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COMPARISON ANALYSIS OF EXPONENTIAL RULE AND MAXIMUM THROUGHPUT ALGORITHMS FOR UPLINK CHANNEL SCHEDULING ON LONG TERM EVOLUTION (LTE) NETWORK

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ABSTRACT

Scheduling is a setting process on a system for better service. One of the system that uses scheduling is the Long Term Evolution (LTE) network. Scheduling on Long Term Evolution is used for allocating radio resource to serve users at a certain frequency and time. One of the methods that can be used is by using channel scheduling algorithm for uplink LTE direction. Exponential rule algorithm has the advantage of being able to support a fair system fairness index, but unable to maximize throughput user. On the other side, maximum throughput algorithm is able to maximize user throughput with the best channel condition, but has disadvantage on the fairness index side. This study will analyze the comparison between exponential rule and maximum throughput for LTE network uplink channel scheduling based on throughput user and system fairness index. This study uses 4 scenarios with variations in the distance of 1-4 km and variations in the number of users 4, 8, 12, and 16 in 2 track conditions, namely LOS (Line of Sight) and NLOS (Non-Line of Sight).

Keywords: channel scheduling, LTE, exponential rule, maximum throughput, throughput, fairness.

INTRODUCTION

The need for internet service provider in Indonesia is increasing every year. However, with limited sites that can be provided, there will be a build up of users at one site. To minimize that, scheduling is needed in order to prevent crash with other system process. Long term evolution (LTE) is one of the systems that uses a scheduling process that aims to allocate radio resources to serve users on a certain frequency and time slot. Scheduling process will be compared in this study is the uses on exponential rule and maximum throughput algorithms. Exponential rule algorithm ensures fairness quality while maximum throughput algorithm maximizes the throughput value. How distance and number of users affect the use of these algorithms on uplink direction of LTE network from throughput and fairness aspects will be the focus of this study.

Long term evolution (LTE) network

Long term evolution (LTE) is a wireless data access communication standard, Internet Protocol (IP) based. LTE is a development from GSM/EDGE and UMTS/HSPA networks. LTE was first launched by Telia Sonera in Oslo and Stockholm on December 14, 2009. While LTE was marketed as 4G technology, the LTE marketed now cannot be entirely called 4G technology as the LTE set by 3GPP ON 8 and 9 release does not meet the standards of Telecommunication Union Radio Communication Sector organization (ITU-R) [1].

Table-1. LTE Specifications.

Parameter	Value/Type
Bandwidth	1,4-20 MHz
Duplexing	FDD, TDD, half-duplex FDD
Mulitiple access	OFDMA (Downlink)
	SC-FDMA (Uplink)
Modulation	QPSK, 16QAM, 64QAM

LTE scheduling

Scheduling on LTE occurs in the scheduler package module that is in the MAC sub-layer. The scheduler is placed on eNodeB. Scheduling aims to meet the respective services requirements. Therefore, scheduling package should be designed to be reactive to changes in the channel so that it can respond to the QoS of each service.

Single carrier frequency division multiple access (SC-FDMA)

Single Carrier Frequency Division Multiple Access (SC-FDMA) is a multiple access technique that uses several subcarriers perpendicular to each other. SC-FDMA is a development of Orthogonal Frequency Division Multiple Access that already existed before, that the advantages of OF-DMA are also owned by SC-FDMA. SC-FDMA works on Long Term Evolution uplink channel technology [2]. SC-FDMA uses serial transmission scheme that transmits symbol data on every subcarrier groups orderly as single carrier. The advantage of SC-FDMA is power efficiency since SC-FDMA has Peak to Average Power Ratio (PAPR) value. PAPR is a

performance used to determine power efficiency indicated by a transmitter. The lower the PAPR, the higher the power efficiency produced. Uplink transmission needs a low PAPR for when the uplink transmission signal transmitted has a high PAPR that will resulting in wasteful use of batteries in User Equipment (EU).

