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COMPARATIVE ANALYSIS OF THREE INDOOR MODELS IN TERMS OF ENERGY LOSS & BER USING DIFFERENT CONSTRAINTS

Pinky Devi[1], Dr. Shelly Garg[2], Mr. Kapil[3]

[1]*ECE Deptt., INDUS, KUK, India., pinky.sharan007@gmail.com*
[2]*Professor, ECE Deptt., INDUS,KUK, India, S.singla428@gmail.com*
[3]*Asst. Professor, ECE Deptt, INDUS, KUK, India, sachkapil10@gmail.com*

***Abstract**: - In indoor mobile networks the investments are highly based on spectrum availability and its associated authorization options. Some physical properties of the network like spectrum type, propagation type are set up when the network environment is defined which control the network communication. There are number of constraints which affect the communication over network and all the constraints depend upon network type, its topology and type of communication. It is required to define the network under defined constraints to obtain the optimum output from the network. The application of constraint satisfaction programming is used in the indoor environment to predict the signal processing. In this paper communication analysis on indoor mobile network is focused which considered small area like a room or the building. A comparative analysis has been done in the presented work in terms of BER and energy loss for three indoor propagation models named Rayleigh propagation model, Friis propagation model and Log-distance shadowing propagation model using distance, density and energy parameters which define the constraints and reduction or BER in indoor mobile network. Most of the radio simulators predict only the mean power but fading also affects the system performance so noisy channel also considered in this work so that optimum output is obtained in indoor environment.*

***Keywords**- Indoor mobile network, Friis transmission equation, Rayleigh propagation model, Log distance shadowing propagation model, BER,.*

I. INTRODUCTION

In indoor environment past studies of signal propagation have used several models with varying degree of success and complexity. The indoor propagation is a method for data communication which used short-range radio links for the replacement cables between computers and their connected units. In indoor propagation distances covered are much smaller and variability of the environment is much greater. Due to the occurrence of various physical phenomenon which are based on specific building structure propagation prediction is difficult insides buildings. Generally indoor channels may be classified as LOS or OBS with varying degree of clutter. In indoor environment the losses between floors of building are determined by the external dimensions and materials of the building as well as the type of construction used to form the floors and external surroundings. In indoor environment channel model is useful in order to determining the mechanism by which propagation takes place. Indoor radio propagation is not affected by the terrain profile as in case of outdoor propagation but it can be influenced by the layout in a building. Due to reflection, refraction and diffraction of radio wave by objects such as walls, doors and windows in a building the transmitted signal often reaches to the receiver by more than one path.

A quantitative approach is used to compare the differences between macro-cell and femto-cell deployments which focus on deployment cost and spectrum demand [1].

II. INDOOR MOBILE NETWORK

In indoor environment it is desired to predict radio coverage inside buildings to choose optimum location of base station for maximization of capacity and minimization of co-channel interference so that satisfactory operation of mobile system can be obtained. These types of prediction are very useful for the mobile operators in cities where population is becoming dense and subscribers are requiring that coverage be provided inside buildings [2]. The success of outdoor positioning and applications based upon the global positioning system (GPS) which cannot be used within buildings and in dense urban areas due to its poor signal reception when there is no line-of-sight from MS to at least three GPS satellites. So in case of indoor positioning system there is requirement of alternative means to find out the MS's location without relying on direct radio frequency signal from GPS satellites. For indoor positioning systems major technologies used are infrared, RF and ultra sound signals [3].

The radio propagation models are required to determine coverage of a transmitter [4]. In indoor environment radio propagation modeling methods which are commonly used are mainly partition into four types which are stochastic models, empirical models, deterministic models and semi-deterministic models. Empirical models are based on channel measurements which are conducted at some typical places and stochastic models are used for modeling the random aspect or radio channel with random variables. Deterministic models are used to simulate the real physical propagation phenomenon of radio waves [5].

III. FRIIS PROPAGATION MODEL

The first source of signal strength loss is related to the distance covered by the signal during its propagation. The signal strength losses power when going through the atmosphere. In a free space environment the loss can be determined by the friis transmission equation. The friis transmission equation is used in telecommunication engineering and gives the power received by one antenna under idealized conditions when it is given the another antenna some distance away transmitting a known amount of power. The formula was derived by Danish-American radio-engineer Harald T. Friis at Bell Labs in1945.

