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Receiver diversity with selection combining for drone communication around buildings at frequency 10 GHz

Andrita Ceriana Eska*
Electrical Engineering Department, University of Jember
Kalimantan Street 37 Kampus Tegalboto, POS 159 Jember, Indonesia
*Corresponding email : andritacerianaeska@gmail.com

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Abstract—The communication network for cellular network keep development. This research analyzed about cellular network was used drone network. The mobile drone used frequency at 10 GHz for communication. The mobile drone moved around buildings. Buildings were used high variation. Base Station placed around building. This research was using macro diversity Base Station for drone communication with some variations was used such as buildings (5m, 15m, 35m, and 45m), modulation (QPSK, 16 QAM, and 64 QAM). Macro diversity mechanism used for that two Base Station. Selection Combining (SC) method was used for that macro diversity mechanism. The modulation communication based from Adaptive Modulation and Coding (AMC). Adaptive Modulation and Coding (AMC) was used Modulation and coding scheme (MCS). Modulation was used QPSK, 16 QAM, and 64 QAM. As the result described signal to noise ratio (SNR) at every node communication, probability MCS, and percentage coverage of drone trajectory. MCS probability for 64 QAM become increased with selection combining method. The percentages coverage of drone trajectory was obtained 77.2% of the first BS, 66.8% of the second BS, and 87.2% with SC method. The communication drone location was used adjustment of high variation with necessity.

Keywords- selection combining; drone; MCS; building;

I. INTRODUCTION

Drone technology keep development. Drone technology was used for security, detection, capture, etc. Many concerns were used drone technology, such as capture, take video, take packet, take sensor, etc. Special necessity for drone communication was used widely coverage communication. The cellular communication network used Base Station (BS). This research used drone communication with cellular network at base station. Many research for communication used microwave and millimeter wave.

Some research was related with super high frequency or extremely high frequency for propagation such as Propagation for mobile communication around tree used OFDM-QAM at 10 GHz [1], propagation from outdoor to indoor with AMC using 10 GHz [2], the communication system caused doppler shift effect around buildings with 10 GHz [3], and outdoor to indoor for path loss model at picocell and femtocell [4]. Some research was related with usage femtocell or picocell such as resource allocation schemes for cognitive LTE-A femtocells [5], code rate was influenced from communication systems at RBS femtocell at street pole lamp [6], and RBS femtocell propagation at street pole lamp used 10 GHz frequency [7].

Some research was related with specific millimeter wave such as 3GPP rural macrocell path loss models for millimeter wave [8], propagation measurement at indoor used millimeter wave for wireless network 5G [9], determination location for mobile station around the building with AoA method at 47 GHz frequency [10], measurement at base station diversity for 5G using millimeter-wave with 73 GHz [11], multipath effect around the building environment for mobile communication was used 47 GHz frequency [12], millimeter wave for 5G communication at small area [13], rural macrocell path loss models for millimeter wave wireless communication [14], propagation was depended with angle for cellular and wireless communication [15], self-backhauling with flexible reuse of the resources for access and backhaul in street scenario with 5G network [16], the millimeter wave network for self-backhauling relay nodes and centralized transmission coordination [17], and performance of in-band self-backhauling with integrated access and backhaul in a real-life street canyon scenario for 5G systems [18].

Amount of BS caused increasingly communication coverages. The communication was used for data transmission, traffic measurement, video, voice, etc. That communication was influenced with propagation. Propagation condition influenced SNR value from communication. That SNR value resulted decision for Adaptive Modulation and Coding (AMC). The research was related with AMC such as AMC around the building environment for mobile station communication at the train [19].

Propagation communication also was influenced from building environment. The high of building caused diffraction mechanism. Some research was related with that diffraction such as mobile communication systems with diffraction propagation around the building environment [20], mobile communication systems was influenced by tree that used Giovanelli Knife Edge method with 2.3 GHz frequency [21], and Cellular Communication Propagation at Drone around Building Environment with Single Knife Edge at 10 GHz [22].

This research described of simulation about drone communication with cellular communication systems. Mobile drone trajectory used horizontal line around building environment. The high drone was used 20 meters. Frequency was used 10 GHz. Atmospheric attenuation was caused oxygen and water vapor. Environment building used high building variations. The communication propagation around building environment was caused diffraction mechanism. Single knife edge method was modeled for diffraction mechanism. Fresnel zone was used for diffraction range value. Analyze this research was used macro diversity with two Base Station (BS), Adaptive Modulation and Coding (AMC), transmitter power 20 dBm, single knife edge method, and selection combining BS. AMC used Modulation and coding scheme (MCS). MCS was used such as QPSK, 16 QAM, and 64 QAM. QPSK modulation was used code rate consist of 1/8, 1/5, 1/4, 1/3, 1/2, 2/3, 3/4, and 4/5. 16 QAM modulation was used code rate consist of 1/2, 2/3, 3/4, and 4/5. 64 QAM modulation was used code rate consist of 2/3, 3/4, and 4/5. Every BS used some Radio Base Station (RBS). That RBS was used for communication propagation at mobile drone. This communication was used uplink condition. As the result was showed consist of LOS and NLOS distances, MCS probability, SNR communication, and coverage percentages at drone trajectory.