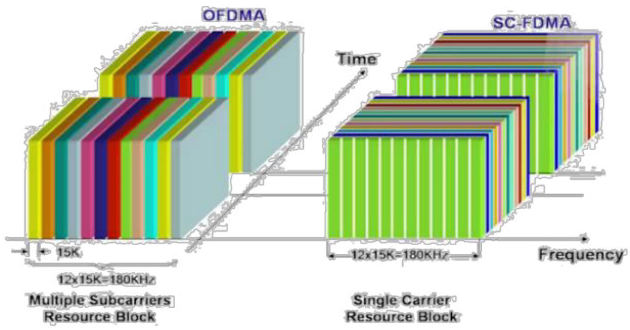

Figure-1. SC-DMA Scheme.

Resource block

Resource Block is a transmission block arranged from time and frequency domains. The number of resource blocks depends on the bandwidth (BW) used. The bigger the bandwidth, the bigger the resource block provided and maximal throughput produced [3].

Table-2. Number of every bandwidth on LTE's resource block.

Bandwidth (MHz)	1,4	3	5	10	15	20
Quantity of RB	6	15	25	50	75	100

Exponential rule algorithm

Exponential rule is an algorithm that chooses the highest channel level compared to average channel level. This scheduling is able to meet the fairness level [4]. For non real time service, exponential rule algorithm scheduling can be defined as:

$$user_{(i)} = \left(\frac{C_{(i)}}{\sum_{i=1}^{n} C_i}\right) \quad (1)$$

$user_{(i)}$ = number ofresource block for user numberi
$C_{(i)}$ = user's channel capacity

Maximum throughput algorithm

Maximum Throughput (MT) is an algorithm used to maximize throughput on certain user on the network, with allocating resource block to users with good channel conditions (user who has a SNR value of ≥ 26, 91 dB) and between those users, package scheduler determines the user with the best channel condition on the network as the main priority on allocating RB or on other words, RB allocations is prioritizing user with the highest channel capacity [6]. After the prioritized user secured their RB allocations, RB are allocated to other users.

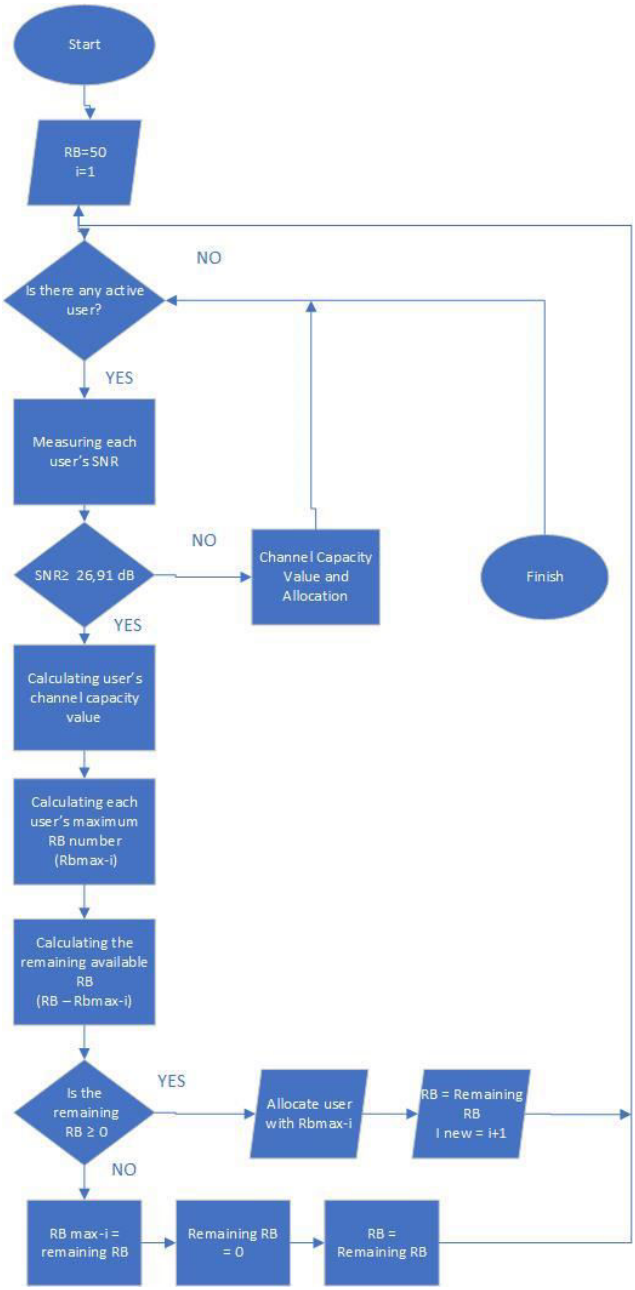

Figure-2. Maximum Throughput Algorithm Flowchart.

