The Effects of AMC-AMS to Mobile WiMAX System Quality

Nur Andini
Post Graduate Faculty
Telkom Institute of Technology
Bandung, Indonesia
andini_dhine@yahoo.com

Rina Pudji Astuti
Post Graduate Faculty
Telkom Institute of Technology
Bandung, Indonesia
rpa@ittelkom.ac.id

A. Ali Muayyadi
Electro and Communication Faculty
Telkom Institute of Technology
Bandung, Indonesia
aly@ittelkom.ac.id

Abstract*— The movement of the users may decrease the quality of the information signal because this movement can affect the channel propagation conditions in unpredictable manner. This case can be occured on mobile WiMAX (IEEE 802.18m) system. Mobile WiMAX is able to serve users with high mobility. The capability of the system to serve users with high mobility should be balanced with a quality of the information signal. To overcome this problem, AMC (Adaptive Modulation and Coding) can be applied. Applying AMC technique, the quality of the information signal can be maintained. Another way to overcome these problems is the application of different types of MIMO or AMS (Adaptive MIMO Switching). Implementation of combination techniques of AMC and AMS in mobile WiMAX systems was able to improve system performance in terms of BER and SNR. When the user velocity was 3 km/hr, to achieve a BER of 10^{-3} with AMC-AMS system required a SNR of 55.37 dB. When the uservelocity of 60 km/hr, to achieve a BER of 10^{-3} with AMC-AMS system required a SNR of 58.47 dB.

***Keywords-** mobile WiMAX, AMC, AMS, user velocity, BER, and SNR*

I. INTRODUCTION

Mobile IEEE 802.18m is one of the mobile WiMAX that is able to serve users with high mobility both at low and high data rate. The capability of the system to serve users with high mobility should be balanced with a quality of the information signal. The movement of the users may decrease the quality of the information signal because this movement can affect the channel propagation conditions in unpredictable manner. To overcome this problem, AMC can be applied. AMC is a technique to change the channel coding and mapping techniques according to the condition of propagation channel. Applying AMC technique, the quality of the information signal can be maintained. Another way to overcome this problem, AMS can be appied. AMS is a technique to change the type of MIMO according to the condition of propagation channel. Applying AMS technique, system is able to change the type of MIMO according to the condition of channel propagation.

Combination of AMC and AMS can improve system performance in term of quality (BER and SNR). Not only combination AMC and AMS that can improve system quality but combination of AM (Adaptive Modulation) and AMS also can improve system quality. Combination of AM and AMS improved system E_b/N_o up to ±1.5 dB [2].

This research investigated the effects of AMC and AMS combination to mobile WiMAX (IEEE 802.16m) system. In this research, MIMO 4x4 scheme and SOFDMA (Scalable Orthogonal Frequency Division Multiple Access) were applied. The effects of AMC and AMS combination was performed by simulation to generate graphs of BER against SNR.

II. AMC (ADAPTIVE MODULATION AND CODING)

AMC is an adaptive modulation and coding technique that is implemented to mitigate the fading channels. In this technique, there are many choices of channel coding and mapping used according to channel conditions. To overcome the change of channel conditions, system may change channel coding and mapping too.

At the transmitter, there is power control. This power control is functioning to control the power of signal (P_t). The signal will be sent through a channel with variation of SINR, so the transmitter must be able to transmit a signal with data rate adapted to the condition of channel propagation. If the condition of channel propagation is good, the signal will be sent with high data rate. However, the condition of channel propagation is poor, the signal will be sent with low data rate. At the receiver, channel estimation predicts the condition of channel propagation. The Channel Estimation block output will be entered to the AMC Controller. With this feedback, transmitter can know the receiver SINR (γ_r). Transmitter needs to know the channel SINR (γ) by dividing the receiver SINR to transmit power (P_t) according to (1).

