Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Geometrically Based Elliptical Model**
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Re:	IEEE 802.16m-07/014r1, “Call for Comments on Draft 802.16m Evaluation Methodology Document”. Reference: C80216m-07/080r1
Abstract	This contribution provides the text to the section 4.3.2 Interference Channel Modeling and 4.3.4 Spatial Channel Model
Purpose	Suggest adding geometrically based elliptical model in system level simulation in order to capture the multi-path interference impact to the network performance from multi scatters.
Notice	
Release	
Patent Policy and Procedures	

References:

[1] P. Petrus, J. H Reed and T. S. Rappaport, " Geometrically based statistical channel model for macrocellular mobile environments". In Proc. IEEE GLOBECOM, 1996, pp 1197-1201.

[2] J. C. Liberti and T.S. Rappaport, " A geometrically based mobile for line-of sight multipath radio channels," in Proc. IEEE Vehicular Technology Conf., Apr. 1996, pp.844-848

[3] R. B. Ertel, P. Cardieri, K. W. Sowerby, T. S. Rappaport, and J.H. Reed, " Overview of spatial channel models for antenna array communication systems," IEEE Personal Commun., PP. 10-22, Feb. 1998

[4] Richard B. Ertel and Jeffrey H. Reed, " Angle and Time of Arrival Statistics for Circular and Elliptical Scattering Models," IEEE Journal on Selected Areas in Communications, Vol. 17, No. 11 Nov. 1999

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1. Introduction

This document provides the description on the Geometrically Based Elliptical Model (GBEM) which is used for multi antenna/beamforming network system simulation purposes. In the multi antenna system network, it is inadequate to simulate the interference from multi scatters as a one-path Rayleigh fading channel. The simulation results and measurement data show that GBEM is a good fit for the multi antenna system.

Proposed Text to Section 4.3.2

2. Geometrically Based Elliptical Model description

The Geometrically Based Elliptical Model (GBEM) assumes that scatters are uniformly distributed within an ellipse, as shown in Figure 1, where the Base Station (BS) and Mobile Station (MS) are at the foci of the ellipse.

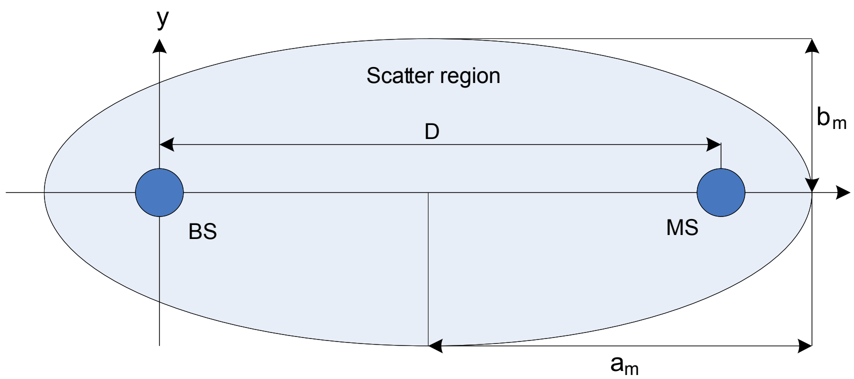

Figure 1 Elliptical scatter density geometry

The model is proposed for micro cell environments where antenna heights are relatively low and therefore multipath scattering near the BS is just as likely as multipath scattering near the MS.
The GBEM parameters are specified in the following and these parameters are used to characterize the particular features of multi antenna radio channels.

GBEM can be used for fixed/nomadic and mobile environments. It captures all the essential channel characteristics which include space, time and frequency domain characteristics, such as

Spatial characteristics

Power delay profile

Doppler characteristics

In multi antenna systems, the angular distribution of the multi-path components is important in determining system performance.

Figure 2 shows an example of multipath propagation and related characteristics.

