CQI), Round Robin and proportional fair. After simulating the 5G system and gain results the best CQI was selected as the best scheduling algorithm in 5G.

Key words: 5G, massive MIMO, downlink scheduling, round robin, best-CQI, proportional fair

INTRODUCTION

In the last decade, the mobile data usage increments and the appearance of new application (as mobile-TV, Web-2.0 and other streaming services) increase the demand of 3rd Generation Partnership Project (3GPP) to develop the 4G (also named as Long-Term Evolution (LTE). The LTE was the newest radio access technology developed by the 3GPP in order to provide smooth steps toward the (4G) wireless systems (Krzyzanowski, 2014). In the 3rd Generation Partnership Project (3GPP) the architecture of LTE radio network, there is one node named as eNodeB that exist between the user and the LTE-core network (Silberschatz *et al*., 2013), this node is used to control all the functions of the Radio Resource Management (RRM) (Miao *et al*., 2016). The packet-scheduling is a one of the main functions of the radio resource management. Because of its smart way to select user and transmission of their packets, the radio resources in this network are utilized in efficient way and Quality of Service (QoS) is also parameters are maintained. Recently, the packet scheduling of wireless communications has been an active research area, because of the rapidly increasing demands on data services with a high demand of traffic (as internet, e-mails and multimedia streaming) (Miao *et al*., 2016). In order to support services packet data, the limited wireless resource must be used in intelligent way in order to enhance the security and capacity with maintained QoS parameters, providing priority access or fairness. The throughput of a UE depends on the many factor such as scheduling algorithms, distance from eNodeB, multipath propagation, multiple antenna diversity technique and UE-speed. Within this research, a study and investigating on the effects of scheduling algorithm with throughput performance is done. Three algorithms were applied (first one is Proportional Fair (PF) scheduler, second one is round robin and third one is best CQI on LTE network) in order to find best scheduler which provides high-quality cell throughput and enhanced fairness. The scheduler algorithm has to provide services to multiple numbers of users and also doing specific user requirements on delays and bit rates. The fairness algorithm is a method to combine the scheduler algorithms and it facilitate improve the overall sharing of resources between users.

Problem definition: Many scheduling was developed in order to serve using without a time delay that cases a network congestion which leads to packet loss. Moreover, serving users should be fair for the network resources since the resource allocation in wireless network is limited thus the scheduling of user may effect on the system performance.

Objectives

General objective: To simulate three different turbo coding decoding algorithm and evaluate the performance of each.

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Specific objective:

- Study and analysis the turbo coding methods and techniques
- Study the encoding and decoding algorithms
- Choose more than one algorithm to be evaluated through a comparison
- Design and simulate into simulation program and investigate the resulting

MATERIALS AND METHODS

Mathematical model best CQI: The best CQI stands for Channel Quality Indicator it is information on the wireless communication channel quality that give the condition of the wireless communication channel (Anonymous, 2016). The best CQI can be defined as the information that sent to the core network by User Equipment (UE) and practically it implies to the following:

Current communication channel quality situation: The UE require to fetch the data with a required transport block with specific size that is converted into throughput value directly. In HSDPA, the best-CQI value ranges are detected from 0-30. The range thirty refers to that the best channel quality condition is good and 0 or 1 refers to that the channel quality condition is bad. Depending on which value user equipment reports, network transmit data with different size of transport block. When the network gets high condition of CQI value from user equipment, it transmits the data with a larger size of transport block. When the network sends a large transport block even while the user equipment reports a low CQI condition which indicates probable that User Equipment (UE) failed to decode it (cause CRC error on user equipment side) and User Equipment (UE) send acknowledgment message to the network in order to retransmit which cause waste of radio resources. When User Equipment (UE) reports best CQI while the real channel quality is bad the network sends a large transport block size based on the value of CQI and which indicates that user equipment be unsuccessful to decode it (cause CRC error on UE side) and UE send acknowledgment message to the network to retransmit it which in cause a waste of radio resources (Li *et al*., 2009). User Equipment (UE) measures the CQI which the CQI is calculated then, based on the following factors:

- SNR: Signal-to-Noise Ratio
- SINR: Signal-to-Interference plus Noise Ratio
- SNDR: Signal-to-Noise plus Distortion Ratio

The best channel condition equation represent the maximum of channel estimated in term of low bit error rate or high signal to noise ratio at I is the index of the channel and t is the current time.

