



## Investigating Effects of Propagation Model under Different Traffic Conditions on Beacon Enabled Wireless Sensor Network

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**Abstract-** Wireless Sensor Network consists of tiny nodes capable of sensing physical quantity and converting it into electrical form. The IEEE 802.15.4 standard is supported by Wireless Personal Area Network (WPAN) which consists of tiny sensor node, have features like short range, low bit rate and low cost. The support of QoS in sensor networks faces several challenges due to the wireless nature, limited energy, low reliability of nodes, distributed architecture and constantly changing network topology. To obtain the optimum value of QoS parameter, we analyzed the effect of various radio propagation models on performance of wireless sensor network with varying traffic models using network simulator tool.

**Keywords-** Wireless Sensor Network, IEEE 802.15.4, Traffic Models, Radio Propagation Models, Network Simulator.

### I. Introduction

Wireless Sensor Network promises a new domain in which computer and human interact with our environment. In Wireless Sensor Network, the physical layer and link layer have the standard 802.15.4 which is a member of IEEE family. Short range, low bit rate and low cost are the features of IEEE 802.15.4. There are total 27 channels in IEEE 802.15.4 physical layer, out of 27 channels one channel is allotted to 868MHz band, ten channels to 915MHz band, and sixteen channels to 2.4GHz band [1][2]. There are two modes in which IEEE 802.15.4 can operate they are beacon enabled mode and non beacon enabled mode. The performance of wireless sensor network is severely affected by mobile radio channel. The path followed by data packet from source to destination can be a direct line of sight path or it can be obstructed by mountains, buildings, monuments and foliage [3]. Various propagation models are used to predict the strength of received signal. In our analysis, we considered the effect of two ray ground reflection model and shadowing model on the performance of wireless sensor network. These two models have different impacts on performance of wireless sensor network. The study of different propagation models under different network scenarios to analyse the performance of wireless sensor network is the focus of our work. The rest of the paper is outlined as follows: Section II presents propagation models we used in our analysis. Section III describe about simulation environment. Section IV gives details of performance metrics and simulation results and finally section V presents conclusions.

### II. Radio Propagation Models And Traffic Models

The received signal power of each packet can be predicted by radio propagation model. In our analysis we used two ray ground reflection model and shadowing model which are discussed below.

#### A. Two ray ground reflection model

In two ray ground reflection model, the direct path and a ground reflection path i.e. the reflection from ground between sending and receiving antenna both paths are considered. At distance  $d$ , the received signal power can be predicted as follow [7]

$$P_r(d) = \frac{P_t G_t G_r h_t^2 h_r^2}{d^4 L}$$

where  $P_t$  is power of transmitted signal.  $G_t$  and  $G_r$  is the gain of transmitting and receiving antenna respectively.  $h_t$  and  $h_r$  is the height of transmitting and receiving antenna respectively.  $d$  is the distance between transmitting and receiving antenna and  $L$  is the system loss and its value is always greater than or equal to 1. A cross over distance  $d_c$  is used in this model. It is the distance at which the received signal power calculated from free space model and from two ray ground model become equal.  $d_c$  can be predicted as

$$d_c = (4\pi h_t h_r) / \lambda$$

When  $d > d_c$ , two ray ground reflection model is used for calculation of received signal power.

#### B. Shadowing model

Shadowing model consider the phenomena of fading effect. Fading effect occurs due to multipath components of received signal. The shadowing model can be described into two parts. The first part depicts the mean value of received signal power at distance  $d$  and it is known as path loss model. A reference distance is used in this model which is known as close-in distance  $d_0$ . If  $\overline{P_r}(d)$  is the mean received power at distance  $d$  and  $P_r(d_0)$  at close-in distance  $d_0$  then

$$\frac{P_r(d_0)}{P_r(d)} = \left(\frac{d}{d_0}\right)^\beta$$

where  $\beta$  is known as path loss exponent and the value of  $\beta$  is determined by field measurement. Larger value of  $\beta$  indicates that as distance increases the value of received signal power also decreases.  $P_r(d_0)$  can be calculated as

$$P_r(d_0) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L}$$

The value of path loss exponent is generally measured in dB as

$$\left[\frac{P_r(d)}{P_r(d_0)}\right]_{dB} = -10\beta \log\left(\frac{d}{d_0}\right)$$

The variation in received power as a function of distance is indicated in second part of shadowing model. In second part of shadowing model a lognormal random variable is used which is measured in decibel and it follows Gaussian distribution. The overall shadowing model can be represented as

$$\left[\frac{P_r(d)}{P_r(d_0)}\right]_{dB} = -10\beta \log\left(\frac{d}{d_0}\right) + X_{dB}$$

where  $X_{dB}$  is a Gaussian random variable with zero mean which is having standard deviation equal to  $\sigma_{dB}$  which is obtained by measurement[4].

In this particular analysis, we considered the effect of traffic conditions. The various traffic models which we have used in our analysis are discussed below [4].

#### A. CBR Traffic Model

It generates traffic according to deterministic rate. The size of packet is constant.

