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The Communication System of Building from Outdoor to Indoor with AMC at 10 GHz

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Abstract—The propagation model of communication systems was used propagation from outdoor to indoor of building. In the inside that building used partition with brick. That propagation condition used downlink condition from mobile station side. The communication frequency used 10 GHz. Some parameter variation was used in this research such as radio base station coverage, mobile station location of building, and code rate communication. The coverage variation of radio base station used femtocell and picocell. As the result described signal to noise ratio (SNR)at every node communication, adaptive modulation and coding (AMC) variation, and coverage area percentage in the building. The modulation and coding scheme (MCS) was used consist of QPSK, 16 QAM, and 64 QAM.

Keywords-picocell; AMC; femtocell; indoor; building

I. INTRODUCTION

The technology of cellular communication keep development. Some research was related with communication systems from outdoor to indoor consist of propagation measurement at indoor used millimeter wave for wireless network 5G [1], and outdoor to indoor for path loss model at picocell and femtocell [2]. Some research was related with usage femtocell or picocell such as resource allocation schemes for cognitive LTE-A femtocells [3], femtocell enhanced multi target spectrum allocation strategy in LTE-A Het Nets [4], code rate was influenced from communication systems at RBS femtocell at street pole lamp [5], and RBS femtocell propagation at street pole lamp used 10 GHz frequency [6].

The diffraction mechanism was caused by the building. Some research was related with that diffraction such as mobile communication systems with diffraction propagation around the building environment [7], and mobile communication systems was influenced by tree that used Giovanelli Knife Edge method with 2.3 GHz frequency [8]. Some research was related with OFDM at mobile communication systems such as OFDM and OFDMA with DFT based [9], edge windowing for communication systems with OFDM based [10], and algorithm allocation for OFDM systems [11].

Millimeter wave can be used at the communication systems. Some research was related with millimeter wave such as determination location for mobile station around the building with AoA method at 47 GHz frequency [12], multipath effect around the building environment for mobile communication was used 47 GHz frequency [13], millimeter wave for 5G communication at small area [14], millimeter wave communication of 5G at wireless network [15], propagation was depended with angle for cellular and wireless communication [16], Propagation for mobile communication around tree used OFDM-QAM at 10 GHz [17], self-backhauling with flexible reuse of the resources for access and backhaul in street scenario with 5G network [18], the millimeter wave network for self-backhauling relay nodes and centralized transmission coordination [19], and performance of in-band self-backhauling with integrated access and backhaul in a real-life street canyon scenario for 5G systems [20].

This research described about the communication systems from outdoor to indoor in the building with adaptive modulation and coding (AMC). Frequency communication used 10 GHz. That frequency was influenced by atmospheric attenuation such as oxygen and water vapor. The coverage variation of radio base station (RBS) used femtocell and picocell. The mobile station was located with distance variation at every floor in the building. The partition at every room was used by brick. The propagation of communication systems was influenced by permeability of brick. As the result was described adjustment of AMC at communication, signal to noise ratio (SNR), and coverage area percentage. Modulation and coding scheme (MCS) was based from threshold modulation value. That modulation and coding scheme was used for AMC. Modulation and coding scheme was used

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consist of QPSK, 16 QAM, and 64 QAM. The research was related with this research such as AMC around the building environment for mobile station communication at the train [21].

The propagation communication was influenced by atmospheric attenuation and brick permeability attenuation. The communication frequency used 10 GHz. RBS femtocell was located at outdoor, and mobile station was placed at indoor. The variation of location mobile station was placed at every brick partition. Diffraction mechanism was propagated from transmitter to receiver. That diffraction mechanism was modelled with single knife edge method.

II. RESEARCH METHOD

A. Environment Model

The transmitter location was existed at outdoor the building. The RBS coverage variation was used consist of femtocell and picocell. RBS was placed at near street with high of 30 meter, showed at Figure 1. That figure was showed the communication propagation from transmitter to receiver at inside the building. Mobile station was showed with node at every brick partition and every floor. The diffraction mechanism was caused by the building. The diffraction was modelled by single knife edge method [22]. The detail of single knife edge method was showed at Figure 2 [21].

