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PHYSICAL RESOURCE BLOCK (PRB) ALLOCATION USING MODIFIED ROUND ROBIN SCHEDULING ALGORITHM IN DOWNLINK LTE NETWORK

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ABSTRACT

Physical Resource Block (PRB) allocation is an important part that must be set so well so all users can be served by eNode-B in LTE downlink network. One of the optimization methods can be applied by resource scheduling that can allocate PRB to the user based on channel and capacity conditions. This study aims to produce a resource scheduling algorithm that have the best performance. The algorithms are used in the simulation such as Round Robin, Modified Round Robin, Maximum CSI and Proportional Fair. The performance parameters are used as indicators of algorithm performance such as spectral efficiency, average user throughput, eNode-B throughput and eNode-B payload. With appropriate scheduling algorithms will increase spectral efficiency and user throughput to improve quality of service. Knowing the condition of channel capacity aims to maintain quality of service sustainably. Different resource scheduling algorithm will produce different performance. In the Round Robin algorithm has method that each user who occupies the channel first or first active will be the top priority to obtain the resource block. In Round Robin Algorithm, the resource blocks allocation does not consider the channel conditions. The users does not have the best channel condition which does not has the maximum spectral efficiency value. So the Round Robin algorithm has been modified to produce more maximal spectral efficiency. Some modifications have been done that like resource scheduling based on priority scheme. Initial condition, user will send channel state information (CSI) value to eNode-B and eNode-B store CSI data into matrix and compile it. The CSI will be used as a consideration for scheduling resource blocks. Users who have the highest or best CSI and the first user that occupy the channel or first active will be the first priority who are allocated resource block. In varied users (1-50 users), Modified Round Robin has the highest spectral efficiency, average user throughput, eNode-B throughput and eNode-B payload that compared to other algorithms performance. Spectral efficiency is 4.892 bps/Hz, average user throughput about 0.88 Mbps, eNode-B throughput about 44.031 Mbps and eNode-B payload about 158.512 Gigabits.

Keywords: Physical Resource Blok (PRB), Round Robin, Maximum CSI, Proportional Fair

INTRODUCTION

To support high speed data transfer as well as 3GPP standards releases for LTE. LTE has introduced resource scheduling technology in the downlink direction which will be used to optimize resource block allocation. Some resource scheduling algorithms are Round Robin, Maximum CSI and Proportional Fair Algorithm. A good resource scheduling scheme is required to allocate resources blocks to the users to maximize network performance.

Round Robin algorithm is often used in resource scheduling process. This algorithm scheme allocates the resource to the user who first occupied the channel will be served first or first in - first serve without considering channel state information (CSI) condition. The Maximum CSI Algorithm is one of the most commonly used algorithms in optimization and also in scheduling process. Maximum CSI algorithm is deterministic that only the user with a certain priority scale than will be served. The priority scheme base on channel state information (CSI) condition. The biggest CSI will be first priority to get PRB allocation. Scheduling algorithm that has been implemented in some telecommunication vendors is proportional fair algorithm. In Proportional Fair Algorithm, the fulfillment of throughput and fairness index among users also become one of the reference in the scheduling. Proportional fair is an algorithm that balances the throughput and fairness of the system. This scheduling algorithm demonstrates an acceptable throughput level while providing some fairness between users.

In this study, Modified Round Robin is a scheduling algorithm that use priority base on the highest CSI and the first in - first serve scheme. User have the highest CSI and occupied the first channel will be the top priority that get resource first. Then the next user who has a lower CSI will be allocated the next PRB slot. Performance parameters will be observed in this simulation such as spectral efficiency, average user throughput, eNode-B throughput and eNode-B payload. The expected result using the

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Modified Round Robin algorithm to maximize performance.

SYSTEM MODEL

In this study, resource scheduling has been simulated with several algorithms in downlink LTE network. The frequency carrier is used 1800 MHz and the bandwidth is 10 Mhz. eNode-B is designed with a single cell that serves 50 users at different locations, which do not move and do not interfere. Performance parameters that will be observed are spectral efficiency, average user throughput, eNode-B throughput and eNode-B payload. The performance parameter is used as an indicator to understand the performance of each scheduling algorithm in allocating resource blocks from eNode-B to the user and knowing the capacity of available services.

