Analysis of 5G Implementation in Indonesia

Gilbert
Computer Science
Bina Nusantara University
Jakarta, Indonesia
2440013430

Hanrich Marcius
Computer Science
Bina Nusantara University
Jakarta, Indonesia
2440013922

Freidrich Lim
Computer Science
Bina Nusantara University
Jakarta, Indonesia
2440004924

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I. Introduction

The 5G network has recently been implemented in Indonesia .Network implementation is not an easy problem, it takes time to design implementation of a network both in the short and long term. In the short term we need to design a way for 5G to quickly spread across the nation with its full potential and how to maximize it. Spectrum space is needed by the network to be implemented on a wide range, therefore in the long-term design, we need to think about the availability of spectrum space for all the technology in the future.

In this paper, we will focus on optimizing 5G networks in Indonesia by comparing several algorithms that can be used to make the 5G network more efficient.

II. Literature Review

The implementation of a 5G network requires a good design and architecture to achieve maximum results [15][26]. The current 5G development still has to be developed for the future where more and more users will be connected to the internet [2], the implementation of a network requires well thought design, modeling, and planning so that it can be used optimally [1], spectrum space is one of the thing that must be considered in the implementation, not only to be able to implement a new network at this time, but also to be able to predict and prepare the space for network technology in the future [2][19]. This deficiency can occur due to the ineffective distribution of the spectrum on the network which can be solved by some solution [3][4][20][22].

Once spectrum space is available, it must be ensured that 5G performance in optimal implementation and Sminimal problems must be ensured. There are a number of problems that can occur given that 5G is a relatively new network. Several algorithm solutions were found to optimize the efficiency of the 5G network [5][11][14], transmission technology [6][27], and filters [7] so that 5G can be used to its best potential.

Seeing the development of the times that the internet network will not only be used by more people but will also require better performance where this refers to the need for further carriers to improve the performance of the 5G network [24]. FBMC is one of the techniques that can be implemented to improve the performance of the 5G network [10]. Spectrum sharing is also a part of implementing FBMC where efficient use of spectrum space is an important factor that can improve 5G performance [17].

In addition to optimizing and improving the quality of the 5G network, we must also look at external factors such as radiation and energy use. Radiation from 5G can be overcome by implementing thermal radiation mode [12]. As for the energy efficiency used in 5G, the 5G NR design can be implemented [6][13][16]. In addition, energy savings can also be achieved by using 5G appropriately in various fields, for example implementing 5G in smart homes which can reduce excessive use of electricity to create a cleaner environment with reduced carbon emissions [18][25].

In addition to the optimization problems mentioned above, security is also an important factor in network usage [8] so that users feel their privacy is secured and are not pressured by the potential for data leak [21]. Therefore, we also need public opinion on the readiness of 5G technology to be implemented in various fields [9].

III. Methodology

1. Introduction

5G mobile network aims to deliver a 1,000-fold increase in capacity without higher additional costs on existing networks. Snce network power changes a lot during the day, the 5G network must be able to change power consumption (Navarro-Ortiz et al.2020). Massive MIMO should be the primary technology that is capable of handling extremely high capacity. In a massive MIMO system, each base station uses hundreds of antennas to support dozens of user devices on the same time-frequency resource (Gampala et al. 2018).

Massive MIMO is based on spatial multiplexing, which requires full channel information from the base station in the uplink and downlink. Massive MIMO increases power by a factor of 10 or more while also improving on-demand radiated power efficiency by a factor of one hundred. Regulating Energy Efficiency plays an important role in the development of large 5G MIMO systems and is estimated by the actual number of bits that can be transferred per joule as in the equation below and has become an improvement in performance in wireless communications (Salh,et al. 2019; Zappone and Jorswieck 2015).

$$EE = \frac{\text{Throughput [bit/s/cell]}}{\text{Power Consumption}\left[\frac{\text{W}}{\text{cell}}\right]}$$

Service quality and costs are compared to power consumption which can be the metric for network's bit delivery reliability. Spectral efficiency can also be defined as average bits of information that can be transmitted under consideration over the channel (Miao et al. 2016).

$$SE = \frac{Data\,rate\,or\,Throughput\,(pbs)}{channelBandwidth\,(Hz)}$$

Massive MIMO systems employ many antena which receviening in each base station that can increase Spectral efficiency in cell network (Gupta and Jha 2015), energy efficiency doesn't reliant only on spectral efficiency but also on circuit power utilization, where large numbers of Base station antennas will significantly increase power consumption of the digital signal processing and radio frequency circuit which could affect energy efficiency (Rusek et al.2014; Sarajli"c et al 2017).