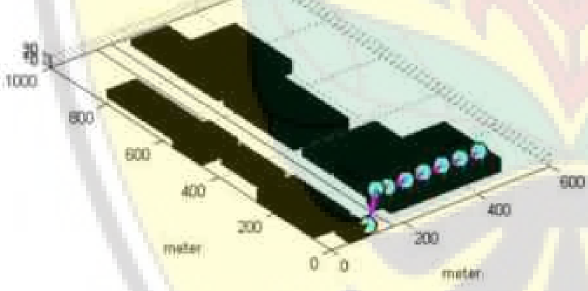

Fig. 1. The propagation of model with tree obstacle

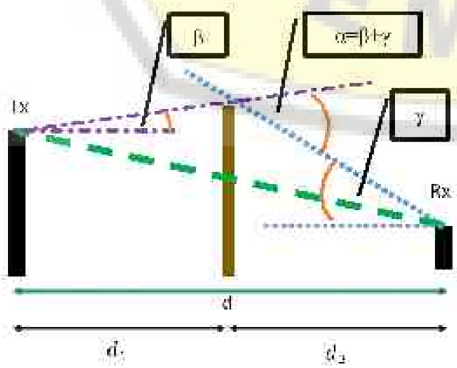

Fig. 2. Single Knife Edge Diffraction Model

B. Knife Edge

Equation for single knife edge method could be seen at equation (1). *v* parameter was represented as Fresnel Kirchoff [22]. λ parameter was represented as long wave (m), h parameter was represented as high of diffraction (meter), d_1 parameter was represented as transmitter distance through node (meter), and d_2 parameter was represented as receiver distance through node (meter).

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

Figure 3 was showed communication propagation at the first building. That building was used three floors. Every floor was available of rooms. That room was partition with brick. That brick was used permeability of 3.4.

The communication system from outdoor to indoor at another the building was showed at Figure 4. The second building was modeled with more partition and more floor than the first building. SNR value was showed at equation (2). Transmitter power of femtocell was used 14 dBm. *s* parameter was signal value, *N* was noise power, and SNR value was signal to noise ratio [22].

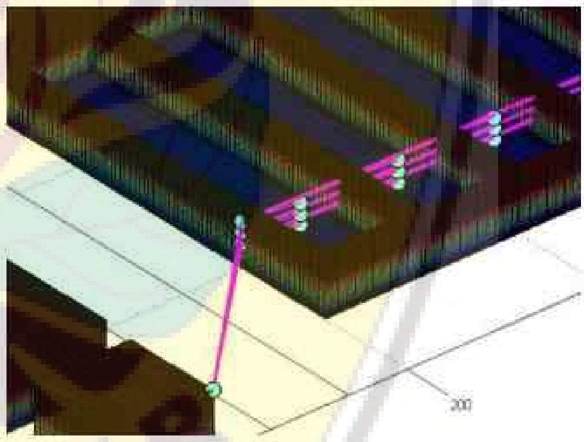

Fig. 3. The outdoor to indoor propagation at the first building

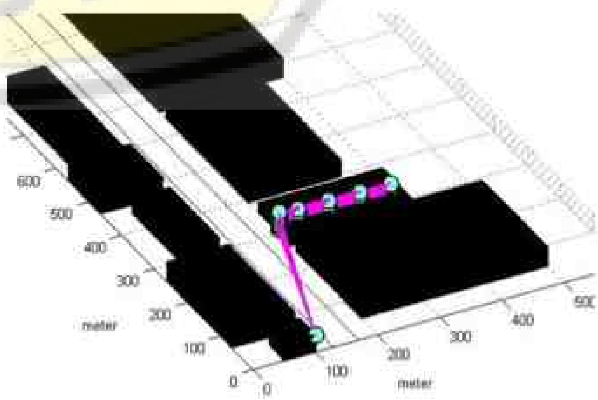

Fig. 4. The outdoor to indoor propagation at the second building

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$$SNR = \frac{S}{N} \qquad (1)$$

N parameter was showed at equation (3). *K* parameter was Boltzman constant, *B* parameter was bandwidth, *F* parameter was noise figure, T parameter was standard noise temperature (290°K) [22]. *F* value was used 5 dB, and *B* value was used 3 MHz [23].

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

The attenuations of communication were caused by atmospheric attenuation, and material permeability attenuation. Atmospheric attenuations were influenced by oxygen and water vapor, could be observed at equation (4) [24]. γ and r_o parameter 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. AMC process at communication propagation was based from threshold modulation and coding scheme.