The research scenario is described as follows. The first process is resource block scheduling using the Modified Round Robin algorithm. The next process is resource block scheduling with Maximal CSI and Proportional Fair algorithms. The simulation produces performance parameter data from each scheduling algorithm with different values. Performance values are reviewed and compared to determine which algorithm has the best performance based on the performance parameter.

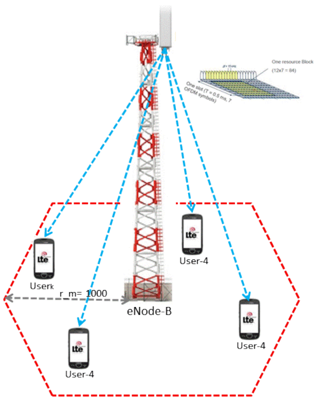

Figure 1. Modeling System

This simulation uses parameters that refer to the LTE standard. In accordance with the criteria in the standard, then used the parameters.

Table 1. Simulation Parameters

Parameters	Remark
Layout cellular	1 site hexagonal, 1 sector antenna
Frequency carrier	1800 MHz
Number of frames each TTI	1
Time Transmission Interval (TTI)	1000
System bandwidth	10 MHz
Number of RBs	50
Subcarrier per RB	12
Bandwidth subcarrier	15 kHz
Bandwidth PRB	180 kHz
Path loss	PL = 58,83 + 37,6*log10 *dn (km)+ 21*log10 *Fc (MHz)
Minimal range from UE to eNB	20 m
Lognormal shadowing	Lognormal shadowing, μ=3, σ=0
Power Transmit eNB	48 dBm
Number of active UEs	400
Gain antenna eNB	18 dB
Gain antenna User Equipment (UE)	0 dBi
Noise Figure UE	7 dB
Model Adaptive Modulation and Coding	64-QAM
Cyclic prefix	Normal
Scheduler	Algorithm Round Robin, Max CSI & Proportional Fair

1) Simulation Process

The simulation process begins with the user distribution within the coverage of an eNode-B that consisted of a single cell to allocate PRB to a number of $user_k$ using a scheduling algorithm. The communication system consists of transmitters, receivers and fading or loss channels that occur during wave propagation in free space. The antenna system is a single antenna, either on the transmitter side or on the receiver side or the familiar one is called Single Input Single Output (SISO)…

2) Initialization process

The initialization process is the process of determining or calculating the values of input data parameters that required by simulation such as number of users, power transmit eNode-B, Rayleigh and Shadowing attenuation, numbers of resource block allocation and others. The data will be formed into a data matrix. Data matrix is used as input data to perform resource block scheduling process with different algorithm.

3) User Distribution

In this study, a number of userk were distributed in the eNode-B coverage randomly (normal distribution). So each userk has r_k distance in meters against eNode-B. From this distance r_k can be observed userk location in the serving area of eNode-B. User distribution process with range 20 meters to 1 Kilometer against eNode-B. In this simulation the number of users is represented by k = {1,2,3, ..., k} and the number of resource blocks are symbolized by n = {1,2, ..., n} [8]. Simulation measurement process is repeated as many as thousand times that is by using some type of user number starting from 5 user with multiples of 5 until reaching total 50 user.

4) Generate Channel State Information (CSI)

The CSI is sent by the receiver to the transmitter that used as information to apply the PRB scheduling to the user [23]. CSI is calculated on all users. In this study, CSI is represented by SNR, Signal to Noise Ratio of userk and PRB_n are influenced by path loss, shadowing, and multipath fading that occurs in the communication process between Tx and Rx. Shadowing values is range from 6 to 10 dB. Multipath fading is distributed by Rayleigh which attenuates the signal power at the receiver.

$$PL_k = 58.83 + 37.6\log R_k + 21\log f \quad (1)$$

With PL_k, R_k, f, respectively a path loss, the userk range and the frequency used. The value of shadowing practically has a range of 6-10 dB with the Gaussian distribution. The values of Rayleigh fading, shadowing, and path loss are assumed to vary according to channel conditions and the distance from each userk to eNode-B.