Propagation channel

Propagation channel is a transmission media used to transmit information from the transmitter to receiver [5]. Disruptions that have an effect on the propagation system are as following:

- Noise

Noise is unwanted signals that are always present in a transmission system. Noise will disrupt quality of the desired received signal and disrupts the data receiving and transmitting process.

- Fading

Fading is a phase change, polarization and/or level from a particular signal, occurs due to the level

fluctuations of signal power received by receiver. Fading is related to propagation mechanism that involves refractions, reflections, difractions, scattering and attenuation of radio waves. In the transmission process, it does not only pass through one path, but from various paths (multipath). Multipaths fading make it possible for signal to be received while the line is blocked, but will affect signal receiving. In multipath fading, the distribution often used to explain the signal shape is Rayleigh Fading.

- Propagation Losses

Propagation losses is a line condition that causes a decrease in signal receiving power level as the distance between the user and eNodeB. Line conditions that determines the propagation losses are Line of Sight (LOS) and Non Line of Sight (NLOS).

Signal to noise ratio (SNR)

Signal to Noise Ratio is a ratio between signal strength and noise level. SNR value used to show the connection line (medium) quality. The higher the SNR value, the higher the line quality. That is, the greater the likelihood that the line is used for data and signal communication traffic at high speeds. The SNR value of a line are generally constant, regardless of the data speed through that line. The SNR average value is shown in the following equation:

$$\mathrm{SNR} = 10 \log \frac{\mathrm{Pr}}{\mathrm{No}} \tag{6}$$

SNR = Signal to Noise Ratio(dB)
Pr = power received (mW)
No = noise power on the transmission channel(mW)

Channel capacity

Channel capacity is the number of information passes on a channel. The bigger the capacity, the better it is. According to Shannon Theorem, channel capacity can be calculated by the following equation:

$$\mathrm{C} = \mathrm{B} \times \log_2 (1 + \mathrm{SNR}) \tag{7}$$

C = Channel capacity (Mbps)
B = Bandwidth (Hz)
SNR = Signal to Noise Ratio (dB)

Parameter analysis

- Throughput

Throughput is an actual bandwidth measured by a certain time unit and on a certain network conditions that are used to transfer data of a certain size. To determine the throughput of each user, the equation is:

$$\mathrm{Throughput} = \frac{\mathrm{B}}{\mathrm{N}} \times \mathrm{RBuser_i} \tag{10}$$

B = Bandwidth (Hz)
N = Resource Block Number
$\mathrm{RBuser_i}$ = Resource Block user numberi

- Fairness

Fairness is a process on every user to obtain the same processing time. Fairness has a range of values between 0-1. The higher the index, the more fair. Fairness can be defined by the equation:

$$\mathrm{F} = \frac{|\Sigma_{i=1}^{K} \mathrm{D_i}|^2}{\mathrm{K}.\Sigma_{i=1}^{K} \mathrm{D_i^2}} \tag{11}$$

$\mathrm{D_i}$ = Data rate user-i (Mbps)
K = User number

RESEARCH METHODOLOGY

This study is a simulation analysis using Matlab R2016a software according to literature study. Algorithms used in this study are Exponential Rule and Maximum Throughput. Parameter used in this study includes Throughput and Fairness. Steps taken in the research methodology are problem identification, literature study, system design, testing and analysis of results, conclusions and suggestions.

Determination of problems identification carried out in this study is to provide treatment of variations in distance and users number to understand BER, throughput, and fairness using Exponential Rule and Maximum Throughput algorithms. Literature study is by collecting theories and related parameters as secondary data.

Table-3. Secondary Data.