$$\gamma_r = P_t \gamma \qquad (1)$$

III. System Model of Mobile WiMAX with AMC-AMS

A. *Scenario of Downlink Network*

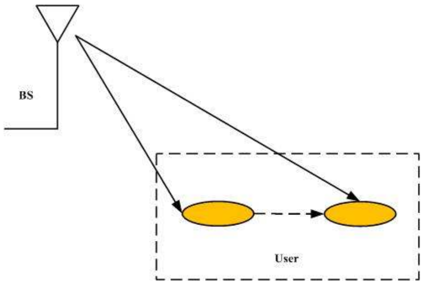


Figure 1. Downlink scenario of mobile WiMAX

This scenario shows downlink communication of mobile WiMAX system with BS in the form of ABS (Advanced Base Station). ABS is BS on IEEE 802.16m that is able to serve users of mobile WiMAX with IEEE 802.16e standard and IEEE 802.16m standard. Fig. 1 shows the movement of mobile mobile WiMAX user with a certain velocity. The movement of user allows the change of propagation channel conditions. Therefore, the system should be able to change channel coding or mapping techniques that will be applied according to the conditions of channel propagation. On the other hand, many types of MIMO also can be applied.

Performance parameters were be observed in the term of BER and SNR graphically. The mathematical model of the relationship between BER against SNR is shown in (2) for QPSK and (3) for M-QAM [6].

$$P_b \approx Q(\sqrt{2\gamma_b}) \quad (2)$$

$$P_b \approx \frac{4}{Log_2 M} Q\left(\sqrt{\frac{3\gamma_b Log_2 M}{M-1}}\right) \quad (3)$$

B. *AMC and AMS*

In this research, AMC and AMS with Threshold Algorithm was applied as Fig. 2. Selection of channel coding, mapping, and the type of MIMO that will be applied is based on the channel SNR. This SNR was a reference (threshold) SNR that was obtained from each scenario with different channel coding, mapping, and types of MIMO. There were sixteen scenarios that were simulated to obtain their channel SNR for each user velocity. Before simulation of system with AMC and AMS techniques was done, simulation of system without these techniques had been done to achieve threshold SNR. On each scenario, threshold SNR was determined when BER of 10^{-3}.

In Fig. 2, output of SOFDMA was consist of four signals based on the number of antennas. This signals are shown in (4). When the signals are propagated, the signals are affected by channel with Rayleigh distribution and AWGN (Additive White Gaussian Noise). This process is shown in (5). H is a channel matrix and N is AWGN matrix, each matrix is shown in (6) and (7). In receiver, the signals are received by four antennas as in (8).

$$S = [s_1 \quad s_2 \quad s_3 \quad s_4] \quad (4)$$

$$R = S * H + N \quad (5)$$

$$H = \begin{bmatrix} h_{1,1} & h_{1,2} & h_{1,3} & h_{1,4} \\ h_{2,1} & h_{2,2} & h_{2,3} & h_{2,4} \\ h_{3,1} & h_{3,2} & h_{3,3} & h_{3,4} \\ h_{4,1} & h_{4,2} & h_{4,3} & h_{4,4} \end{bmatrix} \quad (6)$$

$$N = [n_1 \quad n_2 \quad n_3 \quad n_4] \quad (7)$$

$$R = [r_1 \quad r_2 \quad r_3 \quad r_4] \quad (8)$$

AMC-AMS controller determines channel coding, mapping, and the type of MIMO which will be applied. AMC-AMS controller receives channel SNR. This research implemented AMC and AMS with Threshold Algorithm, so the AMC-AMS controller worked with comparing SNR with threshold SNR. After that, AMC-AMS controller determined the channel coding, mapping, and the type of MIMO would be applied.

Determination of channel coding, mapping, and type of MIMO consists of:

1. Comparing the channel SNR obtained with the reference threshold SNR.
2. If the channel SNR ≤ threshold of SNR, AMC-AMS controller will select channel coding, mapping, and type of MIMO that is the same as previous scenario. This scenario is more resistant to the propagation channel.
3. If the channel SNR > threshold of SNR, AMC-AMS controller will select channel coding, mapping, and type of MIMO that is not the same as previous scenario.