Let γi be the SNR value of i, that value is specified in the equation below

$$\gamma_i = |h_i|\frac{E_x}{N_o}, \ \ i = 1,2, \dots N_R \quad (2)$$

Then from equation 2.2 we get CSI on each PRB is

$$\rho_n = E\left\{\max_i (|h_i|^2)\right\} \cdot \frac{E_x}{N_o} \quad , i = 1,2, \dots N_R \quad (3)$$

$$\frac{C}{BW} = \log_2\left(1 + \frac{N_R}{N_L} \cdot \frac{S}{N}\right) \quad (4)$$

In formula 2.4 consecutively c is capacity, BW is bandwidth, and N_L is min $\{N_T, N_R\}$.

CSI generation process by generating all channel conditions for userk on each PRBn on each $path_i$. This is done in order to know the response of each channel $H_{i,k,n}$ to the loss that occurs and the effects of Rayleigh fading and shadowing which is certainly different on each path.

The CSI generation is k x n sized matrix which contains the best channel condition of the $path_i$

$$CSI = \begin{bmatrix} H_{1,1} & H_{1,2} & \dots & H_{1,n} \\ H_{2,1} & H_{2,2} & \dots & H_{2,n} \\ \dots & \dots & \ddots & \dots \\ H_{k,1} & H_{2,k} & \dots & H_{k,n} \end{bmatrix} \quad (5)$$

5) Scheduling Methods

Resource scheduling in this research using Modified Round Robin, Maximum CSI and Proportional Fair algorithm. In general, the purpose of this study is to analyze the resources block allocation that is PRBn to $user_k$ based on the selection of appropriate algorithmic methods and functions that result in high performance such as spectral efficiency and user throughput by looking at constrains to be followed. The problem formulation that becomes the objective of the study can be formulated as follows:

$$\max_{C_{k,n},P_{k,n}} \frac{B}{N}\sum_{k=1}^{K}\sum_{n=1}^{N} c_{k.n}\log_2\left(1 + \frac{\gamma_{k,n}}{\Gamma}\right) \quad (6)$$

$$\gamma_{k,n} = p_n \times H_{k,n} \quad (7)$$

$$\Gamma = \frac{-\ln(5BER)}{1,5} \quad (8)$$

Γ is a SNR gap which is the difference between SNR required with SNR when achieving a particular transmission throughput for a practical system and a theoretical limit.

While to achieve the objectives of the study, then used several subjects which also become constraints or provisions that must be followed for the implementation of resource scheduling:

$$\max_{C_{k,n},P_{k,n}} \frac{B}{N}\sum_{k=1}^{K}\sum_{n=1}^{N} c_{k.n}\log_2\left(1 + p_n\frac{H_{k,n}}{\frac{-\ln(5BER)}{1,5}}\right)$$

Subject to

$$C1 : \in \{0,1\}, \ \forall k,n,$$

$$C2 : \ \sum_{k=1}^{K} c_{k,n} = 1, \ \forall n, \quad (9)$$

$$C3 : \ Pc_{k,n} \geq 0, \quad \forall k,n,$$

$$C4 : \ \sum_{k=1}^{K}\sum_{n=1}^{N} c_{k,n}p_{k,n} \leq P_{Total}, \quad (10)$$

All constraints are denoted C1-C4. C1 and C2 are constraints that ensure that each PRB is allocated to only one user so there is no possibility of more than one user occupying or obtaining the same PRB allocation at the same time.

For C3-C4 is a constraint on power allocation P_{Total} or total transmit power on the system and the transmit power allocated to each user is flat depending on the many PRB that allocated to the user.

$$P_n = \frac{P_{Tot}}{N} \quad (11)$$

5.1 Round Robin Algorithm

The Round Robin algorithm has a principle, first come - first serve. Round Robin (RR) is one of the fundamental and widely used scheduling algorithms. Its running process is very simple and easy to implement. RR gives every user an equal opportunity to obtain RB and does not consider the channel conditions. The RR algorithm [10] assigns equal portions of packet transmission time to each user in a circular order. Each user is allocated an equal and fixed number of time slot(s) in a ring fashion. Each user can use the resources in proper time interval. The first user will use the resource for the given time interval. The first user will be served with the whole frequency spectrum for a specific period of time and then serve the next user for another time period. After the resources will be assigned to another user.