Basic form of equation:

Given two antennas, the radio power available at the input of receiving antenna, P_r,to the output power of transmitting antenna, P_t, is given by

$$\frac{P_r}{P_t} = G_t G_r \left(\frac{\lambda}{4\pi R} \right)^2$$

Where

G_t is the gain of transmitting antenna

G_r is the gain of receiving antenna

λ is the wavelength and

R is the space between the antennas

The friis free space equation shows that the received power falls of as the square of transmitter receiver separation distances. The inverse of the factor in parentheses is called free space path loss. To use the equation as it is written, the wavelength and distance units must be same and the antenna gain may not be in the units of decibels. The equation is slightly modified if the gain has units of dB as given below

$$P_r = P_t + G_t + G_r + 20 \log_{10} \left(\frac{\lambda}{4\pi R} \right)$$

The gain has units of dB and power has units of dBm or dBW. Since the wavelength and frequency f are related by the speed of light. The friis transmission equation in terms of frequency can be written as

$$P_R = \frac{P_T G_T G_R c^2}{(4\pi R f)^2}$$

It shows that more power is lost at higher frequencies. This is the result of friis transmission equation. It can be understood that the energy transfer will be peak at lower frequencies for antennas with specified gains. The difference between the received power and power transmitted is known as path loss. Friis transmission equation shows that path loss is higher for higher frequencies.

IV. RAYLEIGH PROPAGATION MODEL

The Rayleigh fading model is most commonly used for modeling of multipath fading when there is no line of sight path between transmitter and receiver. The received signal amplitude is distributed according to the Rayleigh distribution when there is no line of sight path. The Rayleigh distribution is used to describe the statistical time varying nature of envelope of individual multipath component which is given by

$$P(r) = \frac{r}{\sigma^2} \exp\left(\frac{-r^2}{\sigma^2}\right) \qquad 0 \leq r \leq \infty$$

Where σ is the rms value of the received signal

$r^2/2$ is the instantaneous power

σ^2 is the local average power of the received signal before detection[6].

Rayleigh fading is caused by the multipath reflections of the received signal before it reaches to the receiver. It is considered that the magnitude of the signal which is passed through the transmission medium will vary randomly or fade in accordance with the Rayleigh distribution. Rayleigh fading is seen as a reasonable model for ionospheric or tropospheric signal propagation as well as the effect of heavily build-up urban environment on radio signals. In the environment when there are many objects which scatter the radio signal before it reaches to the receiver then Rayleigh fading is a reasonable model. If there is sufficiently much scatter then according to the central limit theorem the channel impulse response will be well-modeled as a Gaussian process irrespective of the distribution of the individual components of the signal. A process will have zero mean and phase evenly distributed between zero and 2π radians when no dominant component to the scatter. Therefore the envelope of the channel response will be Rayleigh distributed.

V. LOG DISTANCE SHADOWING PROPAGATION MODEL

The log-distance path loss model is a radio propagation model which is used for prediction of path loss of a signal encounters within a building or the areas which are densely populated over distance. This model is used for prediction of the propagation loss for a wide range of environments. Normally the log-distance path loss model is represented as

$$PL = P_{Tx_{dBm}} - P_{Rx_{dBm}} = PL_0 + 10\gamma \log_{10} \frac{d}{d_0} + X_g,$$

Where

PL is the total path loss which is measured in dB

$$P_{Tx_{dBm}} = 10 \log_{10} \frac{P_{Tx}}{1mW}$$ is the transmitted power measured in dBm

P_{Tx} is the transmitted power in watt

$$P_{Rx_{dBm}} = 10 \log_{10} \frac{P_{Rx}}{1mW}$$ is the received power measured in dBm

P_{Rx} is the received power in watt

PL_0 is the path loss at reference distance d_0

d is the length of path

γ is the path loss exponent

X_g is a normal or Gaussian random variable having zero mean which reflects the attenuation due to flat fading and it is zero in absence of fading. This random variable may have Gaussian distribution having σ standard deviation in case of only slow fading or shadow fading which results in log-normal distribution of received power in watt. But in case of only fast fading which is caused by multipath propagation the corresponding gain in watts $F_g = 10^{\frac{-X_g}{10}}$ can be modeled as a random variable having either Rayleigh distribution or Ricean distribution.