Fig. 3 illustrates AMC-AMS algorithm:

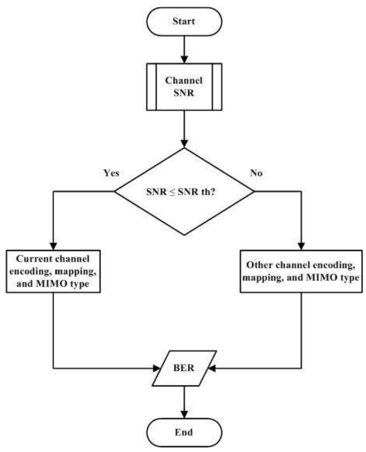


Figure 3. Flow chart of AMC-AMS with Threshold Algorithm

C. MIMO 4x4 Scheme

In this research, MIMO 4x4 scheme was applied. This scheme was based on MIMO scheme of mobile WiMAX. In this case, the number of each trasmit and receive antenna were 4. Fig. 4 illustrates the MIMO 4x4 scheme in this research. The matrix of this MIMO scheme is shown in (6).

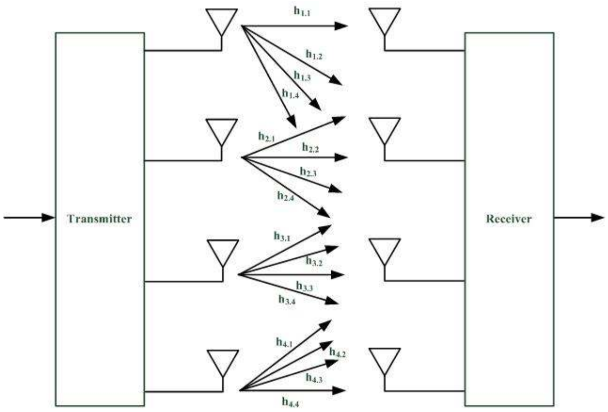


Figure 4. MIMO 4x4 scheme

D. ITU TDL (International Telecommunication Union Taped-Delay-Line) Channel

In this research, channel model of mobile WiMAX was applied. This channel model is ITU TDL channel that has six taps and each tap is Rayleigh distributed. Fig. 5 shows the TDL ITU channel model that is applied.

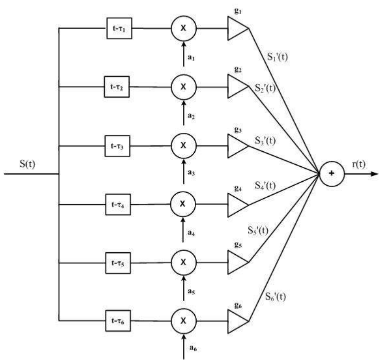


Figure 5. ITU TDL channel model

IV. SYSTEM PERFORMANCE

This section discusses the performance of downlink mobile WiMAX system with AMC and AMS or without and AMS. System with AMC and AMS used some channel coding, mapping, and the type of MIMO. System performance obtained from the BER against SNR graph. The determination was done by observing the effect of user velocity with single user. The variation of user velocities were 3 km/hr and 60 km/hr.

A. Parameter of Simulation

TABLE I. PARAMETER OF SIMULATION

System	Mobile WiMAX with IEEE 802.16m standard
Frequency	2,3 GHz
Channel coding	Convolutional Code ½ dan Convolutional Turbo Code 1/3
Interleaver	Matrix Interleaver
Mapping	QPSK, 16-QAM, 64-QAM, dan 256 QAM
Type of MIMO	SM 4x4 and SFBC 4x4 with code rate ½
Scalable OFDMA	128 and 2048 with cyclic prefix 1/8
Propagation channel	6-tapped Rayleigh fading and AWGN
User velocity	3 km/hr and 60 km/hr

TABLE II. SUBCARRIER ELECTION OF USER VELOCITY

User velocity (km/hr)	Number of subcarrier	
	MIMO SM	MIMO SFBC
3	2048	2048
60	128	128

TABLE III. DETECTOR ELECTION OF EACH MAPPING

Mapping	Detektor
QPSK	*Maximum Likelihood*
16-QAM	*Zero Forcing*
64-QAM	*Zero Forcing*
256-QAM	*Zero Forcing*

