

Device-to-Device (D2D) Communication Power Control for Interference Management in Existing Cellular Network

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ABSTRACT

Increasing the number of service users every time requires progress in service quality. One of the technologies that continue increasing the capacity of the service network is Device-to-Device (D2D) communication. The aim of this study is to focus on the management of communication interference by controlling the output power (power control) on the cellular device. In this study, interference management analysis was performed on a cellular system containing D2D and MUE devices. The scenario we use is in one network, there is one MUE device with 50 D2D devices. The analysis was carried out in the downlink and uplink periods. SINR improvement was done by using the signal power control method on the transmission. This study used two schemes of power control methods, they are fixed power control and adaptive power control. Power control keeps the overall D2d device transmitting power in the environment. The second power control algorithm is adaptive power control, which controls the transmit power of multiple devices in the vicinity of the MUE. The simulation results showed that the power control CDF analysis scheme was still able to increase the SINR by 11.45% and adaptive power control had an increase of 8.65% in the downlink period. And in the uplink period, the SINR value increased to 3.29% with fixed power control and 2.24% with adaptive power control. From the simulation results obtained, we can conclude that the proposed algorithm can manage interference and increase QoS value.

Keywords : Device-to-Device Communication, Interference Management, Power control, SINR, Throughput

I. INTRODUCTION

The development of information and communication technology is increasing rapidly. One of the rapid developments is felt in cellular telecommunications technology [1]. As the fourth generation began to be held since 2010 [2]. Where the technology in this generation was considered to bring drastic changes from the previous technology so that it is declared as long-term evolution (LTE) technology [3]. One of the advantages of LTE technology is its

large bandwidth so that it can deliver more information[4].

This development cannot be separated from the increasing number of mobile users who continue to increase. Based on 2016 data collected by the Association of Indonesian Internet Service Providers (APJII), the amount of internet penetration in Indonesia is 132.7 million out of a total of 256.2 million people in Indonesia. This is an increase of 88 million penetrations compared to 2014. And 63.1 million penetrations of which are mobile device users[5].

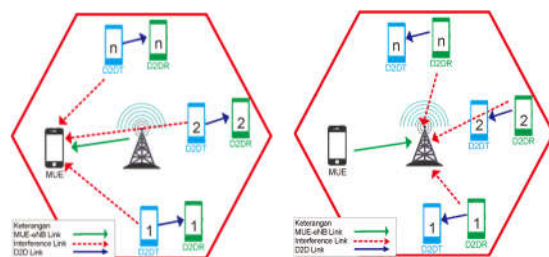


Figure 1. D2D Communications Signal Line

As the number of users continues to increase, the data passing through the communication channel will also increase. An increase in the amount of information passing through the channel will cause the channel to become full and the network service performance will decrease [6]. To ease the workload of the communication channel, the thing that can be done is to bring the source of information closer to the user. As one of the technologies proposed as the next generation of communication technology. The devices ability is storing information (content) and then distributing it to other devices. This technology is called device-to-device communications (D2D)[7].

D2D is a technology that allows user devices to interact with each other directly [8]. Where in the previous technology, a device wanted to contact another device, it had to go through an intermediary, namely BTS. So the innovation of D2D is to reduce the need for devices to connect to BTS, which will improve BTS performance and the overall quality of the cellular network service [9]–[11]. One of the challenges of using this technology is the interference problem caused between D2D communication and conventional cellular communication. Common interference occurs due to the use of the same working frequency or close together [12], [13]. While the most possible solution when the two protocols work on adjacent frequencies is to set the transmitter output power on each device [14]. The illustration of how the D2D devices interfered existing cellular network can be seen in figure 1[15]

The transmit power provided by the transmitter in wireless communication is one of the determinants of service quality [16]. If the power provided is greater, the wider the area of communication coverage will be the same. However, excessive use of power will cause interference or interference to the receiver or transmitter, including interference to adjacent transceivers [17].

Therefore, the aim of this study is to focus on the management of communication interference by controlling the output power (power control) on the device in the cellular. The power control method is to manage the interference in wireless communication. This method manages interference by adjusting the power supply used by a transceiver device. This study will focus on the effect of the application of power control in interference management in terms of the

quality of service (QoS) value which includes the average throughput and SINR value.

II. LITERATURE STUDY

Y. Zhao, B. Pelletier, and P. Marinier in their research related to D2D Neighbor Discovery communication interference on LTE networks. This aim is to perform interference management and minimize the influence of interference when there is D2D Neighbor Discovery. This research involves several D2D devices using uplink resources. The device discovery process uses the ProSe algorithm. This research was conducted in three different scenarios. First, all eNBs use the same frequency. Second, the frequencies used by the eNB are different. Finally, the frequency allocation is carried out. From this research, the results of interference management are more efficient by using the third scenario [19].

