MOBILE-TO-MOBILE GAUSSIAN SCATTERING CHANNEL MODEL

Anas Bilal.[1], Muhammad Riaz.[2] and M. Yaqoob Wani.[3]

[1,2,3] School of Information Technology, university of Lahore, Islamabad Campus ,Pakistan

Corresponding Author: chanasbilal@gmail.com

ABSTRACT: *Modeling of scattering objects around the mobile stations in mobile-to-mobile (M2M) communication environment is a hot area of research in wireless communication. It is the scattering distribution that decides about various channel statistics like angle-of-arrival (AoA), time-of-arrival (ToA), angle spread and Doppler shift etc. Numerous geometric channel models have been presented in the literature assuming uniform scattering distribution in M2M communication environment. In this paper, we propose a 2D circular channel model for M2M communication scenario employing Gaussian scattering distribution. Utilizing the proposed channel model, we develop a simulation model and derive mathematical expressions for the joint and marginal probability distribution functions of AoA and ToA. Moreover, we present a comparison with other geometric scattering channel model.*

Keywords: Three dimensional, Angle-of-Arrival, Cellular Mobile Communications, Channel Modeling, semi-ellipsoid.

INTRODUCTION

Mobile to Mobile (M2M) radio channels are very different as compare to Fixed to Mobile (F2M). In M2M radio channels both Transmitter and receiver are in motion with low elevation antennas but in Fixed to Mobile the Base Station (BS) is fixed and elevation of antennas at BS is high. Now a days M2M system are used in many real life applications such as AD-HOC wireless systems, relay based cellular networks, Intelligent transport system(ITS), intelligent vehicular systems such as VNET (vehicular ad-hoc networks)[1].To increase the performance of M2M radio channels it is very important to understand the precise perceptive of M2M radio channels. Different types of geometrical channel models are described in the literature review.In [2] authors proposed a M2M propagation channel modeling for SISO (single input single output) system's. The proposed model is also used in urban and sub- urban areas with the help of SISO(single input single output) Mobile to Mobile Rayleigh fading channels. In [3] 2D (Two Dimensional) ray tracing model is derived by the authors for MIMO (multiple input multiple output) channels with the help of narrowband M2M channels using two ring geometrical scat- tering model. In [4] author proposed a ray tracing narrowband 2D channel

model based on M2M MIMO channel model with the help of 2-ring geometrical channel model.

The concept suggested in this model is similar to [3].Authors suggested a multipara metric stochastic model in [5] with the help of this model they describe the supportive result of distribution of signal power in both AoA and ToA with the help of azimuth and elevation domians.In [6]authors proposed two different scattering models named as elliptical and circular scattering model to calculate joint and marginal function of ToA (time of arrival), AoA (angle of arrival) and pdf's (probability density function). In both models scatters are uniformly distributed with in the scattering region. In [7] author proposed a two ring geometrical model using MIMO channel model in M2M domain. Authors elaborate the and modified the previous presented single bounce two ring model in this research. In [8] Gaussian scattering model is used in 2-D circular and elliptical models. Gaussian scattering distribution is used around the MS. Also calculate the AoA and ToA for .the Pdf's in both azimuth and elevation planes.Singlebounce 2-Dimesional geo-metrical model is proposed in [9]. Researcher used directional antennas at the base station for power distribution with in the multipath components to calculate probability density function of AoA and ToA accordingly. Three dimensional quasi model is

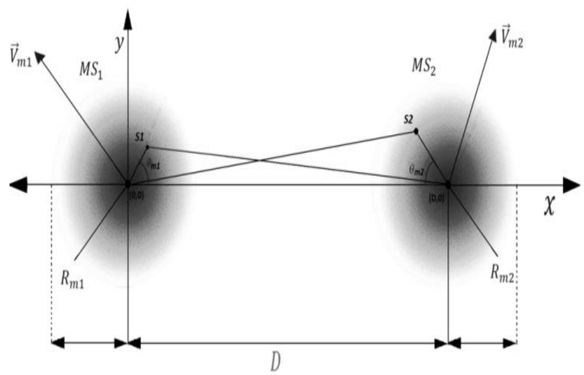

Figure 1:Mobile to Mobile Gaussian scattering model.