B. System Performance when User Velocity of 3 km/hr

In this sub-section, the performance of mobile WiMAX system on downlink communication with single user that is affected by the user velocity of 3 km/hr is shown. Fig. 6 shows the system performance with different mapping (QPSK, 16-QAM, 64-QAM and 256-QAM) while TABLE IV shows the SNR of mobile WiMAX system to achieve a BER of 10^{-3}. After the implementation of AMC and AMS techniques, system performance is shown in Fig. 7. Fig. 7 shows the amount of SNR required to achieve BER of 10^{-3} is 55.37 dB.

978-1-4673-4550-7/12/$31.00 ©2012 IEEE

TABLE IV. PERFORMANCE OF MOBILE WIMAX SYSTEM WHEN USER VELOCITY OF 3 KM/HR AND BER OF 10^{-3}

Mapping	SNR (dB)			
	SFBC-CTC	SFBC-CC	SM-CTC	SM-CC
QPSK	8,883	14,2	16,45	20,27
16-QAM	32,08	37,43	40,73	50,64
64-QAM	42,38	49,21	51,95	56,16
256-QAM	47,12	53,16	56,62	59,67

TABLE V. PERFORMANCE OF MOBILE WIMAX SYSTEM WHEN USER VELOCITY OF 60 KM/HR AND BER OF 10^{-3}

Mapping	SNR (dB)			
	SFBC-CTC	SFBC-CC	SM-CTC	SM-CC
QPSK	8,1	11,54	14,15	17,09
16-QAM	38,29	41,94	46,87	50,97
64-QAM	46,39	52,63	55,49	61,07
256-QAM	52,79	55,6	60,68	62,13

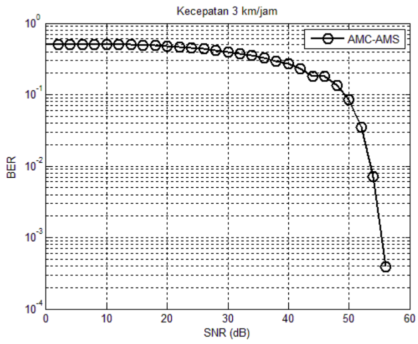


Figure 7. Performance of mobile WiMAX with AMC and AMS when user velocity of 3 km/hr

After implementation of AMC and AMS, system performance was increased. This performance was better than the performance of some scenarios that required greater SNR. It's because system chose the next channel coding, mapping, and type of MIMO according to the condition of propagation channel. On the other scenarios, these techniques decreased system performance.

C. System Performance when User Velocity of 60 km/hr

In this sub-section, the performance of mobile WiMAX system on downlink communication with single user that is affected by the user velocity of 60 km/hr is shown. Fig. 8 shows the system performance with different mapping (QPSK, 16-QAM, 64-QAM and 256-QAM) while TABLE V shows the SNR of mobile WiMAX system to achieve a BER of 10^{-3}.

Fig. 9 shows the system performance after the implementation of AMC and AMS techniques. Fig. 9 shows SNR required to achieve BER of 10^{-3} is 58.47 dB. Implementating of AMC and AMS increased system performance for some scenarios that required the greater SNR. It's because of the capability of system to choose the channel coding, mapping, and type of MIMO.

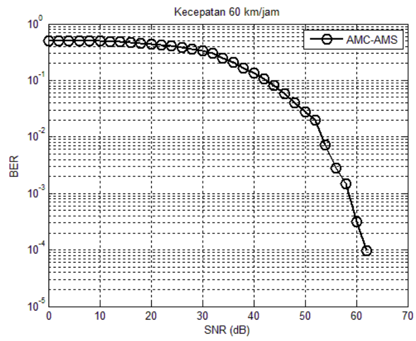


Figure 9. Performance of mobile WiMAX with AMC and AMS when user velocity of 60 km/hr

V. CONCLUSIONS

After conducting some experiments about AMC-AMS implementation on mobile WiMAX, I can conclude that implementation of the combination techniques of AMC and AMS increased system quality for several scenarios, although in several scenarios the combination of these techniques decreased system quantity. When the velocity of the user was 3 km/hr and BER of 10^{-3}, the system with the combination techniques of AMC and AMS required SNR of 55.37 dB. When the velocity of the user was 60 km/hr and BER of 10^{-3}, the system with the combination techniques of AMC and AMS required SNR of 58.47 dB.