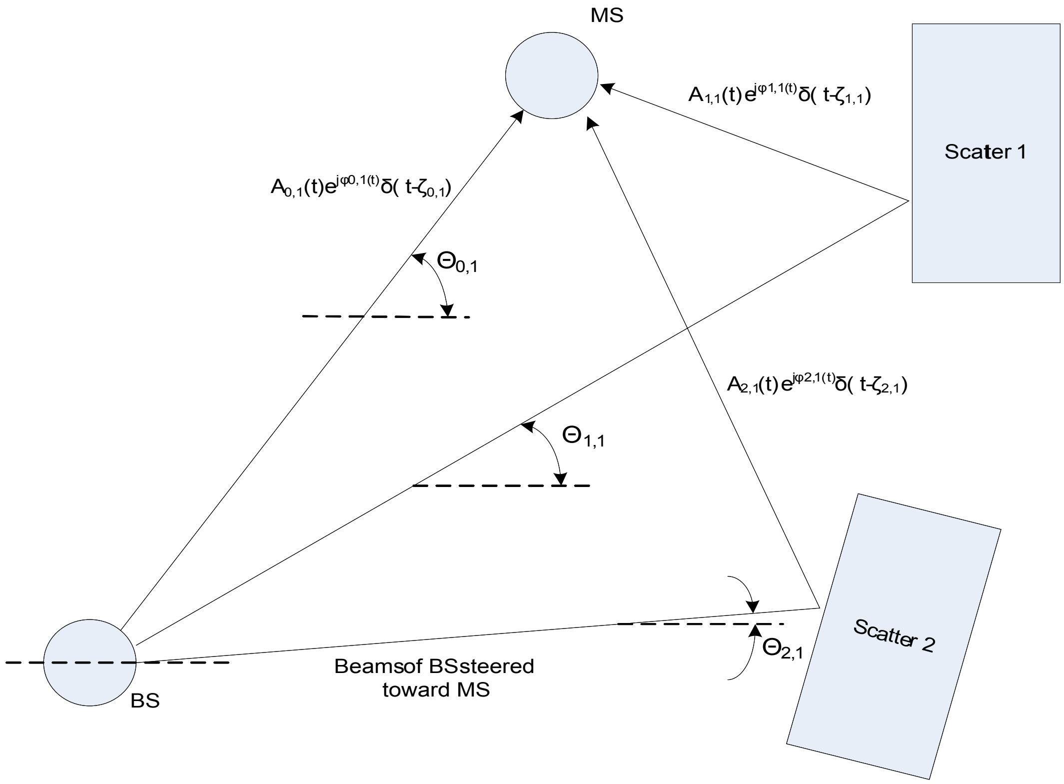

Figure 2 an example of multipath propagation

The channel impulse response is shown in equation (1)

$$\vec{h}_k(t,\tau) = \sum_{l=0}^{L(t)-1} A_{l,k}(t)e^{j\varphi_{l,k}(t)}\vec{\alpha}(\theta_{l,k}(t))\delta(t-\tau_{l,k}(t)) \qquad (1)$$

where $A_{l,k}(t)$ is the amplitude of the multipath, $\varphi_{l,k}(t)$ is the carrier frequency shift, $\tau_{l,k}(t)$ is the time delay and $\theta_{l,k}(t)$ is the Angle Of Arrival (AOA) of the l- th path of the k- th MS. $L(t)$ is the number of multipaths. $\alpha(\theta_{l,k}(t))$ is the array response vector and it is a function of the array geometry and AOA. The resulting array response vector is given by

$$\vec{\alpha}(\theta_{l,k}(t)) = \begin{bmatrix} \exp(j\Psi_{l,1}) \\ \exp(j\Psi_{l,2}) \\ \vdots \\ \exp(j\Psi_{l,M}) \end{bmatrix} \qquad (2)$$

where $\Psi_{l,i}(t) = [x_i\cos(\theta_{l,k}(t)) + y_i\sin(\theta_{l,k}(t))]\beta$ and $\beta = \frac{2\pi}{\lambda}$ is the wavelength number. M is the number of antennas.

In general, all the parameters are time varying.

In Figure 1, the parameters a_m and b_m are the semi-major axis and semi-major axis values which are given by

$$a_m = \frac{c\tau_m}{2} \quad (3)$$

$$b_m = \frac{1}{2}\sqrt{c^2\tau_m^2 - D^2} \quad (4)$$

where c is the speed of light and τ_m is the maximum Time Of Arrival (TOA). The joint TOA and AOA density function is given by

$$f_{\tau,\theta_b}(\tau,\theta_b) = \begin{cases} \dfrac{(D^2 - \tau^2c^2)(D^2c + \tau^2c^3 - 2\tau c^2 D\cos(\theta_b))}{4\pi a_m b_m (D\cos(\theta_b) - \tau c)^3}, & \dfrac{D}{c} \le \tau \le \tau_m \\ 0, & elsewhere \end{cases} \quad (5)$$

where θ_b is AOA observed at BS or MS.

The choice of τ_m determines both the delay spread and angle spread of the channel. Table 1 summarizes the techniques for selecting τ_m. L_r is the reflection loss in dB, n is the path loss exponent and τ_0 is the minimum path delay.

Table 1 Methods for selection τ_m

Criteria	Expression
Fixed maximum delay τ_m	τ_m=constant
Fixed threshold T in dB	$\tau_m = \tau_0 10^{(T - L_r)/10n}$
Fixed delay spread σ_t	τ_m=3.244 σ_t+ τ_0
Fixed maximum excess delay τ_e	$\tau_m = \tau_0 + \tau_e$

In order to obtain the channel impulse response from Equation 1, the multipath delay profile τ_i, AOA (θ_b) and multipath power profile should be provided. By giving the maximum delay τ_m and the distance between BS and MS, the PDF of TOA and AOA can be calculated from Equation (5). Multipath power profile can be obtained from Hata Cost 123 model or Walfish-Ikegame model.

There are two approaches for multi antenna channel modeling: Aisle Elliptical Model (AEM) and Random Elliptical Model (REM). AEM is used for constricted scattering environments such as city blocks with rows of building (outdoor) and hallways (indoor) and REM is used for unconstrained scattering environments such as suburban and urban areas (outdoor) and factories and warehouses (indoor).