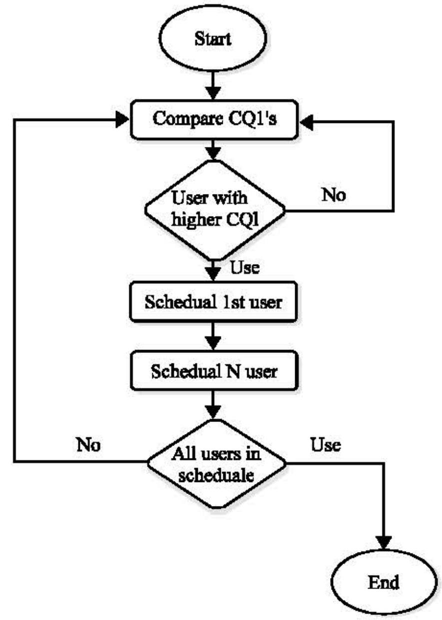

Fig. 1: Best CQI channel indicator flowchart

Best CQI computer model: Figure 1 represent the algorithm flow of best CQI which starts with comparing the CQI's and then schedule each channel according to the channel quality indicator.

Mathematical model for round robin: The Round-Robin (RR) is an algorithms that is specialized in its process on network schedulers in computing. Generally a preconfigured time-slices (also known as time of portion) are assigned to each process entered to the system with an equal processing time and in circulating order, to handle all operations without priority just based on the time of arriving (also named as cyclic executive) (Jacek *et al*., 2001). RR scheduling is a non-complex algorithm to be implemented. Round-robin scheduling is applied to a various fields to solve scheduling problems, as (data packet scheduling) in computer networks. The round-robin name comes from its principles known from where each person takes an equal share at a specific time.

In Round robin schedule is the user I having the longest Queuing time, $Q_i(t)$ of the head-of-line packet. Thus, the user to be served at time instant t is chosen according to:

$$\max_{i} Q_i(t)$$

Where:

i = The user with data
Q_i = Index of the Queuing time
Max = Maximum queuing time

Robin computer model: Figure 2 represents the algorithm flow of Round Robin which starts with scheduling users