VI. BIT ERROR RATE (BER)

The bit error rate is described as the rate at which errors occur in a transmission system [6]. The bit error rate will be very small if the medium between the transmitter and receiver is good and signal to noise ratio is high. The Bit Error Rate (BER) is a key parameter which is used for measuring the quality of radio links. It is defined as the ratio of the number of error bits to the total number of transferred bits

$$BER = \frac{N_{error}}{N_{total}}$$

Where Nerror are the number of error bits and Ntotal are the number of total bits transmitted. It provides an end-to-end measure of radio links. Unlike other parameters stated above which reflects radio link quality indirectly, the BER directly measures the link quality i.e. the SNR (signal to noise ratio), the average fade duration etc reflect the radio link quality through their impacts on the BER. Hence bit error rate is the fundamental parameter for radio link quality and it has been widely used. Another relevant parameter is BEP (bit error probability). The BER can be assumed as the estimate of the BEP. The larger the total number of the transferred bits is, the more accurate the estimate becomes.

The received signal power fluctuates as a function of the time, space and frequency in radio propagation channels. A wireless network designer must quantify first the distribution of the received signal power or voltage envelope, mean received signal power, SINR and SNR to find out the impacts of fading channels on the system performance. Among all the first-order fading statistics, the mean received signal power may be the most common parameter because it is the most intuitive measure of the radio link quality. The Shannon's Theorem states that the achievable channel capacity C is a function of the available bandwidth B and the Signal-to-Noise Ratio (SNR) as given below

C = B _ log 2(1 + S/N) (3.22)

Where N is the mean noise power, S is the mean received signal power and S/N is the signal to noise ratio

In AWGN channel the signal to noise ratio has an explicit relationship with the bit error rate of radio channels. Hence when the SNR is high then BER will be small (i.e. the better the radio channels).

VII. RESULTS

The results are figured out based upon the Friis transmission model, Rayleigh propagation model and Log distance shadowing propagation model .The initial parameters are set as the creation of 30 nodes is done in a topological environment. The network topology coverage area is set as given below

Coverage area= (2* width*height) / total no. of nodes

Where the height and width are set to 100 & 100 then the graph between capacity of signal & distance is figured out. The spectrum frequency is figured out against the time on the basis of signal strength and then the Energy Loss of signal transmission is the final output.