Round Robin Initialization
$C_{k,n}$ = 0, $k \in \{1, \dots, K\}$ and $\forall_n \in \{1, \dots, N\}$
R_k = 0 , $k \in \{1, \dots, K\}$
$p = P_{tot}/N$

Constrain 1
$\mathcal{K} = \{1,2\dots,K\}$
$C_k = C_{k,n}$
If any *user* has been scheduled
$R_k = R_{k,n} + \frac{B}{N}\log_2(1 + p\frac{H_{k,n}}{\Gamma})$
Else
Constrain 2
$\mathcal{K}^* = \mathcal{K} - 1$
$C_{k^*} = C_{k^*,n}$
$R_{k^*} = R_{k^*,n} + \frac{B}{N}\log_2(1 + p\frac{H_{k,n}}{\Gamma})$

Figure 2. Pseudo code of Round Robin

5.2 Round Robin Algorithm

The Round Robin algorithm scheme has been developed that called the modified Round Robin algorithm. The development is added the channel or CSI priority scheme. The first active user that have the highest CSI value will be allocated PRB first. A new scheduling algorithm that assigns the RB to the user that maximizes the CSI in the first slot period of each sub frame whereas in the second slot period the scheduler assigns the RB in turn to each user. At the beginning of the scheduling process the BS compares the CSI from different terminals and selects the user with the highest CSI. If there is more than one terminal with the highest CSI, a random one is picked by the scheduler. In the first time slot the terminals with higher CSI are scheduled. In the second time slot the terminals are scheduled cyclically in turn. At the end of the second slot period the process begins again. Thus in the first slot of the second sub-frame the terminal with the higher CSI is selected and in the second time slot the terminals are assigned the RBs in turn. Scheme changes are made to improve the algorithms performance such as spectral efficiency and user throughput.

Modified Round Robin Initialization
Ck,n = Ck,n , k $\in \{1, \dots, K\}$ and $\forall n \in \{1, \dots, N\}$
Rk = 0 , k $\in \{1, \dots, K\}$
p = Ptot /N

Constraint 1
for k = 1 to K
Sort Hk,n in ascending order
$n = \arg\max_{n \in N} |H_{k,n}|$

Constraint 2
K* = K – 1
Ck* = Ck*,n
Rk* = Rk*,n + $\frac{B}{N}\log_2(1 + p\frac{H_{k,n}}{\Gamma})$

Figure 2. Pseudo code of Round Robin

5.3 Maximum CSI algorithm

As explained in the previous chapter, the maximum CSI algorithm is an optimization algorithm that has a principle of just allocating such PRB to users who have the best channel conditions. [9] Based on:

$$k^* = \arg\max H_{k,n}(t) \quad \text{for PRB}_n \qquad (12)$$

k * is the user who will get the PRBn allocation. With this algorithm, the overall system throughput can be maximized [7] because with this algorithm it is possible that one userk get more than one PRBn. The maximum CSI is also an algorithm that has a low complexity [20]. The pseudo code and flow chart of the maximum CSI algorithm used in this study are as follows.

Initialization
$C_{k,n}$ = 0, k $\in \{1, \dots, K\}$ and $\forall_n \in \{1, \dots, N\}$
R_k = 0 , k $\in \{1, \dots, K\}$
$p = P_{tot}/N$

Scheduling
For n = 1 to N
$n = \arg\max_{n \in N} |H_{k,n}|$
$c_{k,n} = c_{k,n} + 1$
$R_{k,n} = R_k + R_{k,n}\frac{B}{N}\log_2(1 + p\frac{H_{k,n}}{\Gamma})$

Figure 3. Pseudo code of the maximum CSI algorithm

5.3 Proportional Fair Algorithm

This is the proportional fair algorithm, in each scheduling slot s, Resources Block (RB) n is assigned to the user k * which has the maximal comparison between the momentary quality parameters (CSI or data rate) with the average quality parameters received. Formulated with:

$$k^* = \arg\max \Gamma_{k,n} = \arg\max \frac{r_k(n,s)}{R_k(s)} \quad (13)$$

Where rk (n, s) is the current quality parameter in RB_n and, Rk (s) is the average quality parameter received by user k.