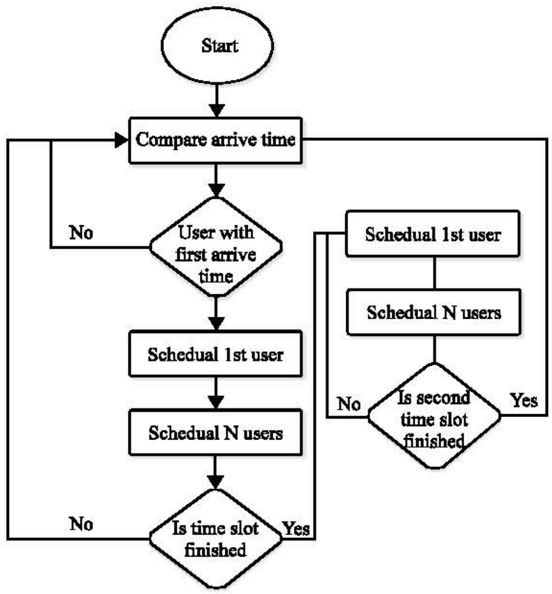

Fig. 2: Round robin algorithm flowchart

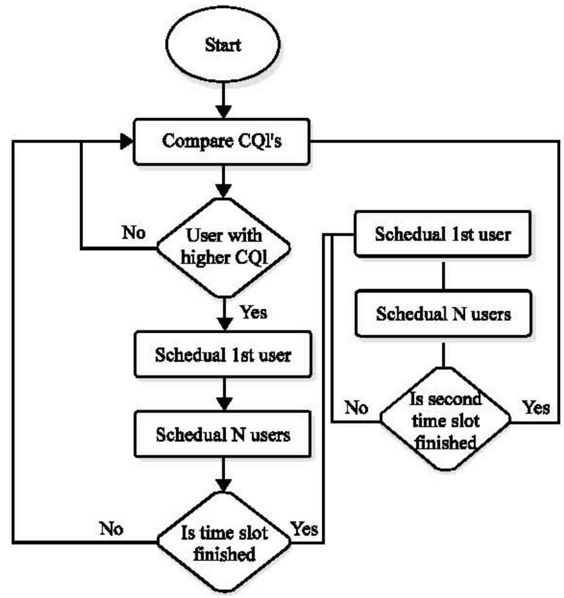

Fig. 3: Proportional fair algorithm flowchart

according to arrive time to the system. Then a processing to the first user is done with a limited time slot and then the served user is stored back to the end of the stack and the next user is served. One again the first used enters to the second time slot to be served and this process will end whenever the user finish the task.

Mathematical model for proportional fair: Proportional fairness is a balanced-based scheduling algorithm. Trying to maximize the total throughput of wireless and wired communication in the same time allow all subscripers at least a minimum level of service. the algorithm works by assigning each required data-flow a data-rate or a priority of scheduling that is inverse proportional to its expected resource consumptions. PFS algorithm considered as a bandwidth allocation attractive standard in wireless networks to support high resource utilization. The proportional fair PF algorithm tries to please both fairness-serving and high throughput requirements. R_is is the maximum rate that user i for the moment can be served with:

$$\max_i \frac{R_i(t)}{\bar{R}_i(t)}$$

Where:

$R_i(t)$ = The maximum Rate that user I for the moment served t

$\bar{R}_i(t)$ = The maximum Rate that user I served in time slot

Proportional fair computer model: Figure 3 represents the algorithm flow of best CQI which starts with comparing the CQI’s and then schedule each channel according to the channel quality indicator. Then using round robin principles, scheduling users according to arrive time to the system (William, 2004). Then, a processing to the first user is done with a limited time slot and then the served user is stored back to the end of the stack and the next user is served.

RESULTS AND DISCUSSION

Scenario No. 1; Best Channel Quality Indicator (CQI): Scenario is to design LTE network with a transmitter and receiver and set a number of users to 15 user, the set the number of channel with different bandwidth and resource allocation, a randomized data was generated for each user and each entered to stack buffer in order to enter the processing stage, then a modulation based on 16 QAM was used to modulate the data after interleaving process and an OFDM stage used to give the orthogonal transmission out to the channel which affected by the Adaptive White Gaussian Noise (AWGN) (Table 1). Figure 4 illustrates the SNR-BER for the best CQI which requires more that 25 db SNR to reduce the errors to minimum.

Scenario No. 2; Round Robin (RR): Scenario is to design LTE network with a transmitter and receiver and set a number of users to 15 user and each user has a unique arrival time to the system, set the time slot for processing, the set the number of channel with different bandwidth and resource allocation, a randomized data was generated for each user and each entered to stack buffer in order to

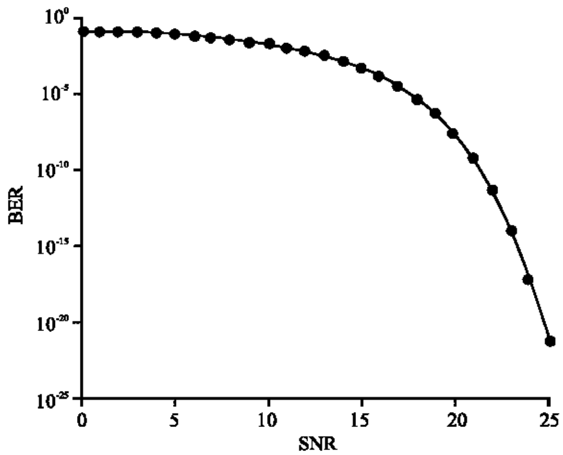

Fig. 4: SNR-BER best CQI (SNR-BER comparison)