ACKNOWLEDGMENT

I thank my parents, Mohamad Kasim and Siti Umrona, for supporting in my life. I thank my advisors, Dr. Rina Pudji Astuti and A. Ali Muayyadi, Ph.D., for helping, advicing, and supervising.

REFERENCES

[1] J. G. Andrews, A. Ghosh, and R. Muhamed, Fundamentals of WiMAX Understanding Broadband Wireless Networking. United States: Prentice Hall, 2007.

[2] H. S. Azis, Analisis Performansi Teknik AMS dan AM pada Sistem MIMO-OFDM (IEEE 802.16e) untuk Kanal SUI-2. Bandung: Institut Teknologi Telkom, 2009.

[3] R. Efendi, Limited Feedback Precoding dan MIMO Spatial Multiplexing untuk Aplikasi 802.16e. Bandung: Institut Teknologi Telkom, 2007.

[4] WiMAX Forum, Mobile Release 1.0 Channel Model. New York: WiMAX Forum, 2008.

[5] WiMAX Forum, Mobile WiMAX – Part I: A Technical Overview and Performance Evaluation. New York: WiMAX Forum, 2006.

[6] A. Goldsmith, Wireless Communications. Cambridge: Cambridge University Press, 2005.

[7] H. Shinsuke and R. Prasad, Multicarrier Techniques for 4G Mobile Communications. London: Universal Personal Communication, 2003.

[8] IEEE, 802.16TM IEEE Standard for Local and Metropolitan Area Networks, Part 16: Air Interface for Broadband Wireless Access Systems. New York: 3 Park Avenue, 2009.

[9] IEEE. IEEE 802.16m System Description Document (SDD). New York: IEEE, 2009.

[10] M. Mandal and A. Asif, Continuous and Discrete TIme Signals and Systems. Cambridge: Cambridge University Press, 2007.

[11] C. Mehlfuhrer, S. Caban, and M. Rupp, Experimental Evaluation of Adaptive Modulation and Coding in MIMO WiMAX with Limited Feedback, EURASIP Journal on Advances in Signal Processing, pp. 12, 2008.

[12] J. Yang, A. K. Khandani, and N. Tin. Adaptive Modulation and Coding in 3G. Ontario: University of Waterloo, 2002.

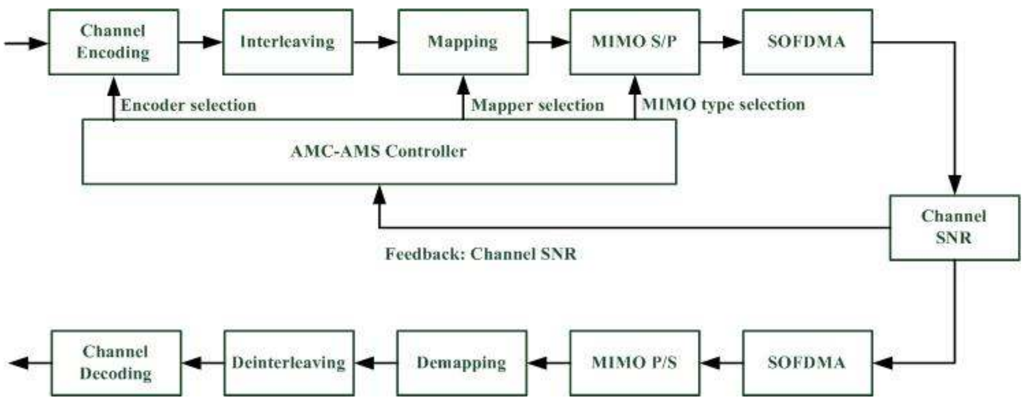
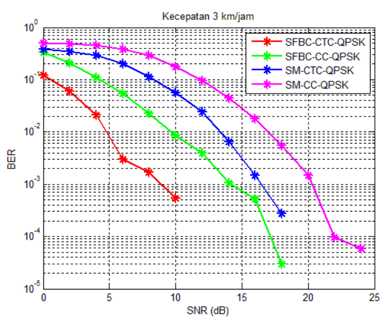
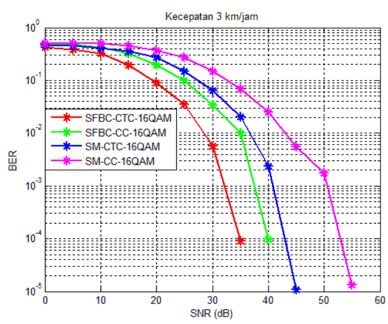