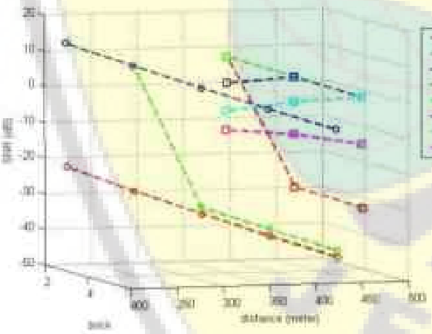

Fig. 5. SNR femtocell

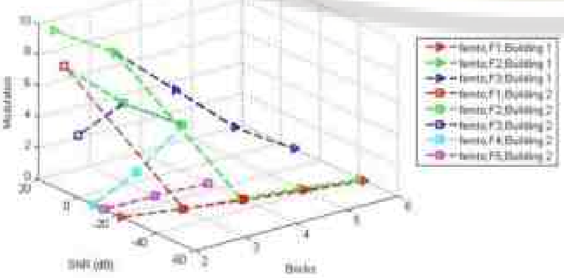

Fig. 6. AMC modulation femtocell at the building

III. RESEARCH RESULT

This section described about research result the communication of building from outdoor to indoor. The communication frequency was used of 10 GHz. That frequency was influenced with attenuation atmospheric from oxygen and water vapor. Some analysis variations were used consist of partition, floor at the building, cell area, and MCS. Cell area of RBS was used such as femtocell and picocell. MCS was used consist of QPSK, 16 QAM, and 64 QAM. The propagation attenuation through building was influenced by brick permeability of every partition in the building.

Figure 5 showed SNR value for femtocell communication systems. F1 described the first floor, F2 described the second floor, F3 described the third floor, F4 described the fourth floor, and F5 was described the five floor. The high of each floor was used 5 meter. Figure 6 showed AMC from modulation and coding scheme when used femtocell communication systems. That figure showed communication propagation of building when communication was used femtocell. Number 1 until number 15 was described modulation and coding scheme variation such as number 1 of QPSK code rate 1/8, number 2 of QPSK code rate 1/5, number 3 of QPSK code rate 1/4, number 4 of QPSK code rate 1/3, number 5 of QPSK code rate 1/2, number 6 of QPSK code rate 2/3, number 7 of QPSK code rate 3/4, number 8 of QPSK code rate 4/5, number 9 of 16 QAM code rate 1/2, number 10 of 16 QAM coderate 2/3, number 11 of 16 QAM code rate 3/4, number 12 of 16 QAM code rate 4/5, number 13 of 64 QAM code rate 2/3, number 14 of 64 QAM code rate 3/4, and number 15 of 64 QAM code rate 4/5. The First building was used three floors. The second building was used five floors. Every floor in the first building was used five partitions, and the second building at every floor was used three partitions. That partition used bricks. Some data was obtained at the first building such as the second floor at the first partition with distance of 222.63 meter and AMC of 16 QAM code rate 2/3obtained SNR 12.08 dB, and the third partition with distance of 322.59 meter obtained SNR -31.41 dB. The third floor of the first partition with distance of 222.09 meter and AMC of 16 QAM code rate 2/3 obtained SNR 12.1 dB, and the third partition with distance of 322.05 meter and AMC of QPSK code rate 1/2 obtained SNR 2.07 dB. Some data was obtained at the second building such as the second floor of the first partition with distance of 396.82 meter and AMC of QPSK code rate 4/5 obtained SNR 7.06 dB, and the third partition with distance of 496.77 meter and AMC of QPSK code rate 1/4 obtained SNR -1.69 dB. The third floor of the first partition with distance of 396.57 meter and AMC of QPSK code rate 1/3 obtained SNR -0.37 dB, and the third partition with distance of 496.52 meter and AMC of QPSK code rate 1/4 obtained SNR -1.69 dB.

Figure 7 showed SNR value for picocell

communication systems. Figure 8 showed AMC from modulation and coding scheme for picocell at the building. That figure showed the communication propagation for two building when communication was used picocell. Some data was obtained at the first building such as at the second floor of the first partition with distance of 222.63 meter and AMC of 64 QAM coderate 4/5 obtained SNR 21.08 dB, and the third partition with distance of 322.59 meter obtained SNR -22.40 dB. The third floor of the first partition with distance of 222.09 meter and AMC of 64 QAM coderate 4/5 obtained SNR 21.1 dB, and the third partition with distance of 322.05 meter and AMC of 16 QAM coderate 1/2 obtained SNR 11.07 dB. Some data was obtained at the second building such as at the second floor of the first partition with distance of 396.82 meter and AMC of 64 QAM coderate 2/3 obtained SNR 16.06 dB, and the third partition with distance of 496.77 meter and AMC of QPSK coderate 4/5 obtained SNR 7.3 dB. The third floor of the first partition with distance of 396.57 meter and AMC of 16 QAM coderate ½ obtained SNR 8.63 dB, and the third partition with distance of 496.52 meter and AMC of QPSK coderate 4/5 obtained SNR 7.3 dB.