k * is the proportional fair metric of the user who gets PRB because it has the highest ratio. With this algorithm, in one time allocation (1 timeslot / TTI) allows 1 user who does not get PRB. But as time passes, the average user that often gets PRB to increases and reduces the comparison. The average user throughput will be updated and will determine the proportional fair metric value at the next timeslot. This process will continue over and over until the number of timeslots is met based on equations (3.8) and (3.9):

$$\overline{R_k}(s+1) = \left(1 - \frac{1}{T_c}\right)\overline{R_k}(s) + \frac{1}{T_c} r_k(n,s)b(k) \quad (14)$$

$$b(k) = \begin{Bmatrix} 1; & \text{if } k = k^* \\ 0; & \text{if } k \neq k^* \end{Bmatrix} \quad (15)$$

With Tc is the number of TTI (Transmission Time Interval) at 1 time observation.

PERFORMANCE AND SIMULATION ANALYSIS

1. Generate and Distribute User

In the allocation PRB process, the first process is an analysis of the Hk,n channel condition, n for each userk in each PRBn. Good or bad channel quality will affect the chances of getting a PRB from eNode-B. The best channel condition has the highest SNR. There are 50 Users that generated with uniform distribution on this simulation. The users' location are distributed with distance 20 - 1000 meters from eNode-B randomly. Every user has different channel conditions. Some factors affect the channel conditions are path loss and fading values. The Path loss changed because every channel frequency propagate in the air or in a particular material will be faded. Fading is changing signal quality that caused by the conditions of electromagnetic propagation in the air.

2. Channel Condition

Every user has been generated and distributed that will communicate to eNode-B. Communication begins with measuring the condition of the user's channel. The channel conditions can be indicated by the SNR value. In this study, the CSI value is represented by the SNR value, the Signal to Noise Ratio of the userk on PRBn which is influenced by path loss, shadowing, and multipath fading that contained in the process of communication between Tx and Rx. CSI is the input data which is provided from the receiver to the transmitter. CSI is contained the condition or state of the channel on the communication system as information for the PRB scheduling. Every user has been generated and distributed that will communicate to eNode-B. Communication begins with measuring the condition of the user's channel. The channel conditions can be indicated by the SNR value. The simulation results state the average SNR is -18.52 dB. SNR value inversely proportional to the user distance, path loss and fading. SNR value is smaller if the distance the user farther or path loss and fading is getting bigger. .

3. Spectral Efficiency

In this section will observe the performance parameter of simulation result by using some scheduling algorithm. The performance parameter that will be observed is spectral efficiency. The spectral efficiency of the modified Round Robin scheduling algorithm will be compared with the Maximum CSI and Proportional Fair algorithms in Figure 4.1. Spectral Efficiency describes the number of bits that can be carried at a frequency. Spectral efficiency describes the average spectral efficiency of each user.

Table 2. Spectral Efficiency

Algorithm	Spectral Efficiency (bps/Hz)
Modified Round Robin	4.892
Round Robin	4.246
Proportional Fair	2.825
Maximum CSI	2.822

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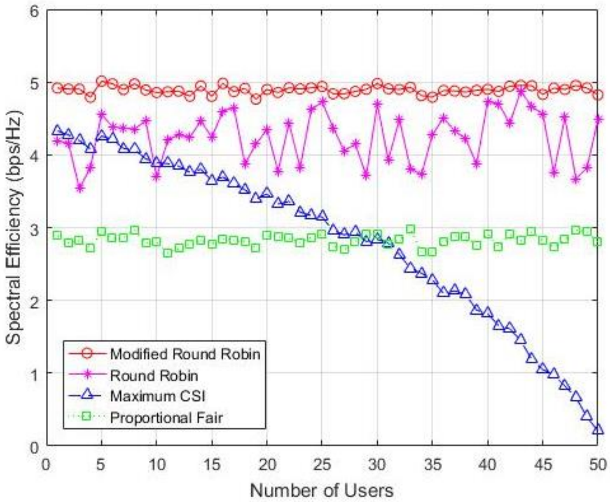

Figure 4. Spectral Efficiency

Round Robin Algorithm has provisions that the first active user will be served first with the principle of first come-first serve. In the Modified Round Robin algorithm, the channel condition becomes a consideration. The userk with the earliest index and the highest CSI value will be considered as the user to be served first. User get PRB that have best channel condition Hk,n,. Figure 4.6 shows the spectral efficiency is stable when the number of users increases, because resource scheduling simulation run as many as 1000 TTI.