II. RESEARCH METHOD

A. Environment Model

Mobile drone moved at horizontal trajectory around building. The high drone was used 20 meters. Building environment was modeled with high building variation. Diffraction mechanism also measurement with Fresnel zone. Fresnel zone used range value for diffraction. Propagation communication was used uplink condition. Transmitter was placed at mobile drone. BS was used some RBS. Figure 1 was modeled communication with one RBS every one BS. The drone communication was used BS 1 and BS 2. Two BS was used macro diversity. Selection combining method was used for macro diversity. The high BS was used 30 meters. That figure was used MATLAB for create simulation.

Figure 2 was showed buildings variation. The percentages of high building variation were used such as 23% of 5 meters, 23% of 15 meters, 24% of 25 meters, 18% of 35 meters, and 12% of 45 meters. The communication propagation caused by high building. Some building was caused diffraction mechanism with NLOS condition. Figure 3 was showed single knife edge method for diffraction mechanism [23]. That method was used this research because that method accordance with building environment.

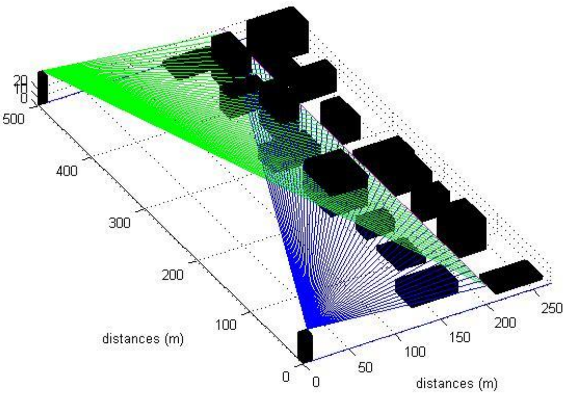

Fig.1. Drone propagation

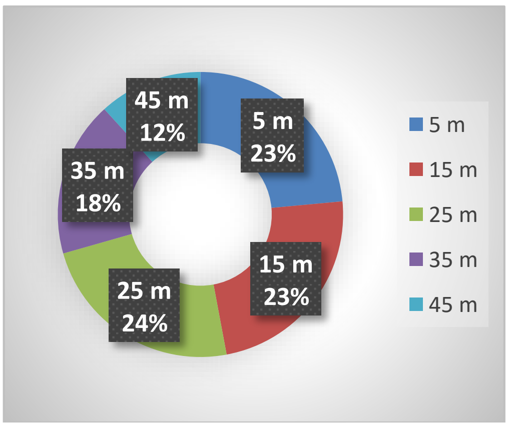

Fig.2. The high building variation

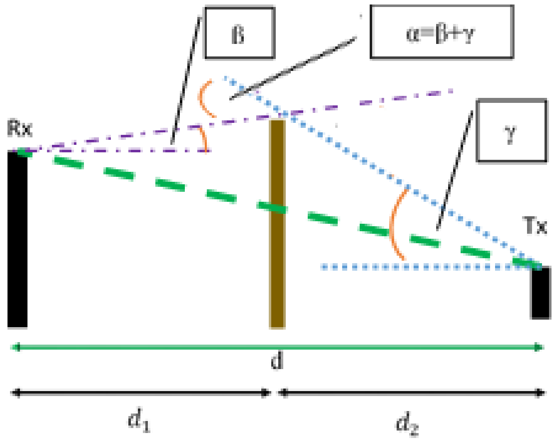

Fig.3. Single Knife Edge Diffraction Model

B. Single Knife Edge Method

Single knife edge method was used for diffraction mechanism. That diffraction was caused high building with NLOS condition. That high building could influence of SNR communication. Fresnel zone was used range value for diffraction. Single knife edge method was showed at equation (1). λ, v, h, d_1, and d_2 parameters showed long wave (m), Fresnel Kirchoff, high of diffraction (m), transmitter distance through node (m), and receiver distance through node (m) [23]. NLOS condition caused decrease SNR value at node of mobile drone trajectory.

$$v = h\sqrt{\frac{d(d_1 + d_2)}{\lambda d_1 d_2}} = \alpha\sqrt{\frac{2d_1 d_2}{\lambda\,(d_1 + d_2)}} \qquad (1)$$