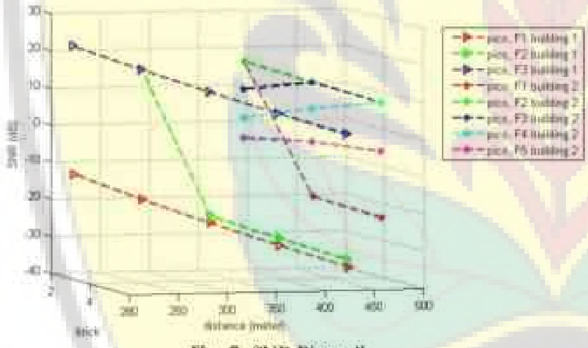
Fig. 7. SNR Picocell

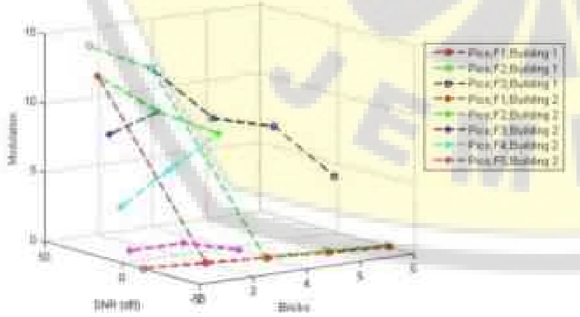
Fig. 8. AMC modulation picocell at the building

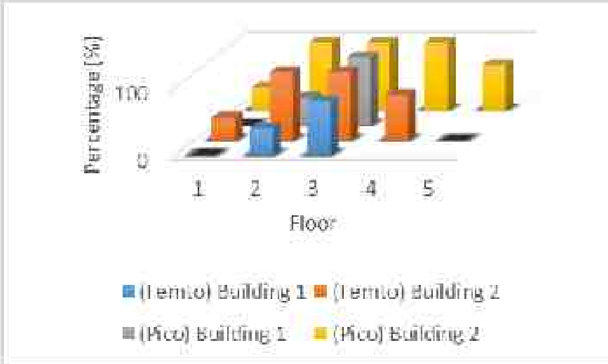

Fig. 9. Percentage coverage area for femtocell and picocell

Figure 9 showed percentage of coverage area at the second building with femtocell and picocell. That figure described percentage of coverage area at the first floor less than other floors. That effect was caused by diffraction through the building. Diffraction at this research was modelled with single knife edge method. The percentage of coverage area for femtocell was consist of the first building of the second floor obtained 40% and the third floor obtained 80%, the second building of the second floor obtained 100% and the third floor obtained 100%. The percentage of coverage area for picocell was consist of the first building of the second floor obtained 40% and the third floor obtained 100%, the second building of the second floor obtained 100%, and the third floor obtained 100%.

IV. DISCUSSSION

This section described about discussion from research result. This research analyzed communication of building from outdoor to indoor. Every partition was caused permeability of brick. The coverage communication was used femtocell and picocell. The communication model was used the building environment, so that propagation method for obstacle was used single knife edge method. AMC process was based from MCS such as QPSK, 16 QAM, and 64 QAM. The higher location of mobile station was placed in the inside building but still lowerthan radio base station location, so the SNR value will be increase. The condition coverage at radio base station was used such as femtocell and picocell. Some data was obtained for femtocell condition at the first building such as the second floor of the first partition with 16 QAM coderate 2/3 obtained SNR 12.08 dB and the third partition obtained -31.41 dB, the third floor of first partition with 16 QAM coderate 2/3 obtained SNR 12.1 dB and the third partition with QPSK coderate 1/2 obtained 2.07 dB. Some data was obtained for picocell condition at first building such as the second floor of the first partition with 64 QAM coderate 4/5 obtained SNR 21.08 dB and the third partition obtained -22.40 dB, the third floor of the first partition with 64 QAM coderate 4/5 obtained SNR 21.1 dB and the third partition with 16 QAM coderate ½ obtained 11.07 dB.

V. CONCLUSION

This section was described research conclusion about communication systems of building from outdoor to indoor with AMC at 10 GHz. That frequency was influenced by atmospheric attenuation. The propagation through building was obstacle with brick permeability at every partition in the inside building. That obstacle was caused by diffraction mechanism. That diffraction was modelled by single knife edge method. The cell variation was used picocell and femtocell. SNR value was obtained picocell more high than femtocell. The higher location of mobile station at the building but still lowerthan radio base station location, so theSNR will be increase. Decrease of SNR was caused by brick partition attenuation and communication diffraction. AMC process used modulation and coding scheme with high threshold such as femtocell of 16 QAM coderate 2/3, and picocell 64 QAM coderate 4/5.

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