Parameter	Values/Types
Type of System	*Single Cell*
Technical access	SC-FDMA
Bandwith (Mhz)	10
Quantity of *Resource Block*	50
Quantity of *user*	4, 8, 12, 16
User distance to eNodeB (Km)	1-4 km
Power transmitter (dBm)	43
Gain antenna (dB)	18

System planning in this study will be divided into several steps shown in the following flowchart:

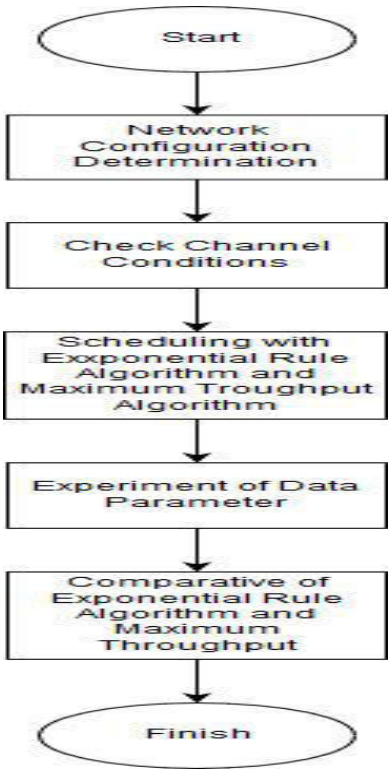

Figure-3. System Planning Flowchart.

After designing the system, results analysis will be perfomed and conclusions and suggestions will be determined.

RESULTS AND ANALYSIS

Scenario planning

Prior to calculating, communication scenerio designed for uplink direction where user is the transmitter and eNodeB is the receiver will be determined. The scenario that will be designed consists of 4 scenarios according to distances and number of users variations that have been determined.

A. Scenario planning 1

Table-4. Scenario Planning 1.

Scenario	User Number	User No-i	User's Distance to eNodeB (m)
1	4	1	1000
		2	1800
		3	2600
		4	4000

B. Scenario planning 2

Table-5. Scenario Planning 2.

Scenario	User Number	User No-i	User's Distance to eNodeB (m)
2	8	1	1000
		2	1400
		3	1800
		4	2200
		5	2800
		6	3200
		7	3800
		8	4000

C. Scenario planning 3

Table-6. Scenario Planning 3.

Scenario	User Number	User No-i	User's Distance to eNodeB (m)
3	12	1	1000
		2	1200
		3	1400
		4	1800
		5	2200
		6	2400
		7	2400
		8	2600
		9	3000
		10	3400
		11	3800
		12	4000

D. Scenario planning 4

Table-7. Scenario Planning 4.

Scenario	User Number	User No-i	User's Distance to eNodeB (m)
4	16	1	1000
		2	1200
		3	1400
		4	1600
		5	1800
		6	2000
		7	2200
		8	2400
		9	2600
		10	2800
		11	3000
		12	3200
		13	3400
		14	3600
		15	3800
		16	4000

Uplink channel scheduling using exponential rule and maximum throughput algorithms

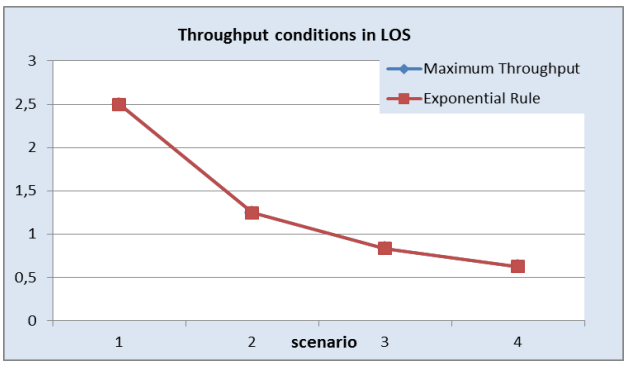

Figure-4. Throughput Graphic System in LOS Conditions.

As the throughput graphic suggests, in LOS condition the throughput value of two channel planning algorithms are equally high. This is because the LOS conditions are ideal path condition where two channel scheduling algorithms allocate all system's RB to network cell.