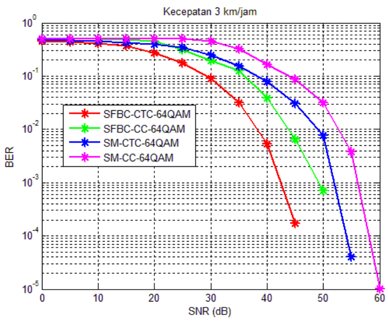
Figure 2. AMC-AMS model for simulation [1]



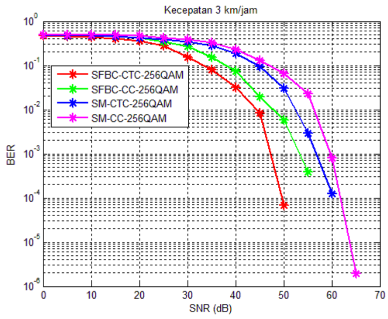
(a)



(b)

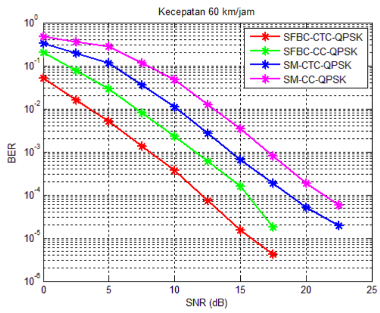


(c)

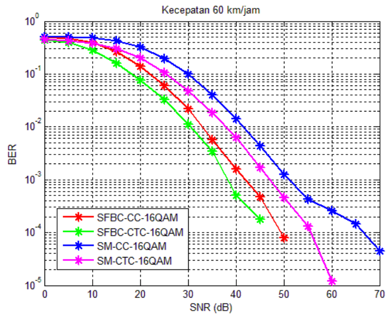


(d)

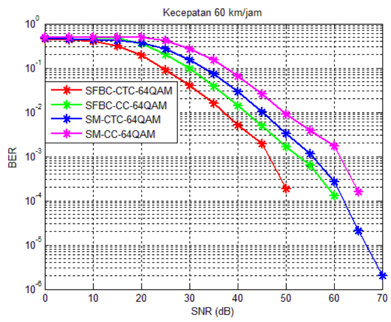
Figure 6. Performance of mobile WiMAX system with mapping (a) QPSK, (b) 16-QAM, (c) 64-QAM, and (d) 256-QAM when user velocity 3 km/hr



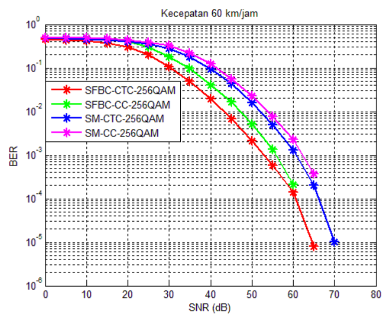
(a)



(b)



(c)



(d)

Figure 8. Performance of mobile WiMAX system with mapping (a) QPSK, (b) 16-QAM, (c) 64-QAM, and (d) 256-QAM when user velocity 60 km/hr