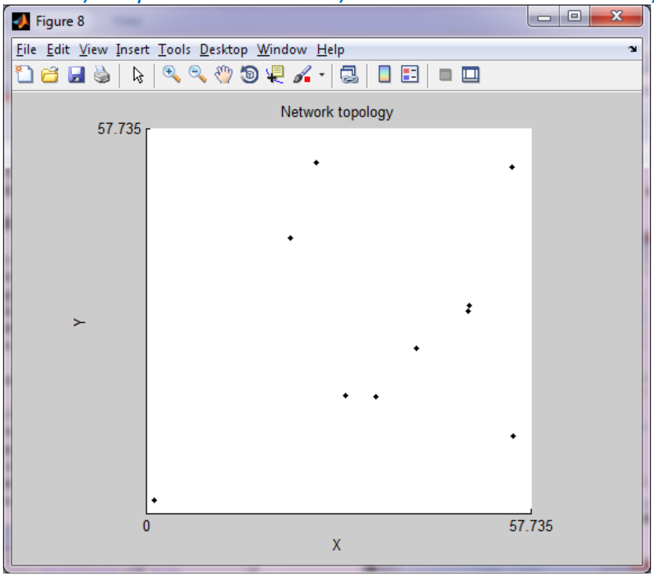

Fig 1: Network topology of 10 nodes

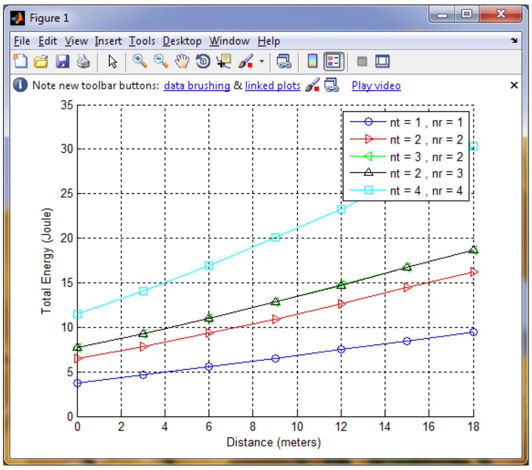

Fig 2: Graph between energy of signal and distance of Friis propagation model

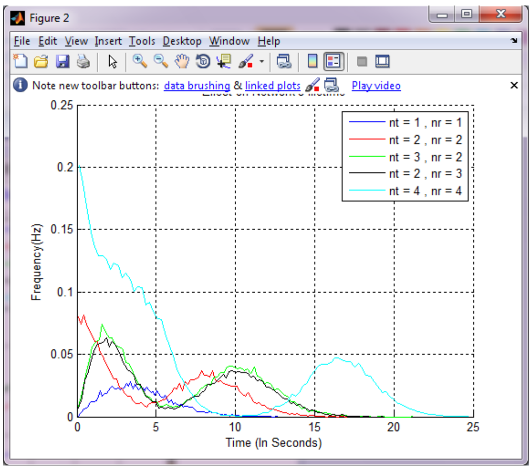

Fig 3: Graph between spectrum frequency and time of Friis propagation model.

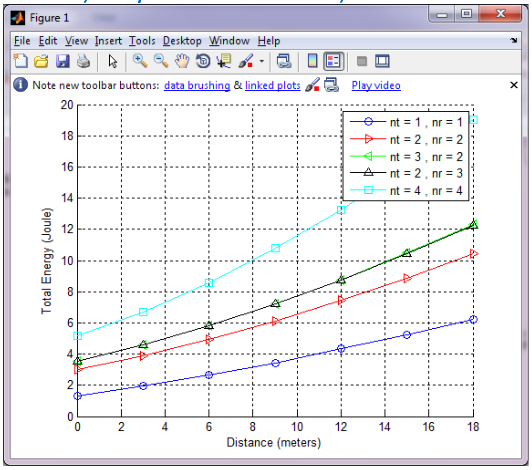

Fig 4: Graph between energy of signal and distance of Rayleigh propagation model

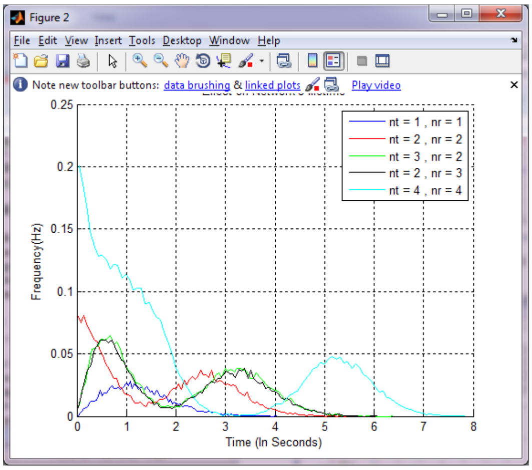

Fig 5: Graph between spectrum frequency and time of Rayleigh propagation model.

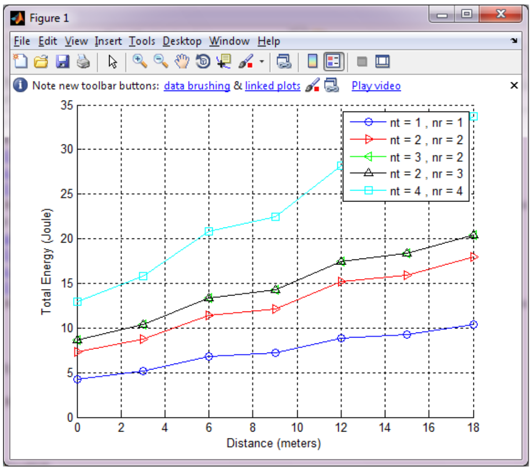

Fig 6: Graph between energy of signal and distance of Log distance shadowing propagation model

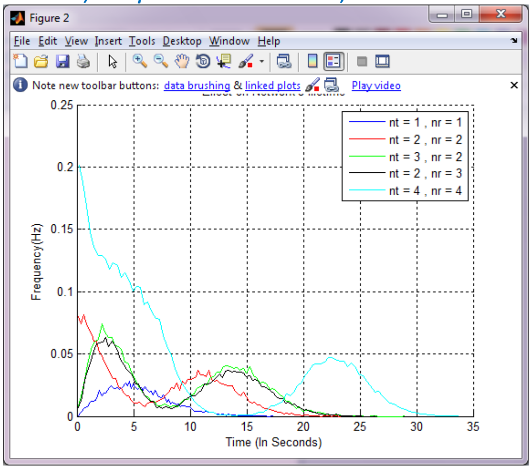

Fig 7: Graph between spectrum frequency and time of Log distance shadowing model.