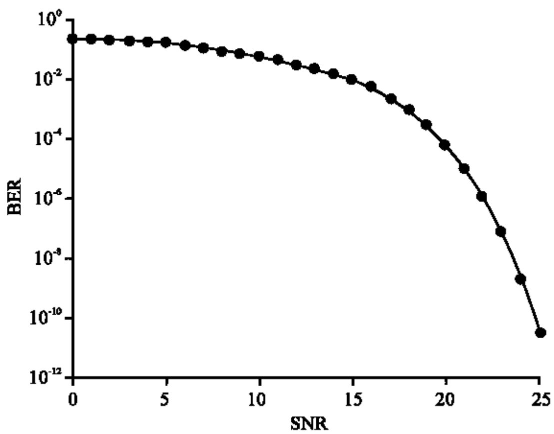

Fig. 5: SNR-BER round robin (SNR-BER comparison)

Table 1: Simulation parameters

Parameters	Description
Modulation	16 QAM
Channel	3 Channels
Number of users	5, 10, 15
SNR Range	0-35 db
Bandwidth	1, 5, 3, 5 Mbps

enter the processing stage, then a modulation based on 16 QAM was used to modulate the data after interleaving process and an OFDM stage used to give the orthogonal transmission out to the channel which affected by the Adaptive White Gaussian Noise (AWGN). Figure 5 illustrates the SNR-BER for the Round Robin which requires more that 25 db SNR to reduce the errors to minimum.

Scenario No. 3; Proportional Fair (PF): Scenario is to design LTE network with a transmitter and receiver and set a number of users to 15 user and each user has a unique arrival time to the system, set the time slot for processing, the set the number of channel with different bandwidth and resource allocation, a randomized data was generated for each user and each entered to stack buffer in order to enter the processing stage, then a modulation based on 16 QAM was used to modulate the data after interleaving process and an OFDM stage used to give the orthogonal transmission out to the channel which affected by the Adaptive White Gaussian Noise (AWGN). Figure 6 illustrate the SNR-BER for the Proportional fair which requires more that 25 db SNR to reduce the errors to minimum.

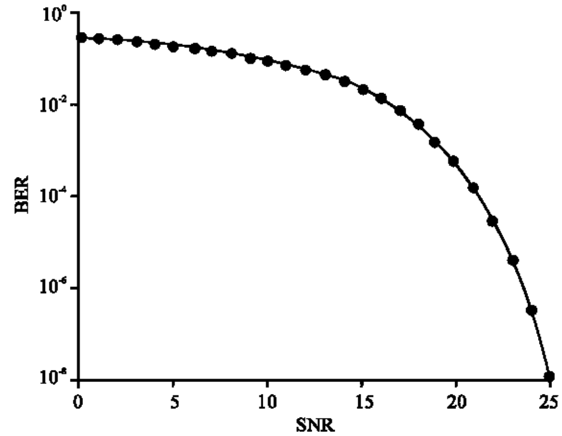

Fig. 6: SNR-BER proportional fair (SNR-BER comparison)

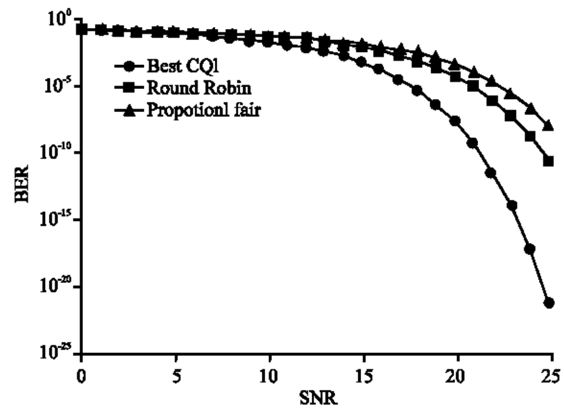

Fig. 7: SNR-BER for three algorithms (SNR-BER comparison)

Comparison snr-ber for three algorithms: Figure 7 illustrates the three algorithms comparison for SNR-BER, it was found that the best CQI requires less power compared to the other algorithms.