Drone communication system was used Tx with 20 dBm. Uplink condition was used for that communication. Some parameters from equation 1 was showed N, S, and SNR parameters was noise power, signal value, and signal to noise ratio [23]. The equation for SNR was showed at equation 2.

$$SNR = \frac{S}{N} \qquad (2)$$

N parameter was showed at equation 3. K, B, NF, and T parameters were Boltzman constant, bandwidth, noise figure, and standard noise temperature (290ºK) [23]. *NF* value was used 5 dB, and *B* value was used 5 MHz.

$$N = k\,T_o\,B + NF \qquad (3)$$

Equation 4 was showed atmospheric attenuation. The atmospheric attenuation was influenced by oxygen and water vapor [24]. γ and r_o parameters were described gaseous attenuation, and path length (km).

$$A = \gamma r_o\ dB \qquad (4)$$

AMC process was based from modulation and coding scheme (MCS). MCS was used such as QPSK, 16 QAM, and 64 QAM [25]. Modulation of QPSK was used some code rate consist of 1/8, 1/5. 1/4, 1/3, 1/2, 2/3, 3/4, and 4/5. Modulation of 16 QAM was used some code rate consist of 1/2, 2/3, 3/4, and 4/5. Modulation of 64 QAM was used some code rate consist of 2/3, 3/4, and 4/5.

III. RESULT

This section described about mobile drone at horizontal trajectory with high of 20 meters. Transmitter power was used 20 dBm. The communication frequency was used 10 GHz. That frequency was influenced atmospheric attenuation. Mobile drone moved around building environment. That building environment was used high building variation. Diffraction was caused by high building. Single knife edge method modeled diffraction mechanism. NLOS condition was used Fresnel zone. Base station was used two base stations. Every BS contain some RBS. AMC used MCS. MCS was used consist of QPSK, 16 QAM, and 64 QAM. SNR value from communication propagation effected AMC.

Figure 4 showed propagation distance when drone at high of 20 meters. LOS and NLOS condition were caused from propagation communication around building. Some data was resulted such as drone moving at 25 meters was obtained communication distances of RBS1 194.24 meters and RBS2 521.76 meters, drone moving at 100 meters was obtained communication distances of RBS1 217.01 meters and RBS2 452.99 meters, drone moving at 200 meters was obtained communication distances of RBS1 278.29 meters and RBS2 364.97 meters, drone moving at 300 meters was obtained communication distances of RBS1 362.93 meters and RBS2 298.77 meters. That simulation was showed distances change when mobile drone at trajectory around RBS 1 and RBS 2 obtained drone distances change become near or far through RBS.