Resource allocation power efficient method can resolve the energy consumption problem in OFDM networks with a lot of base stations. (Ng.et al. 2012, 2013). Adaptive massive MIMO optimization techniques can also be used based on optimizing energy efficiency at full spectral efficiency. To achieve optimum energy efficiency, the number of active antennas must be adjusted based on active user in the network cell which can lead to maximizing energy efficiency on the 5G network massive MIMO system.

The paper will be organized as follows: Sect. 2 Literature Reviews are introduced. Sect 3, simulation analysis and result are determined. Sect 4. Conclusion of the paper is presented.

2. The impact of multiple BS antennas and users in 5G deployment

Although a combination of maximum ratio (MR) and perfect channel information is used at the BS, the uplink (UL) SE of each UE is calculated according to the formula.

$$SE_0 = log_2\left(1 + \frac{M-1}{(K-1) + K\bar{\beta} + \frac{\sigma^2}{P\beta_0^0}}\right)$$

where M is the number of antennas per base station, K is the number of UEs in user equipment, p defines the transmit power, σ2 is the noise power, β is the average gain of the active UE channel, assumed to be constant for all UEs in cell j . Cell EE according to formula 0.

$$EE_0 = \frac{BKSE_0}{K\left(\frac{M-1}{2^{SE_0}-1} - K\bar{\beta} + 1 - K\right)^{-1}\nu_0 + CP_0}$$

where, B denotes the bandwidth, and $\upsilon 0$ is evaluated according to formula

$$\upsilon_0 = \frac{\sigma^2}{\mu\beta_0^0}$$

where, μ is a factor accounts for the Effective Transmit Power (ETP), 0<μ<1

The Circuit Power (CP) model consumed by single UE is estimated according to:

$$CP_0 = P_{FIX} + MP_{BS}$$

where PFIX is the fixed power, PBS refers to the power used by circuit components and I, which are required for the operation of each BS antenna.

In order to calculate the additional Circuit Power (CP) consumed by all the active UEs, CPo is estimated according to formula.

$$CP_0 = P_{FIX} + MP_{BS} + KP_{UE}$$

where, P_{UE}, refers to the power required by all circuit components of each UE's single-antenna

Derivative of formula is obtained to get the Maximum Energy Efficiency (Max EE), yields the expression:

$$\max EE = \frac{d}{dSE0}EE_0$$
$$\max EE \approx \frac{eB}{(1+e)}\frac{\log_2(MP_{FIX})}{P_{FIX}}$$

The equation proves that the maximum EE has a function that increases logarithmically with the number of antennas per base station (M) and decreases almost linearly with the increase of P_{FIX}.

3. EE optimization on Genetic Algorithm

Number of massive MIMO antennas is affected by the number of active users in 5G cell, Many techniques are being tested in order to get the optimum number of massive MIMO antennas. So far, the Genetic Algorithm is the most used technique in the massive MIMO networks [28]. The Genetic Algorithm does support different processes such as selection, crossover, and mutation. The central concept of the algorithm is to find solutions for optimization problems with a given objection function.

Genetic Algorithm starts with the factor that is affecting the optimization problem, which will use the objective function to choose the best ones and will be used directly for the next optimization and the remaining numbers of factor will be processed by crossover and mutation to produce the next optimization. This step will be done until the optimum Energy Efficiency is reached.

The important factor of the algorithm is the Energy Efficiency and the number of users, the main objective is to optimize the consumed energy per cell and improve the Massive MIMO EE in 5G networks.

4. Results

The scenario we used is EE estimated from different numbers of users (5, 10, 30, and 40 users), the process evaluated the maximum value of EE at each number of users at a constant number of antennas which there are ten antennas per array.