Scenario No. 4; Best Channel Quality Indicator (CQI): Scenario is to design LTE network with a transmitter and

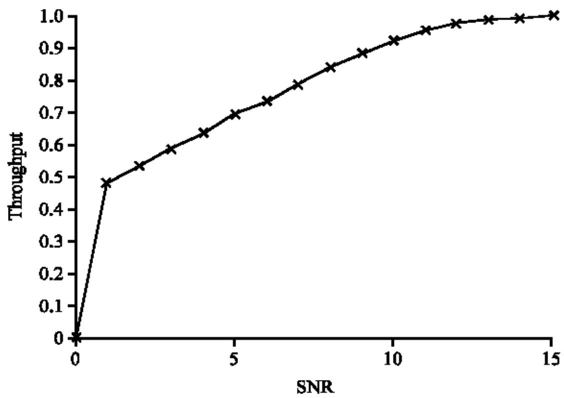

Fig. 8: SNR-throughput for best-CQI (SNR/throughput comparison)

receiver and set a number of users to 15 user, the set the number of channel with different bandwidth and resource allocation, a randomized data was generated for each user and each entered to stack buffer in order to enter the processing stage, then a modulation based on 16 QAM was used to modulate the data after interleaving process and an OFDM stage used to give the orthogonal transmission out to the channel which affected by the Adaptive white Gaussian Noise (AWGN) to evaluate throughput (Fig. 8).

Scenario No. 5; Round Robin (RR): Scenario is to design LTE network with a transmitter and receiver and set a number of users to 15 user and each user has a unique arrival time to the system, set the time slot for processing, the set the number of channel with different bandwidth and resource allocation, a randomized data was generated for each user and each entered to stack buffer in order to enter the processing stage, then a modulation based on 16 QAM was used to modulate the data after interleaving process and an OFDM stage used to give the orthogonal transmission out to the channel which affected by the Adaptive White Gaussian Noise (AWGN) to evaluate throughput (Fig. 9 and 10).

Scenario No. 6; Proportional Fair (PF)
Comparison SNR-throughput for three algorithms:

No. of users = 3

Figure 11 illustrates the three algorithms comparison for SNR-throughput, it was found that the best CQI has the good-put compared to the other algorithms.

Comparison SNR-throughput for three algorithms:

No. of users = 5

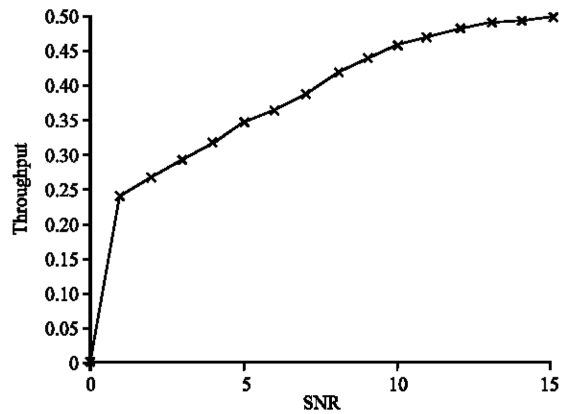

Fig. 9: SNR-throughput for round robin (SNR/throughput comparison)