4. Average Throughput User

To find out the performance of scheduling algorithm in PRB allocation, then in this study is calculated average user throughput on each user based on the number of PRB that has been allocated to the user. Average user throughput describes the average data rate of each user.

Average user throughput is calculated using the Shannon Capacity theorem on the system shown in (3.11). The average user throughput of each algorithm is compared and determined the highest average user throughput. Also in the simulation, the number of users are changed. Table 4.2 shows the average user throughput of Modified Round Robin, Maximum CSI and Proportional Fair on the varied user condition. Average user throughput obtained from 1000 TTI with the number of users as a variable that continues to grow up to 50 users. The average user throughput of the Modified Round Robin algorithm is the highest about 0.880 Mbps. Round Robin algorithm is 0,765 Mbps. Proportional Fair algorithm is 0,507 Mbps and maximum CSI is 0,508 Mbps……

Table 3. Average User Throughput

Algorithm	Average User Throughput (bps)
Modified Round Robin	880,623
Round Robin	765,864
Proportional Fair	508,478
Maximum CSI	507,959

The Modified Round Robin algorithm allocates more RB for first user to occupy the channel and has maximum channel conditions. The Maximum CSI algorithm allocates RB based on the best CSI values. Users with the greatest CSI value will get a higher priority RB allocation. While the Proportional Fair algorithm allocates RB based on the user throughput ratio required at the moment with the current average throughput system and also maintain the fairness of the system.

Bandwidth affects the throughput and the transmission scheme. The increased throughput range of each transmission scheme is the same as by increasing the bandwidth, the width of the path for the user to transmit or access data becomes wider so that the throughput obtained becomes larger. The larger the transmission scheme provides greater channel capacity for data transmission services and by increasing the bandwidth will also affect the throughput that affects the transmission of user data access. Due to the greater bandwidth given to the user then the user performs data transmission will also be faster.

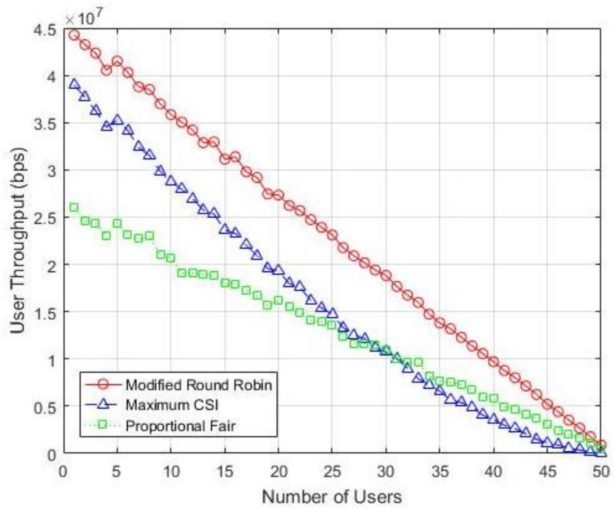

Figure 6. User Throughput

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From Figure 4.8 can be seen the effect of changes in the number of users to the user throughput using modified Round Robin, maximum CSI and Proportional Fair algorithm. The user throughput value decreases when the number of users increases. When the LTE system serves users with a smaller number of PRB. This happens because when the number of users is less than number of PRB then each user will have the opportunity to get more than one PRB allocation so that at the moment usern get more than one PRB allocation. If the number of users served in the system has a large number, then the chances of users who get the allocation of more than one PRB becomes smaller, and this will result in a decrease in the average user throughput rate as the number of user increases.

5. eNode-B Payload

One of the parameters that is used to evaluate the performance of an algorithm in allocating resource block is the eNode-B payload. Payload describes the amount of data sent on the system that iterated as much as the TTI sample within an hour. The eNode-B payload is derived from the formula 3.11 which runs on 1000 TTIs with a growing number of users up to 50 users. The eNode-B payload is the sum of the total bits sent by each user within 1 hour. The largest eNode-B payload on busy hour is obtained by using Modified Round Robin algorithm 158,512 Gbits. While the Round Robin, Maximum CSI and Proportional Fair algorithm are 137.57 Gbits, 91.432 Gbits and 91.526 Gbits.