B. Guo and S. Sun in their research related to D2D communication interference management at the cell edge. The purpose of this research is to increase the capacity of the cellular network. The simulation is done by plotting several conventional cellular devices and several D2D devices on a cellular network system. The interference management used is the Interference-Suppression-Area (ISA) algorithm. The result obtained is a significant increase in capacity compared to without interference management using the ISA algorithm [20].

Y.V. Lima de Melo et al. in research on several schemes of power control methods in increasing energy efficiency in cellular networks and D2D communications. In this study, two main power control schemes were used, namely soft dropping power control (SDPC), and open-loop power control (OLPC). The results obtained from this study are the SDPC scheme gives better results than the OLPC scheme in the interference management of the cellular network section. While the OLPC scheme is more efficient in the management of interference in D2D communication [21].

N. Lee et al. in this work on the existence of D2D devices in cellular network coverage using stochastic geometry algorithms. The purpose of this study is to find a way for MUE devices to obtain sufficient resources by managing interference from D2D devices as much as possible. The schemes implemented are

centralized power control schemes and distributed power control schemes. The result is that centralized power control schemes can improve the performance of cellular networks, resulting in resources being used for D2D communication. The second scheme does not improve the performance of cellular networks, but it can improve the performance of D2D communication. [22].

A. Abadi in his research related to the management of interference that occurs between D2D communication devices and conventional cellular communication devices. The purpose of this research is to improve network performance in terms of SINR, throughput, and BER. There are two power control schemes used in this study, namely a constant decrease in the interference transmit power and a decrease in the interference power based on the calculation of the average interference value. The result of this research is that the power control method could significantly improve network performance [23].

III. RESEARCH METHOD

This research was conducted by simulating cellular network conditions using the MatLab R2017a application. The simulation carried out in this study observed the QoS parameters in two periods, namely downlink and uplink. In the simulation using a single cell (single macrocell). Within the scope of the macrocell, MUE and D2D pairs will be placed. The scheme that will be carried out was placing 1 (one) MUE device and n D2D pair devices. The QoS parameters that will be observed in this final project were SINR and throughput. In the downlink QoS scenario, the receiver was MUE, while in the uplink QoS scenario, the receiver was eNB. In each scenario, two methods of analysis would be applied, namely the analysis without and using the power control method.

A. Simulation Scheme

To measure the distances between devices several trigonometrics function was used, the functions as follow :

Devices Position Function :

$$UE_x = \cos(\alpha) \times Rad \quad (1)$$

$$UE_y = \sin(\alpha) \times Rad \quad (2)$$

Devices Distances Function :

$$D_{UE \rightarrow BS}(m) = \sqrt{(BS_x - UE_x)^2 + (BS_y - UE_y)^2} \quad (3)$$

$$D_{D2DR \rightarrow BS}(m) = \sqrt{(BS_x - D2DR_x)^2 + (BS_y - D2DR_y)^2} \quad (4)$$

$$D_{D2DT \rightarrow UE}(m) = \sqrt{(UE_x - D2DT_x)^2 + (UE_y - D2DT_y)^2} \quad (5)$$

To calculate the signal to interference ratio (SINR) value use the following functions [24].

Power received by devices (S):

SINR Value in Downlink :

$$SINR_{UE}^{DL}(mW) = \frac{S_{BS>UE}}{\sum_1^k (I_{D2DTk>MUE}) + N} \quad (6)$$

SINR Value in Uplink :

$$SINR_{BS}^{UL}(mW) = \frac{S_{UE>BS}}{\sum_1^k (I_{D2DRk>MUE}) + N} \quad (7)$$

$$SINR (dB) = 10 \times \log(SINR(mW)) \quad (8)$$

Throughput function :

$$C (bps) = B (Hz) \times \log(1 + SINR) \quad (9)$$

B. Simulation Parameters

Before the cellular network system simulation modeling is generated, the parameters of the cellular network system are used as follows [25]:

Table 1. Simulation Parameters

Parameter	Nilai
Macrocell Coverage	1000 m
D2D Devices Coverage	100m
BSs Power	46 dB
UE Power	23dB
Frequency Carrier	1800 MHz
Bandwidth	10 MHz
Noise Thermal	-174 dBm/Hz
Distances UE - BS	100 s.d. 600 m
Distance D2D - BS	600 s.d. 900 m
Natural Noise	4E-11 mW

```

Start
Generate:
BS
UE
D2Dpair
Count:
    Distance:
        UE → BS
        D2D → UE, BS
    Power Gain:
        UE → BS
        BS → UE
    Interferences:
        SINR
End
    
```

