SNR Improvement Employing Dynamics Beamforming Based on Angle of Arrival for Mobile WiMax IEEE 802.16e

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Abstract *- **The development of telecommunication technology and services is very rapid. One of telecommunication technology that is being developed is WiMax (Worldwide Interoperability for Microwave Access). The advantages of WiMax is it possess much range and can operate in non - LOS conditions. So it fits implemented in Indonesia to accelerate the internet penetration. Some features of WiMax technology is higher bandwidth and further range/area. SNR Improvement is The effort to increase the range and improve the BER (Bit Error Rate). In this paper, we propose the dynamics beamforming algorithm to improve SNR in mobile WiMax. The algorithm will desire the best beamwidth and number of beam based on Angle of Arrival (AoA) of MS in the cell. In this paper, we also evaluate the algorithm with compared to switched beam antenna. The simulation result shows that dynamics beamforming have SNR performance better than switched beam antenna about 7dB.***

Keywords: Dynamics beamforming, AoA, Mobile WiMax, SNR

I. INTRODUCTION

WiMax technology is one of the wireless broadband technology. WiMax systems are expected to provide broadband access services to residential and corporate customers efficiently and economically. WiMax intended as an alternative to wired technologies (such as cable modem, DSL and T1/E1 links) to provide broadband access to the customer's location. Mobile WiMax use OFDMA orthogonal Frequency Division Multiple Access (OFDMA) air interface to increase the performance in the Non Lighht of Sight environment[1].

The very important faeature of WiMax is adaptive modulation technology. In this technology, the system uses different modulation technique for certain SNR to achieve the best performance. So, at the poor signal condition, WiMax System can still work well[2].

Besides using the adaptive modulation techniques, to improve performance of WiMax System is by SNR improving. Higher of the SNR will provide the wider range and the better BER. The techniques to improve the SNR are power control and beamforming. In this paper, we propose the dynamic beamforming algorithm to increase SNR value. The dynamic beam is one of the types of smart antennas. There are two types of smart antenna, i.e switched beam and adaptive / dynamic beam. At switched beam, the antenna will turn on the beam when there is MS in this area, and otherwise, when there is no user, the antenna will be off. Beam width of the switched beam is fixed. At adaptive or dynamic beam, The antenna will form the beam with vary beam width depending on the users distribution in the cell. In the dynamic beam will direct main lobe to users and null lobe to interferer to maximize SNR[3].

II. SIMULATION ENVIRONMENT

In this research, we develop algorithm and a simulation model to study the performance of mobile WiMax system utilizing dynamics beam forming technique.The basic components of this simulation are discusssed as below.

A. SNR Model and Antenna Parameter

Pr and SNR calculation for downlink respectively can be represented by [4]:

$$P_r = Pt + Gt - Lt \quad (1.a)$$

$$SNR = P_r - 10\log(W) - F - No \quad (1.b)$$

where *Pr* is the power received, Pt is the transmission power, and Gt is the Gain Antenna, W is the effective Channel bandwidth, F is the noise figure, and No is the thermal noise level.

Gain is important parameter in antenna field because gain of antenna determine of received signal strength. The higher gain will give the better received signal.

Gain of antenna is affected by beam width. The biger beam width will give the smaller antenna

gain. Otherwise, the smaller beam width will affect to the better antena gain.
The formula of antenna gain is expressed as follows[5]:

$$g_w = G = D = \begin{cases} \frac{32,400}{\phi\theta} & \text{For small } \phi \text{ and } \theta (\phi \text{ and } \theta < 40^o) \\ \frac{41,253}{\phi\theta} & \text{For large } \phi \text{ and } \theta (\phi \text{ and } \theta \geq 40^o) \end{cases} \quad (2)$$

where ϕ and θ are the 3-dB beamwidth in two planes. The antenna pattern gain is modeled by a sinc^2 function.

B. Propagation model

In this simulation, we use Stanford University Interm Models (SUI Models). In the SUI model, the base station and receiver antenna height can be used from 10m to 80m and 2m to 10m, respectivelly. The cell radius can be used 0.1 km to 8 km[7]. The SUI model describes three types of terrain, they are terrain A, terrain B and terrain C.