Proposed in [10] by Nolkit.In this 3-d model 2-d scattering model is used and correlate with the angle variable. Base station (BS) and mobile station (MS) are combined with delay variable. The analytical properties of M2M Rayleigh fading channel in singleinput-singleoutput (SISO) are different from F2M(Fixed-to-Mobile). Mobile-to-Mobile is Rayleigh-fading under-LOS (Line-Of-Sight). Simulation models proposed in [11] for M-2-M Rayleigh-faded Channels. The concept of 2 ring geometrical model for MIMO-channels are proposed in [12]. Authors use this model for F-2-M communication channel. Scatters are uniformly distributed with the scattering region. Latter on fix-2-fix 2 ring geometrical model for MIMO channels are also available for accommodating soundings [13]. Single-bounce 2-D elliptical model is proposed by blatiz in [14] for structural attribute of Mobile to Mobile radio channels. Mobile station is enclosed by moveable and adjustable hollow ellipses. Scatter are uniformly distributed around the MS author derived close-form expressions for pdf's (probability density functions) for AoA and ToA respectively. In [15] Ricean fading channel is proposed by the author while gener- ation Line -of-sight (LoS) and

SoS(Sum-of-sinusoid) and use narrative LoS among the Mobile-Stations. Level crossing rate and average fading duration is also calculated by the authors. In [16] author's proposed a 3-D hemi-ellipsoid channel-model for M2M radio channels.MS are placed in the middle of the ellipsoid .Hemi-ellipsoids are with changeable dimensions and rotatable around their Y axis to adjust according to commination enjoinment requirements.PDF of angel-of-arrival in both azimuth and elevation planes are also calculated by the authors. In [17] author Janaswamy proposed hemi-ellipsoid geometrical model to the derived the analytical expression for downlink in both azimuth and elevation distribution for AoA and also express uplink azimuth AoA distribution as closed form expressions. In this hemi-ellipsoid the scatters are uniformly distributed with in the scattering region. In [18] author's proposed a V2V faded channel model using MIMO channels .M2M ray-channel geometrical model is describe in T junction scattering environment. Proposed model is used in single-bounce and double-bounce scattering structures and calculate the results of AoD and AoA using their proposed T model.

SYSTEM MODEL

In this paper we proposed a 2-D circular model for M2M channel modeling based on singe-bounce geometrical channels models in Fig 1. Mobile station on transmitting end is denoted by MS_1 and mobile station on receiving end is denoted by MS_2. It is concluded that distance between transmitter MS_1 and receiver MS_2 is less then D and the radius of transmitter (Rm_1) and receiver (Rm_2) are also less than the radius of D. Scatters are distributed in circular regions for MS_1 and MS_2 respectively. We use Gaussian scattering distribution in this model and this will effect during evaluation of AoA, ToA pdfs for this model. As per fig1 scatter place in the region of MS_1 is denoted by S1 and at the receiver end scatter is denoted by S2 respectively. The symbols $\theta_m^{(1)}$ and $\theta_m^{(2)}$ denoted the angel of departure (AOD) of mth wave at transmission side and the angel of arrival (AOA) nth wave at receiver end respectively. Distance between internal elements are also less as compare to MS_1& MS_2. Furthermore V is used for speed and the transmitter S_1 , receiver MS_2 is denoted as V_m1, V_m2 respectively .The angel between the surface and the speed of transmitter (MS_1) , receiver (MS_2) is denoted as α_1 and α_2.

METHOD

Total distance travelled by a signal that propagates from m_1 to s_{m1} and then from s_{m1} to m_2 is $r_1 = r_{sm1}, m_1$, $r_2 = r_{sm2}, m_2$.Total distance is

Distance = $r_1 + r_2$.The time taken to cover this distance is represented as τ.

$$\tau = \frac{r_1+r_2}{c}$$

$$c\tau = r_1 + r_2 \qquad Equ(1)$$

c Is speed of light, r_1&r_2 is total distance and τ is the time to cover distance .Now we can solve the mathematical expressions to find the Time-Of-Arrival (ToA) and Angel-Of-Arrival (AoA) for joint and marginal respectively.