Figure 2. Simulation Algorithm to Generate Cellular Ecosystem

```

Start
Generate Cellular Ecosystem
For AC = 1 : D2D Pair
    If d_D2Dpair < 500
        Power Transmit -1
Calculate :
    Interference :
        SINR
        Throughput
End
    
```

Figure 4. Adaptive Power Control Algorithm

C. Power Control Algorithm

1. Fixed Power Control (FPC)

In this schema, the transmission power control of D2D Devices was carried out by constantly lowering the transmit power on the interference devices. Fixed Power Control algorithm could be seen in Figure 3 below.

```

Start
Generate Cellular Ecosystem
For FC = 1 : D2D Pair
    Power Transmit -1
Calculate :
    Interference :
        SINR
        Throughput
End
    
```

Figure 3. Fixed Power Control Algorithm

2. Adaptive Power Control (APC)

In this model, transmission power control was carried. The value presented were the average value of SINR and throughput in five simulations with five samples of D2D devices from each simulation. In the simulation 50 D2D devices were used. The table showed the comparison of the average values of SINR and throughput of the five simulations. The average value of SINR without power control was 34.29 dB. SINR with fixed power control was 34.45 dB, while SINR with adaptive power control was 34.35 dB. It shows that interference management with FPC method has the highest SINR value than APC. With FPC method SINR increased by 0.16 dB while APC increased SINR by 0.06 dB. By lowering the power on D2D devices at a radius of 500 meters from the MUE.

IV. RESULTS AND DISCUSSION

A. Downlink Period

The analysis in this scheme was an analysis carried out from observations on the MUE device in the system. The analysis carried out on the QoS parameters of a cellular network were the SINR value and the throughput value. In the simulation, the number of interferers namely D2D pairs, will be generated gradually increasing and the MUE device remains one device. It was assumed that the frequency used by the MUE device in conventional cellular network communication was the same as the frequency used in D2D communication. The following was a graph of the SINR value against the number of D2D that occurs. The increasing value also occurred in the aspect of throughput. The increase in the highest throughput value using the FPC with an increase of 0.067 Mbps, while the APC has an increase of 0.025 Mbps. Overall, FPC Algorithm has better management than the APC algorithm.

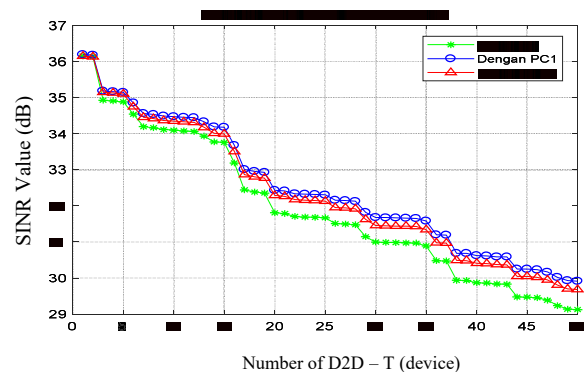


Figure 5. SINR vs D2D Devices in downlink period

Table 2. Average QoS in Downlink Period

No.	Power Control Scenario	SINR (dB)	Throughput (Mbps)
1	Without Power Control	34.29	51.41
2	Fixed Power Control	34.45	51.47
3	Adaptive Power Control	34.35	51.43

Figure 6 was a graph of the SINR value of the MUE in the form of the CDF value after fitting the curve with Matlab processing. Figure 6 showed that in achieving the SINR value of 32 dB the scheme without using the power control method was 51.91%. While the scheme using the fixed power control and adaptive power control was able to improve the SINR value obtained previously by using fixed power control the probability of SINR 32 dB was 39.46%, and adaptive power control the probability is 43.35%. This showed that the fixed power control was able to manage interference better than the adaptive power control, with a decreased probability of the SINR value 32 dB from fixed power control and adaptive power control respectively 11.45% and 8.65% compared to SINR value without using the power control method.