The basic path loss expression of The SUI model with correction factors is presented as [6]:

$$PL = A + 10\gamma \log\left(\frac{d}{do}\right) + X_f + X_h + s \quad for\ d > do \quad (3)$$

where the parameters are
The parameter A and γ is defined as [6], [7]:

$$A = 20\gamma \log\left(\frac{4\pi do}{\lambda}\right) \quad (4)$$

$$\gamma = a - bhb + \left(\frac{c}{hb}\right) \quad (5)$$

d : Distance between BS and receiving antenna [m]
do: 100 [m]
λ : Wavelength [m]
X_f: Correction for frequency above 2 GHz [MHz]
H_h: Correction for receiving antenna height [m]
S : Correction for shadowing [dB]
γ : Path loss exponent

The log normally distributed factor s, for shadow fading because of trees and other clutter on a propagations path and its value is between 8.2 dB and 10.6 dB [1].

where,
hb is height of antenna meters.
a, b, and c is constants depend upon the types of terrain.
Table 1 show types of terrain [7].

TABLE I. THE PARAMETERS VALUES FOR SUI MODEL[7]

Model parameter	Terrain A	Terrain B	Terrain C
a	4.6	4.0	3.6
$b(m^{-1})$	0.0075	0.0065	0.005
c(m)	12.6	17.1	20

The frequency correction factor *Xf* and the correction for receiver antenna height *Xh* for the model are expressed in [6]:

$$X_f = 6.0 \log\left(\frac{f}{2000}\right) \quad (6)$$

$$X_h = \begin{Bmatrix} -10.8 \log\left(\frac{hr}{2000}\right) \ type\ A\ and\ B \\ -20.0 \log\left(\frac{hr}{2000}\right) \ type\ C \end{Bmatrix} \quad (7)$$

where, *f* is the operating frequency in MHz, and *hr* is the receiver antenna height in meter. For the above correction factors this model is extensively used for the path loss prediction of all three types of terrain in rural, urban and suburban environments.

C. Proposal of The Dynamic Beamforming

Given α_{ik}^{j} is the separation angle between MS, γ_{ij} and γ_{kj} is angle of arrivel MS i and MS k respectively. So the algorithm as below:

$(\gamma_{2j}-\gamma_{1j}) < \alpha$ and $(\gamma_{3j}-\gamma_{2j}) < \alpha$,
$(\gamma_{4j}-\gamma_{3j}) > \alpha$ and $(\alpha_{5j}-\alpha_{4j}) < \alpha$,
$(\gamma_{6j}-\gamma_{5j}) > \alpha$,
$(\gamma_{7j}-\gamma_{6j}) > \alpha$ and
$(\gamma_{8j}-\gamma_{7j}) > \alpha$

D. Simulation cycles and parameters

The Simulation cicles and the simulation parameters shown Figure 1 and Table II.

TABLE II PARAMETERS OF SIMULATION

Parameters	Typical Values
Pt (Watt)	**10**
F (dB)	**7**
No (dBm/Hz)	**-174**
Channel Bandwidth (MHz)	10
Radius of cell (km)	5
Height of BS (m)	30
Height of MS (m)	1.5

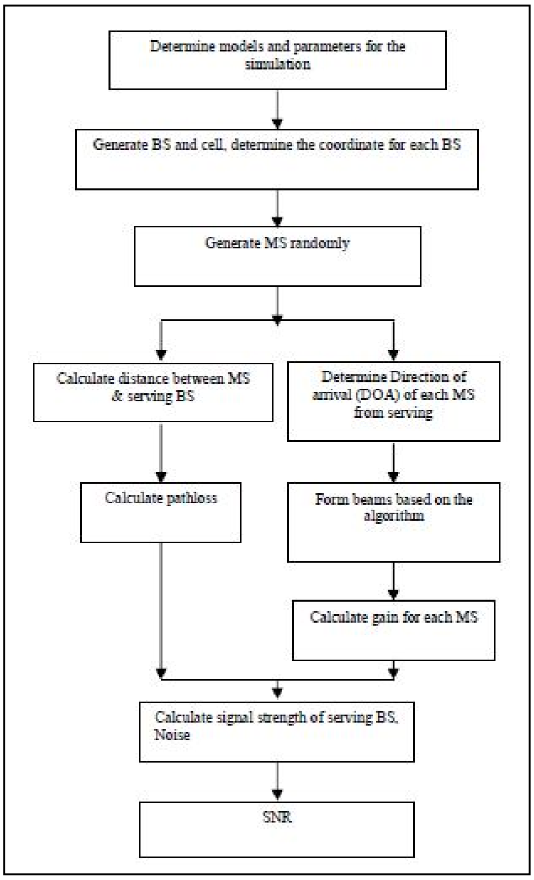
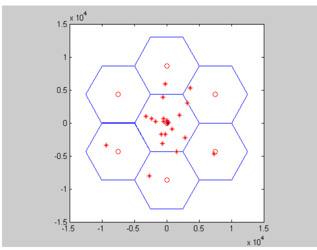