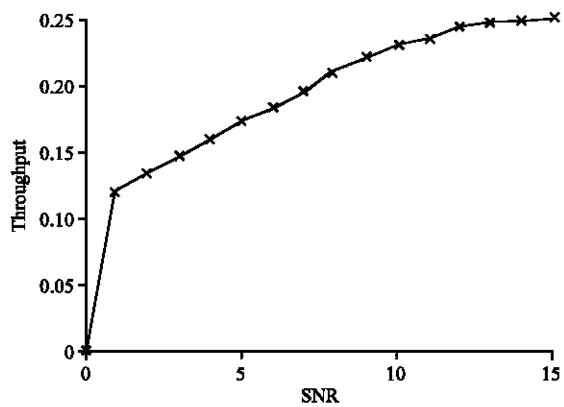

Fig. 10: SNR-throughput for proportional fair (SNR/throughput comparison)

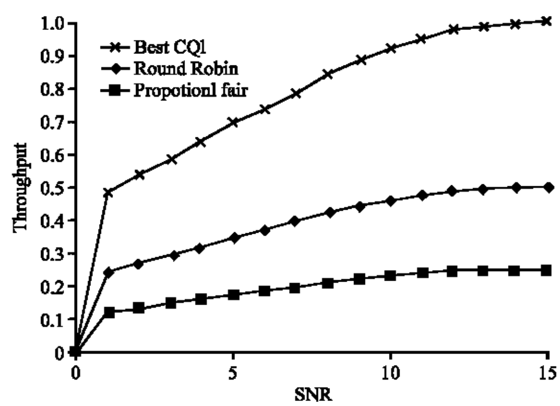

Fig. 11: SNR-throughput comparison for three algorithms while 3 users

Figure 12 illustrates the three algorithms comparison SNR-throughput, it was found that the best CQI has the for good-put compared to the other algorithms while the number of users is 5.

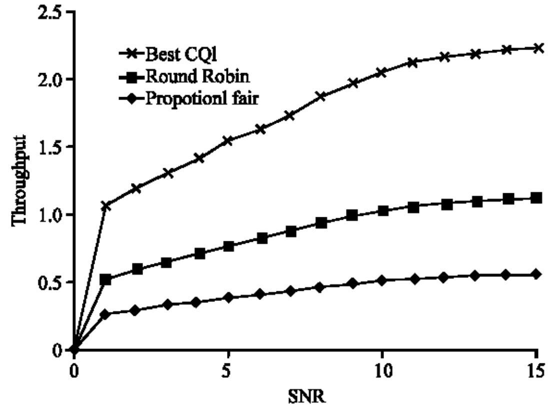

Fig. 12: SNR-throughput comparison for three algorithms while 5 users

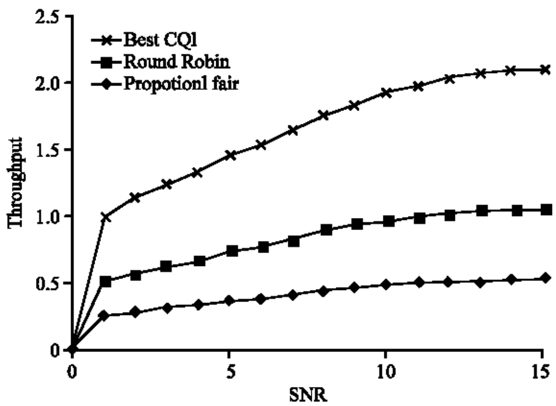

Fig. 13: SNR-throughput comparison for three algorithms while 10 users

Comparison SNR-throughput for three algorithms:

No. of users = 10

Figure 13 illustrate the three algorithms comparison for SNR-throughput, it was found that the best CQI has the good-put compared to the other algorithms while the number of users is 10.

CONCLUSION

In this project three scheduling algorithms was chosen in order to be evaluated, in term of QoS parameters (throughput, SNR/BER), the simulation also uses many configurations and settings including the noise AWGN range and the number of users. The simulation was generated using Matlab environment that help designing the network and the scheduling algorithms. After analysis of results, it was found that the best CQI has good put compared to the round robin and proportional fair. The comparison of SNR-BER the best CQI has a minimum power required.

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