Apply cosine law on $\Delta M_1, s_{m1}, M_2$ we get $on(2)$.

$$\sqrt{r_1^2 + d^2 - 2r_1 d\cos\theta_1} \qquad Equ(2)$$

We get the value of r_2 in $Equation(2)$ now put this value in $Equation(1)$ to find th value of r_1.

$$c\tau = r_1 + \sqrt{r_1^2 + d^2 - 2r_1 d\cos\theta_1}$$

We get the value of r_1 after solving the equation in appendix and get Equation (A) that is represented as $Equation(3)$

$$r_1 = \frac{d^2 - c^2\tau^2}{2(d\cos\theta_1 - c\tau)} \qquad Equ(3)$$

The relation if Joint PDF is shown in $Equation(4)$ using [19].

$$pdf = \frac{f(r_1,\theta_1)}{J(r_1,\theta_1)} \qquad Equ(4)$$

To find the relation of $J(r_1,\theta_1)$ we can use Jacobean transformation.

Jacobean transformation is represented as

$$J(r_1,\theta_1) = \left|\frac{\partial r_1}{\partial \tau}\right|^{-1}$$

Now we can derivate the $J(r_1,\theta_1)$ with respect to tau.

$$\frac{\partial r_1}{\partial \tau} = \frac{d^2 - c^2\tau^2}{2(d\cos\theta_1 - c\tau)}$$

Complete derivation is shown in appendix in Equation (B)

$$= \frac{-4dc^2\tau\cos\theta_1 + 2c^3\tau^2 + 2cd^2}{4(d\cos\theta_1 - c\tau)^2}$$

Take inverse of the results and get

$$= \frac{2(d\cos\theta_1 - c\tau)^2}{c^3\tau^2 + cd^2 - 2dc^2\tau\cos\theta_1} \qquad Equ(5)$$

Now, we can express the relation of joint AoA and ToA with the Gaussian scattering with the help of $Equ(5)$ and $Equ(4)$ joint pdf is shown below in $Equ(6)$.

$$pdf = f(r_1,\theta_1) \times \frac{c^3\tau^2 + cd^2 - 2dc^2\tau\cos\theta_1}{2(d\cos\theta_1 - c\tau)^2} \; Equ(6)$$

The scatter density along any of the path "r_1" using [8]

$$f(r_1,\theta_1) = |r_1| f_{x,y} \qquad Equ(7)$$

Where $f_{x,y}$ comes from Gaussian scattering distribution

And $\partial^2 r_1$ is the standard deviation of scatters distribution around the base station.

$$i.e \quad f_{(x,y)} = \frac{1}{2\pi\partial^2 r_1} exp[-\frac{x_s^2+y_s^2}{2\partial^2 r_1}]$$

$$f_{(r,\theta)} = \frac{|r_1|}{2\pi\partial^2 r_1} exp[-\frac{|r_1|^2}{2\partial^2 r_1}] \qquad Equ(8)$$

Put value of $Equ(8) in\, Equ(7)$

$$f_{(r_1,\theta_1)} = \frac{|r_1|}{2\pi\partial^2 r_1} exp[-\frac{|r_1|^2}{2\partial^2 r_1}] \qquad Equ(9)$$

Put $Equ(9) in\, Equ(6)$

$$pdf_{(\tau,\theta)} = \frac{|r_1|}{2\pi\partial^2 r_1} exp\left[-\frac{|r_1|^2}{2\partial^2 r_1}\right] \times \frac{c^3\tau^2 + cd^2 - 2dc^2\tau\cos\theta_1}{2(d\cos\theta_1 - c\tau)^2} \qquad Equ(10)$$

We get joint pdf in $Equ(10)$ for marginal pdf's we integrate $Equ(10)$ w.r.t (τ) to get ToA and if we integrate $Equ(10)$ with respect to (θ) we get Angle-Of-Arrival respectively.