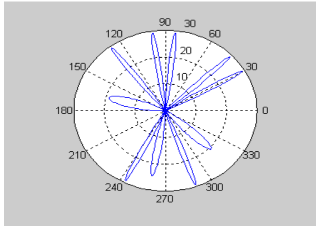
Fig. 1 The simulation cycle

IV. SIMULATION RESULTS

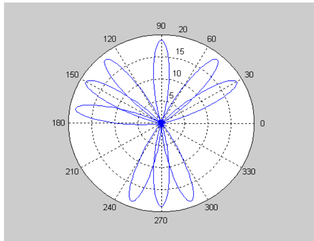
Figure 2 shows example of the result of simulation, include cell topology, MS distribution, and beamforming patern by the dynamic beamforming and switched beamforming.



(a)



(b)



(C)

Fig. 2 The example of simulation result with number of MSs are 20.

The performance of dynamic beamforming shown Fig 3. Fig 3 shows the cumulative distribution of SNR for a dynamic beamforming and switched beam. Simulation results show that SNR for a dynamic beamforming is better than SNR for a switched beam. The improvement is about 7 dB.

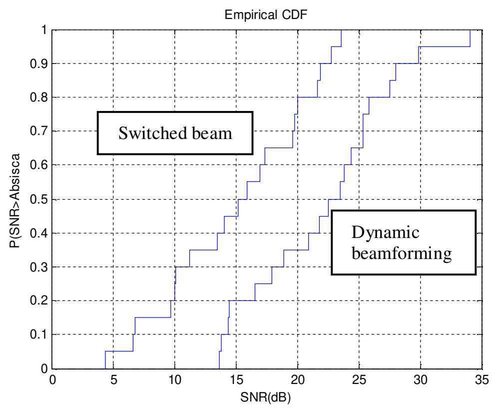


Fig. 3 SNR performance comparison between Switched-Beam and dynamic beamforming

V. CONCLUSION

SNR performance of an dynamic beamforming and a switched beam for mobile WiMax system environment was simulated. The result of the simulation shows that the SNR of the dynamic beamforming better than the SNR of switched beam antenna by 7dB. In the next future, we will develop this algorithm with using soft computing such as artificial intelligent, fuzzy, and ant algorithm. Also other results on capacity improvement and traffic performance for mobile WiMax will be studied.

References

[1] H. Yagoobi, "Scalable OFDMA Physical Layer in IEEE 802.16 WirelessMAN", Intel Technology Journal, Vol 08, August 2004.

[2] Mobile WiMax – Part I : A Technical Overview and Performance Evaluation Copyright 2006 WiMax Forum

[3] M.Ho, G. L. Stiber, M.D. Austin," Performance of Switched-Beam Smart Antennas for Cellular Radio Systems," *IEEE Transactions On Vehicular Technology*, Vol.47, No.1, February 1998.

[4] L.F. Fabricio, C. Paulo,'Coverage Prediction and Performance Evaluation of Wireless Metropolitan Area networks based on IEEE 802.16,' Journal of Communication and Information System, vol.20,No.3,2005

[5] M. Ismail. Cellular Topologies for Personal Communications Systems. Ph.D Thesis, University of Bradford. 1995.

[6]V.S. Abhayawardhana, I.J. Wassel, D. Crosby, M.P. Sellers, M.G. Brown, "Comparison of empirical propagation path loss models for fixed wireless access systems*," 61th IEEE Technology Conference,* Stockholm, pp. 73-77, 2005.

[7] J. Milanovic, Rimac-Drlje S, Bejuk K, "Comparison of propagation model accuracy for WiMax on 3.5GHz," *14th IEEE International conference on electronic circuits and systems*, Morocco, pp. 111-114. 2007.