BER PERFORMANCE OF THREE DIFFERENT MODELS:

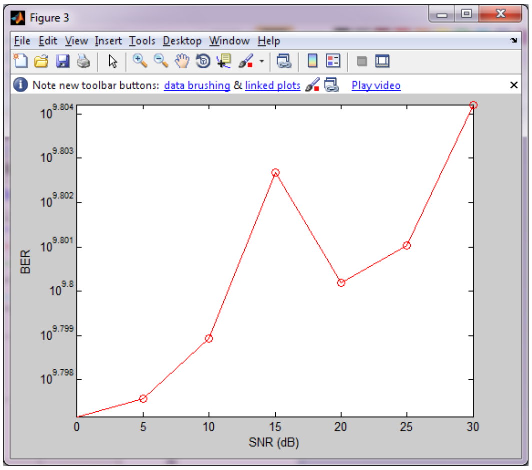

Fig 8: BER performance of Friis propagation model

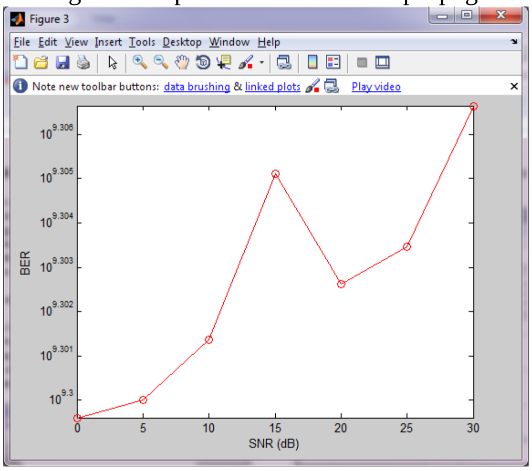

Fig 9: BER performance of Rayleigh propagation model

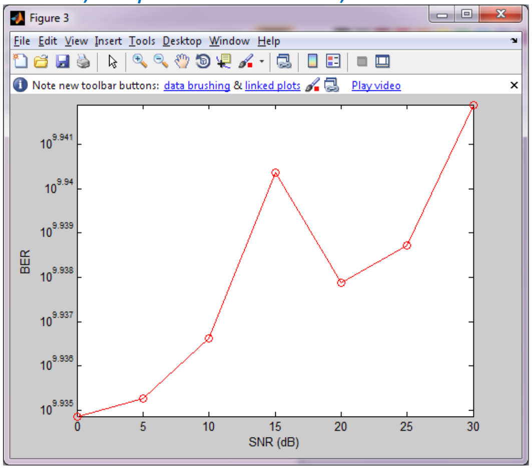

Fig 10: BER performance of Log distance shadowing propagation model

VIII. COMPARISON

The output result of total energy loss given by Rayleigh propagation model is **3.9978 * 10^{10},** the energy loss given by Friis transmission model is **1.2572 * 10^{10}** and the total energy loss given by Log- distance shadowing model is **1.7262 * 10^{10}** which is lesser than the others parameters if we have taken.

IX. CONCLUSION

In this paper a brief survey of basic solving techniques behind constraint programming has been studied. The overview of the main technique for solving constraint optimization problem i.e. branch and bound algorithm has been used. There are various wireless indoor propagation models used for channel communication and to find the energy loss using constraint satisfaction algorithm. Although most of the radio propagation simulators provide only the mean power prediction, but it has been shown that on system performance fading has also an important impact. Hence fading information has been extracted on the basis of Rayleigh model, Friis model and Log distance shadowing model and then an accurate prediction of the energy loss is achieved. The prediction of the energy loss has been tackled for different constraints which are based on three different parameters: distance, density, energy. It is well known that the BER depends not only on the mean power but also on the fading severity. The Friis model is the best one in terms of signal strength and energy loss.

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