RESULTS AND DISCRIPTIONS

Observation and Discussion on the basis of our theoretical results are presented in this section. Marginal PDF of Time of Arrival is shown in Figure 2.We take different randomly values of Gaussian scattering region to verify our theoretical results. Multipath signals with shortest delay have maximum probability.

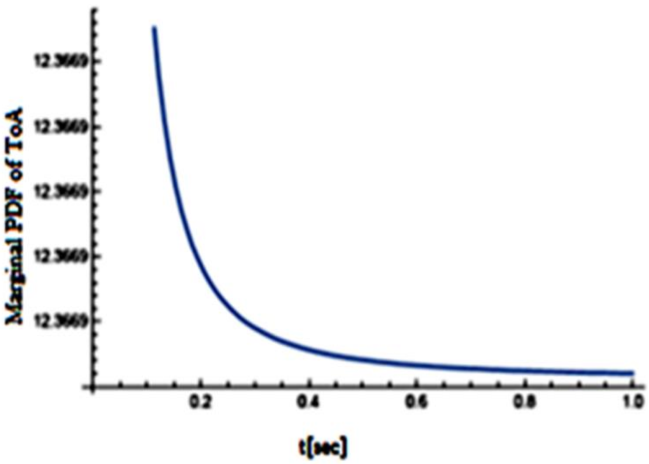

Figure 2: Marginal PDF of ToA

Marginal PDF of Angle of Arrival is shown in Figure 3. Figure 4 elaborate that the value is nearest to zero have high probability then the values are far from the zero. At the point zero it has highest probability.

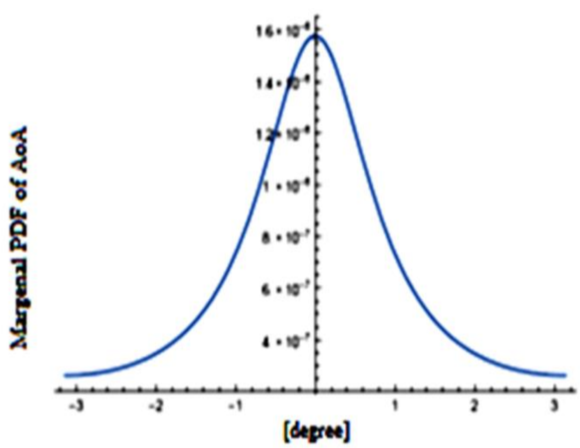

Figure 3: Marginal PDF of AoA

Furthermore, Simulation model is shown in Figure 4 that elaborate our system model from this simulation model we compare our theoretical results with the simulation results.

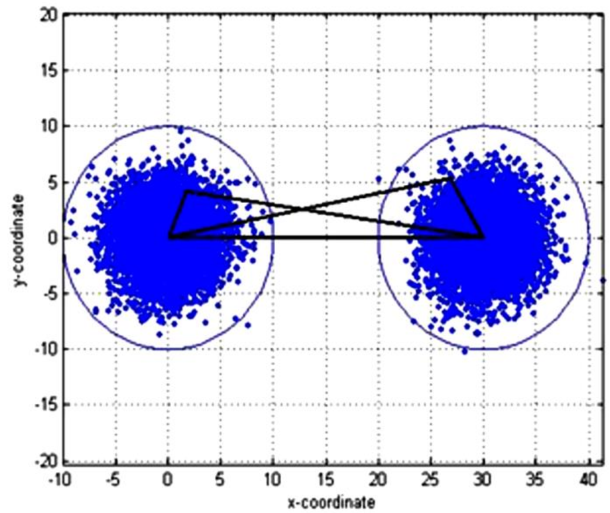

Figure 4: Simulation Model

CONCLUSIONS

This paper describe the 2-D Geometrical channel model with single bounce Mobile-To-Mobile channel .Scatters are distributed using Gaussian scattering density in circular model in which mobile station are located at the center of the circle. Marginal and joint PDF’s for AoA and ToA are derived theoretically. Derived Function are also verified through simulations and compare these result as well. The geometrical model and results are presented in this paper also help to understand the Mobile-To-Mobile Communication in better way .Furthermore its help to design such systems in easy way.

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