B. Uplink Period

The second simulation scheme were an observation and analysis scheme in the uplink transmission period. In this scheme, we used a network system from the same simulation results as the first scheme. During the uplink period, the device would receive the most interference was the eNB. During the uplink period, apart from MUE transmitting to the eNB, D2D-R devices also transmitted to D2D-T. So the transmission power released by D2D-R will interfere with the eNB. The analysis steps used the same steps as the analysis in the downlink period. The following was a graph of the SINR eNB value against the amount of D2D-R:

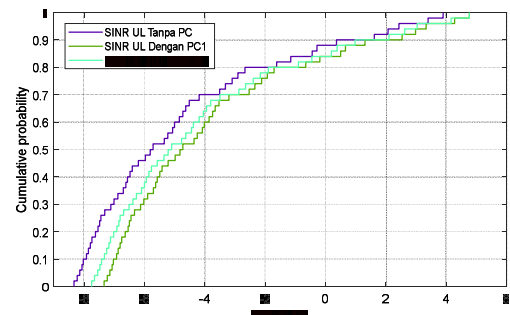


Figure 6. CDF SINR Value Downlink Period

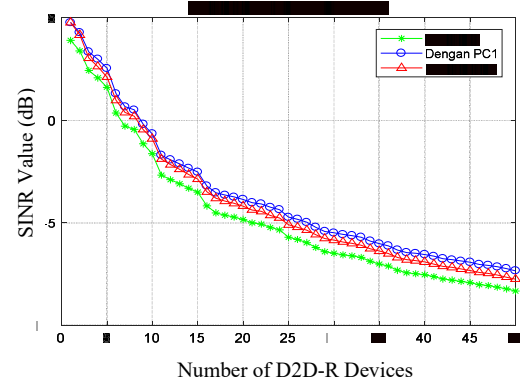


Figure 7. The graph of the SINR eNB value against the amount of D2D-R

After obtaining the QoS parameter values in the cellular network system in each scheme, here were the results of the overall analysis. The following table presented the QoS parameter values, namely SINR and throughput on eNB devices used one MUE device as a transmitter, and 50 D2D devices as interfering.

From Table 3, the SINR and throughput values of the uplink period were obtained from the average results of five simulations with three different interference managements. The highest average SINR value was in interference management with power control 1 of 1.05 dB, an increase of 0.93 dB compared to the SINR value without interference management. While the average value of SINR with interference management power control 2 obtained a value of 0.68 dB, an increased of 0.56 compared to without using interference management. With the increase in the average value of SINR, an increase in the throughput value was obtained. The highest increase in throughput after using interference management with power control method 1, an increase of 5.833 Mbps compared to without using

interference management with a throughput of 10.076 Mbps. While the increase in throughput with the power control method 2 was 3,548 Mbps. So that in the uplink period, the most effective interference management was using the power control method 1. The power control 1 method had an average SINR value and throughput was greater than the power control 2 of 0.37 dB and 2.279 Mbps, respectively.

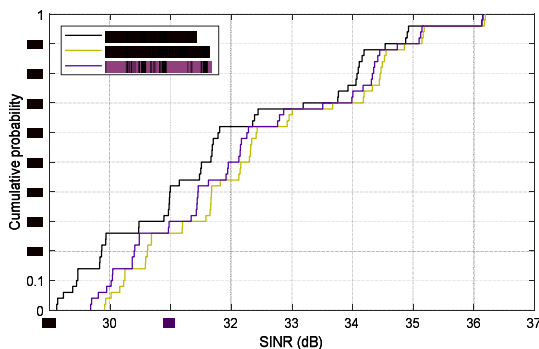


Figure 8. The CDF value of SINR on eNB

Table 3. Average QoS in Uplink Period

No.	Power Control Scenario	SINR (dB)	Throughput (Mbps)
1	Without Power Control	1,21	10.076
2	Adaptive Power Control	2,13	15.903
3	Fixed Power Control	1,68	13.624

Figure 8 showed a graph of the CDF value of SINR on eNB with simulation without and using power control. After fitting the curve, the probability of the SINR value at eNB < 2 dB without using power control was 95.56%, after using power control 1 and power control 2, the probability values were 92.27% and 93.32%, respectively. So that in the uplink period, the fixed power control can improve the SINR by 3.29% and the adaptive power control by 2.24%.

V. CONCLUSION

This study uses the parameters of the distance between devices, pathloss, and the amount of transmission power. Observations of the Quality of Service (QoS) parameters include the SINR value, and throughput. So based on the simulation results and discussion of this study. It can be concluded that

Interference management using the power control method is able to improve the SINR value and increase the throughput value. Power control keeps the overall D2d device transmitting power in the environment. The second power control algorithm is adaptive power control, which controls the transmit power of multiple devices in the vicinity of the MUE. The simulation results showed that the power control CDF analysis scheme was still able to increase the SINR by 11.45% and adaptive power control had an increase of 8.65% in the downlink period. And in the uplink period, the SINR value increased to 3.29% with fixed power control and 2.24% with adaptive power control.

From the simulation results obtained, we can conclude that the proposed algorithm can manage interference and increase QoS value.

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