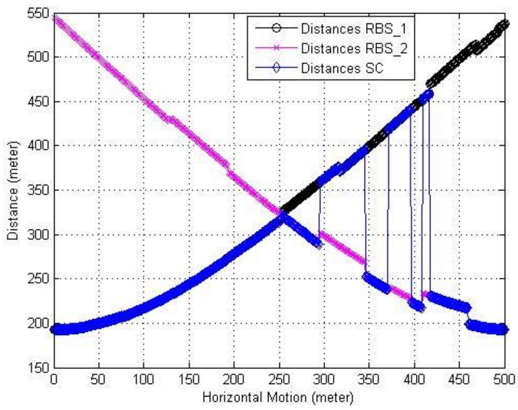

Fig.4. The communication distance from high drone of 20 m

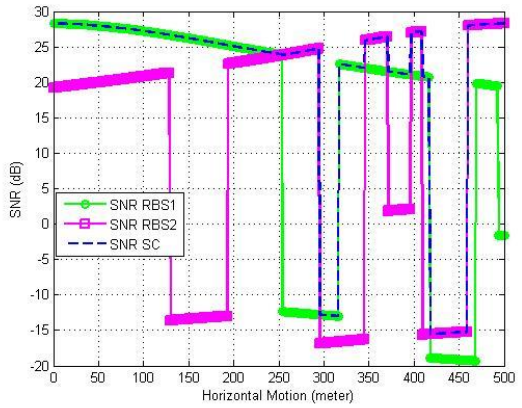

Fig.5. SNR value

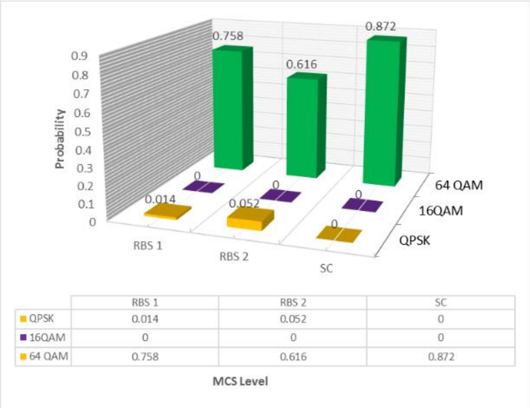

Fig.6. Probability MCS level

Figure 5 showed SNR communication at drone with high 20 meters. SNR value was obtained from RBS 1, RBS 2, and Selection Combining. Some data was resulted such as drone at 25 meters, drone at 100 meters, drone at 200 meters, and drone at 300 meters. When the drone moving at 25 meters was obtained SNR RBS1 28.19 dB, SNR RBS2 19.06 dB, and SNR SC 28.19 dB with MCS 64QAM code rate 3/4. When the drone moving at 100 meters was obtained SNR RBS1 27.22 dB, SNR RBS2 20.83 dB, and SNR SC 27.22 dB with MCS 64QAM code rate 3/4. When the drone moving at 200 meters was obtained SNR RBS1 25.06 dB, SNR RBS2 22.71 dB, and SNR SC 25.06 dB with MCS 64QAM code rate 3/4. When the drone moving at 300 meters was obtained SNR RBS1 -12.82 dB, SNR RBS2 -16.79 dB, and SNR SC -12.82 dB with not coverage condition. Selection combining process was obtained of selected the best SNR from macro diversity BS 1 and BS 2. Some node showed NLOS condition. That condition was caused by high building. That simulation was SNR value when mobile drone at trajectory around RBS 1 and RBS 2 showed SNR value of RBS 1, SNR value of RBS 2, and SNR value with Selection Combining.

Figure 6 showed AMC from MCS level. The communication probability of MSC level was resulted such as MCS at RBS1, MCS at RBS2, and MCS with SC. MCS probability at RBS1 obtained 0.014 for QPSK with 7 nodes, and 0.758 for 64 QAM with 379 nodes. MCS probability at RBS2 obtained 0.052 for QPSK with 26 nodes, and 0.668 for 64 QAM with 308 nodes. MCS probability with SC obtained 0.872 for 64 QAM with 436 nodes. That simulation was MCS determination when mobile drone at trajectory around RBS 1 and RBS 2 showed number probability of nodes with modulation such as QPSK, 16 QAM, and 64 QAM. The result at modulation probability of 64 QAM with Selection Combining Method obtained higher value.

Some data of coverage area percentage from mobile drone was obtained RBS1 77.2%, RBS2 66.8%, and SC 87.2%. Some nodes resulted NLOS condition with decreasingly of SNR value.

IV. DISCUSSION

This research showed drone communication result around building. Frequency communication used 10 GHz. The diffraction effect because building modeled with single knife edge method.

The high of drone was flaying at 20 meters. Macro diversity was used two Base Station. The drone was communicated with one RBS from that Base Station. Selection combining method was used for macro diversity from two RBS. AMC used MCS level that consist of QPSK, 16 QAM, and 64 QAM. Figure 5 was analyzed about SNR value from drone communication. When the drone moving at 25 meters was obtained SNR RBS1 28.19 dB, SNR RBS2 19.06 dB, and SNR SC 28.19 dB with MCS 64QAM code rate 3/4. When the drone moving at 200 meters was obtained SNR RBS1 25.06 dB, SNR RBS2 22.71 dB, and SNR SC 25.06 dB with MCS 64QAM code rate 3/4. That data showed probability for used MCS 64 QAM with selection combining method higher than another.

Figure 6 was analyzed about probability of MSC level such as MCS at RBS1, MCS at RBS2, and MCS with SC. MCS probability for 16 QAM obtained zero point, that caused high SNR was used 64 QAM, and low SNR was used QPSK. That low SNR caused by obstacle from high building. MCS probability with SC obtained 0.872 for 64 QAM with 436 nodes. That data showed increasingly probability of MCS level when used selection combining.

V. CONCLUSION

The conclusion this research from simulation described about mobile drone with cellular communication systems. Mobile drone was flying with high of 20 meters. Drone moved at horizontal trajectory. Frequency communication was used 10 GHz. That frequency was atmospheric attenuation effect. The communication propagation of mobile drone around building environment caused NLOS condition. Diffraction was modelled with single knife edge method. Two Base Station was used for macro diversity mechanism. Mobile drone communicated with one RBS from BS. AMC used MCS level that consist of QPSK, 16 QAM, and 64 QAM. Selection combining method was used for macro diversity from two RBS. That selection combining method was obtained increasingly of MCS probability level for 64 QAM. The coverage area percentages were resulted such as RBS1 obtained 77.2%, RBS2 obtained 66.8%, and SC obtained 87.2%. That percentages were showed the highest value of SC method, and MCS probability with SC obtained 0.872 for 64 QAM with 436 nodes. Some node at mobile drone trajectory was obtained the lowest of SNR value. The communication drone location was used adjustment of high variation with necessity.

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