Figure 1

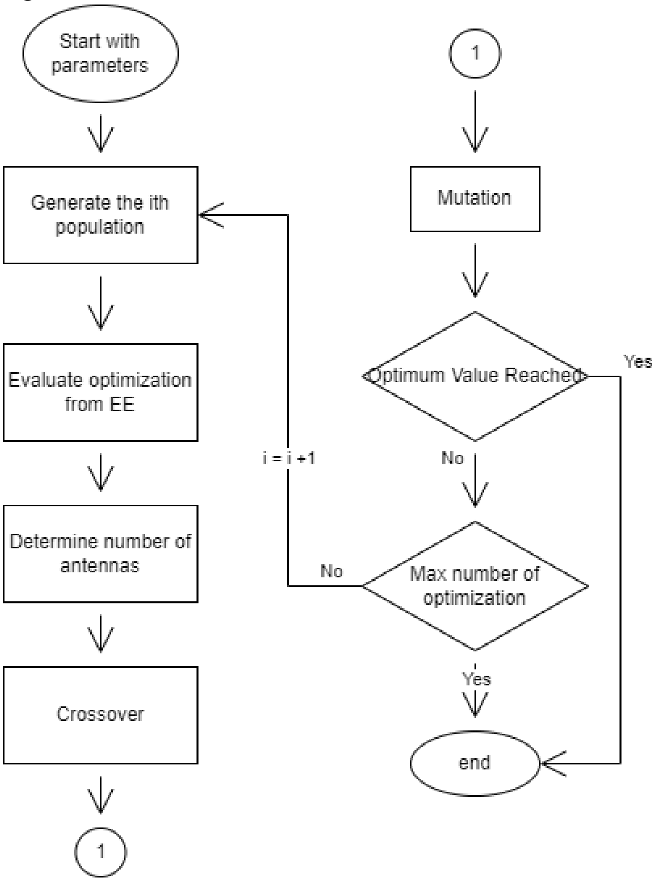

Figure 1 shows the relationship between Spectral Efficiency and estimated Energy Efficiency values for different numbers of users [5, 10, 30, 40] with 10 active antennas. It is observed that the maximum EE value is obtained when there are 10 users served per antenna. In the setup, the maximum value of (K = 10) is obtained when the total spectral efficiency is a slowly increasing function of K when M = 10, but the Power Consumption will increase with User Equipment added each time. Power of User Equipment increases by 0.5W. Therefore, for a given total Spectral Efficiency, the degradation of Energy Efficiency increases as K increases.

The algorithm is considered to make the antennas adaptive to maintain optimum Energy Efficiency, which will make this algorithm ideal for the more of future implementation of 5G in Indonesia.

Table 1

	Users			
Antenna	**5 UE**	**10 UE**	**30 UE**	**40 UE**
10	2,8407	3,0036	2,5642	2,325
20	3,1262	3,7374	3,8699	3,6758
30	2,9914	3,8233	4,477	4,3954
40	2,79	3,7228	4,7529	4,7841
50	2,5924	3,5668	4,8576	4,9862
60	2,4142	3,3991	4,8691	5,0777
70	2,2569	3,2359	4,8281	5,1015
80	2,1186	3,0828	4,7574	5,0828
90	1,9968	2,9414	4,6702	5,0373
100	1,8888	2,8116	4,5743	4,9748
Max(EE)	3,1262	3,8233	4,8691	5,1015

As we can see on the table 1 result, the optimum active antena for 5 users is 20 antennas with (Max EE = 3.1262) and 10 User is 30 antennas (Max EE = 3,8233), 30 users is 60 antennas (Max EE = 4.8691), lastly 40 users will need 70 antennas (Max EE = 5.1015)

While the simulation of the GA large-scale MIMO scheme for active users (K = 10) determines that the optimal number of active antennas in the optimal EE is the best possible performance (M = 20). However, if K = 20, M is estimated to be (M = 40). Therefore, this result is applied as an antenna UE ratio M / K = 2.

In addition, as the number of active users changes, the number of antennas (M) in the 5G cell with the maximum Energy Efficiency changes as the number of active users changes. Based on the results discussed, it has been demonstrated that applying the GA optimization algorithm to the proposed Massive MIMO system improves Energy Efficiency performance. However, unlike traditional wireless networks, the number of antennas in the Massive MIMO grid is optimized based on the number of active users in the cell. It may also improve the overall efficiency and reliability of 5G systems.

IV. Conclusion

After the result of the calculation, we reached the conclusion that the Massive MIMO network with genetic algorithm offers the best efficiency for implementation due to setup that helps us to find the best number of antennas needed to be active to facilitate the numbers of users so that the energy is not less or more than needed.

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