Table 4. eNode-B Payload

Algorithm	eNode-B Payload (bit)
Modified Round Robin	158,512,050,018
Round Robin	137,579,489,887
Proportional Fair	91,526,084,667
Maximum CSI	91,432,555,431

The simulation uses SISO transmission scheme with bandwidth 10 MHz. The bandwidth value affects eNode-B payload on busy hour and throughput transmission schemes. The increasing throughput in the transmission scheme is the same as by increasing the bandwidth, the width of the path for the user to transmit or access the data becomes wider so that the payload eNode-B on busy hour obtained becomes larger. The larger transmission scheme provides greater channel capacity for data transmission and by increasing the bandwidth will also affect the throughput that affects the transmission of user data access. Because with the greater bandwidth that is given to the user then the user will perform data transmission will also be faster and payload value generated will be greater at certain times.

6. Enode-B Throughput

System throughput illustrates the achievement of the average throughput system as much as TTI sample. System throughput can also be called eNode-B throughput. The eNode-B throughput is derived from the formula 3.10 which runs on 1000 TTIs with a growing number of users up to 50 users. For each number of users, downlink average throughput eNode-B is averaged per 1000 TTIs. After that throughput eNode-B summed based on the number of users. The highest eNode-B throughput is obtained by using Modified Round Robin algorithm of 44.031 Mbps. While the Round Robin, Maximum CSI and Proportional Fair algorithm are 38.216 Mbps, 25.397 Mbps and 25.423 Mbps.

Table 5. eNode-B Throughput

Algorithm	eNode-B Throughput (bps)
Modified Round Robin	44,031,125
Round Robin	38,216,525
Proportional Fair	25,423,912
Maximum CSI	25,397,932

Bandwidth affects the throughput and the transmission scheme. The increased throughput range of each transmission scheme is the same as by increasing the bandwidth, the width of the path for the user to transmit or access data becomes wider so that the throughput obtained becomes larger. The larger the transmission scheme provides greater channel capacity for data transmission services and by increasing the bandwidth will also affect the throughput that affects the transmission of user data access. Due to the greater bandwidth given to the user then the user performs data transmission will also be faster.

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CONCLUSION

Modified Round Robin algorithm as resource scheduling is proposed to allocate PRB from eNode-B to user. This algorithm produces the best performance values such as spectral efficiency, average user throughput, eNode-B throughput and eNode-B payload based on the simulation results. From the simulation results can conclude that:

1. The channel condition and the planned power downlink budget in this simulation resulted in the good channel quality and the user's location with the number of users that generated 50 users. The average distance of the user from eNode-B is 510.68 meters. The average path loss obtained is 112.23 dB. The average Fading earned is 378.52 dB. The average SNR is -18.52 dB and CSI is 9.81. This condition if $\Sigma user \leq \Sigma PRB$, then certainly all users will get at least one PRB.

2. The Modified Round Robin scheduling algorithm has the highest spectral efficiency about 4.892 bps / Hz compared with Round Robin algorithm about 4.246 bps / Hz, Proportional Fair about 2.825 bps / Hz and Maximum CSI about 2.822 bps / Hz.

3. Modified Round Robin scheduling algorithm has the highest average user throughput about 0. 880 Mbps compared with Round Robin algorithm about 0. 765 Mbps, Proportional Fair algorithm about 0. 508 Mbps and Maximum CSI about 0. 507 Mbps.

4. Modified Round Robin scheduling algorithm has the highest eNode-B throughput is 44.031 Mbps compared to Round Robin algorithm is 38,216 Mbps, Maximum CSI is 25,397 Mbps and Proportional Fair is 25,423 Mbps.

5. Modified Round Robin algorithm has the highest eNode-B payload about 158,512 Gbits compared to Round Robin algorithm about 137,579 Gbits, the maximum CSI about 91,432 Gbits and Proportional Fair about 91,526 Gbits.

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