#### B. FTP Traffic Model

This model is used for bulk data transfer. This traffic model work by advancing the count of packets available to be sent by a TCP transport agent.

#### C. Poisson Traffic Model

It generates traffic when bit rate is variable and this traffic model is suitable when data traffic is not bursty[5].

### III. Simulation Environment

In order to analyse the effect of various propagation models on wireless sensor network with different traffic conditions we used network simulator tool for our analysis. We used beacon enabled mode of wireless sensor network in our analysis. The Network Simulator is a software tool that simulates the behaviour of network without an actual network is being present. A wide variety of scenarios can be analyzed at low cost relative to making changes to real network [6][7]. The various parameters which we have used in our analysis are depicted in table 1.

TABLE I  
SIMULATION PARAMETERS

Topology	50×50
Routing protocol	AODV
MAC	802.15.4
Simulation time	100 s
Traffic generators	CBR, FTP, Poisson
Radio propagation models	Two ray ground, Shadowing

### VI. Performance Metrics

The goal of performance metrics is to provide guarantee on the ability of a network to deliver predictable results. There are various parameters which affect the network performance [8]. Some of them are used in our analysis.

#### A. Average End-to-End Delay

The total amount of time a network spends to deliver a data packet from source to destination. Ideally the value of end-to-end delay should be as low as possible.

#### B. Normalised Routing Load

Normalised routing load can be defined as the ratio of routing packets transmitted to the data packets delivered at the destination.

#### C. Packet Delivery Ratio

It is the ratio of data packets successfully delivered to the destination to the data packets generated by the source.

#### D. Throughput

The successful transmission of data packets in a unit time is known as throughput. It is usually measured in kbps.

### V. Simulation Result

In this section, analyses of various results of simulation are presented.

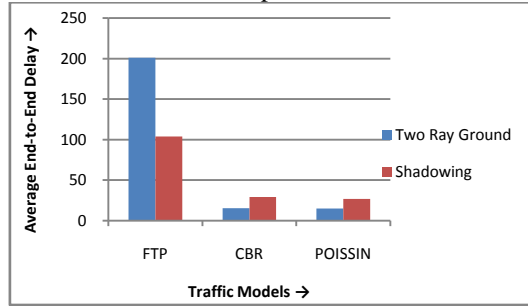


Figure 1. Average End-to-End Delay

The performance of WSN is best with CBR traffic condition under two ray ground propagation model in terms of average end-to-end delay.

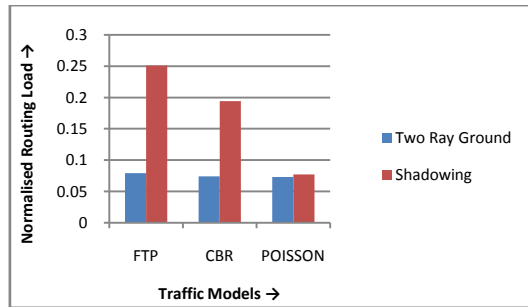


Figure 2. Normalised Routing Load

When two ray ground propagation model is used with all the three traffic conditions, the performance of WSN is better than shadowing model if normalised routing load is considered as performance parameter.

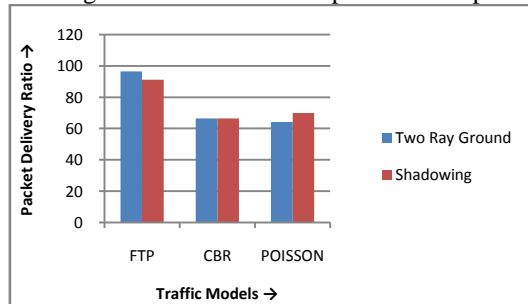


Figure 3. Packet Delivery Ratio

The highest value of packet delivery ratio is achieved with FTP traffic condition under two ray ground propagation model.

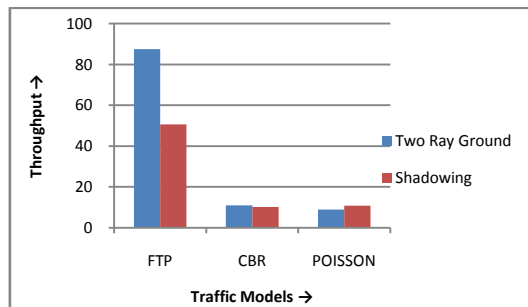


Figure 4. Throughput

Again two ray propagation model is preferred with FTP traffic model to achieve optimum value of throughput for desirable performance of WSN.

### VI. Conclusion

From the above analysis, we conclude that the optimum performance of WSN with beacon enabled mode is achieved in case of two ray ground propagation model is used rather than shadowing model. In two ray propagation model, the optimum value of average end-to-end delay and normalised routing load is obtained with either CBR or Poisson traffic model and FTP traffic model is preferred to achieve optimum value of packet delivery ratio and throughput.

In shadowing model, the optimum value of average end-to-end delay and normalised routing load is achieved with Poisson traffic and the optimum value of PDR and throughput is obtained with FTP traffic condition.

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