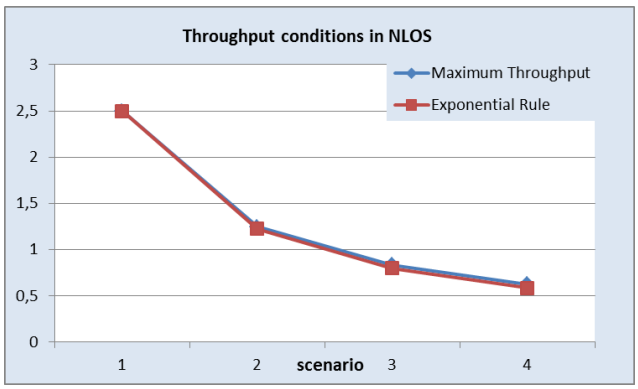

Figure-5. Throughput Graphic System in NLOS Conditions.

As shown on the graphic, in the NLOS condition, the throughput value of Maximum Throughput algorithm is higher than the Exponential Rule algorithm. This is caused by maximum throughput algorithm's way of working that is able to select good and poor users before allocating the RB. This affects maximized throughput users because RB allocation focuses on users with good channel condition (SNR26, 91dB).

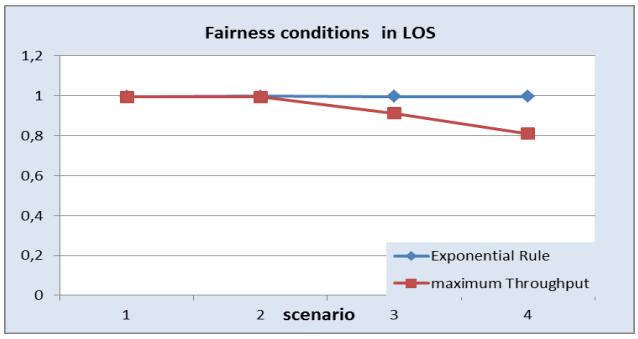

Figure-6. Fairness Index Graphic System in LOS Conditions.

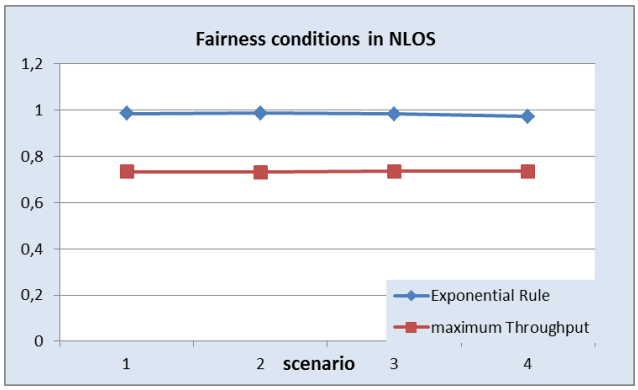

Figure-7. Fairness Index Graphic System in NLOS Condition.

From the index fairness graphics of LOS and NLOS conditions, it can be seen that the fairness index with Exponential Rule algorithm has higher value compared to the fairness index of Maximum Throughput algorithm. Fairness index of Exponential Rule algorithm is

almost close to 1 (Fairness Index maximum value). This is because this algorithm's working is able to allocate RB to each user fairly so that the number of user's RB with one another is not much different and has an impact on the high fairness index value. While Exponential Rule algorithm prioritizes fairness, Maximum Throughput algorithm did not. Its working principle to be able to select users with user's channel condition caused the possibility of active users not getting RB allocations at all.

CONCLUSIONS

a) With variations on the distance on the eNodeB for LTE uplink channel scheduling, it can be concluded that the farther the user is, the more the throughput will decrease. Among the two algorithms, the maximum throughput is able to show higher user throughput results compared to the exponential rule algorithm in both LOS and NLOS conditions.

b) With variations on the users number on the eNodeB for LTE uplink channel scheduling, it can be concluded that as the number of users increase, the throughput will decrease. This is because the limited usage of bandwidth and it affects the user's throughput. Among the two algorithms, maximum throughput algorithms are able to show higher user throughput result compared to the exponential rule algorithm in both LOS and NLOS conditions.

c) With variations on the users number to single cell scenario on LTE uplink channel scheduling, it can be seen from the system's fairness index that exponential rule algorithm has higher fairness level compared to the maximum throughput algorithm in both LOS and NLOS conditions.

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