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Estimation of Signal Strength in a WSN for Application in War Ship

Ananya Sarkar[1], Subhasish Majumdar[2] and Partha Pratim Bhattacharya[3]

[1]College of Engineering and Management Kolaghat, Dist. Purba Medinipur, West Bengal, Pin- 721171, India.
[2] Garden Reach Ship Builders & Engineers, under Ministry of Defence, Govt. of India. Pin- 700 024, India.
[3] Mody Institute of Technology & Science (Deemed University), Lakshmangarh, Rajasthan, India.

Abstract

Wireless Sensor Networks (WSNs) are deployed in war ships for various security issues. In WSN, path loss models are used to estimate the path loss between transmitting nodes and sink for outdoor and indoor applications. In this paper, path loss models for indoor propagation are investigated for multiwall configuration. Here, path loss and signal strength for a war ship environment are estimated using COST 231 models for different floors of the ship. Path loss and signal strength varies from floor to floor based on the propagation environment and hence path loss exponent. The results are found to be satisfactory.

Keywords: Wireless sensor network; war ship communication; propagation path loss; received signal strength; path loss exponent.

1. Introduction

Wireless Sensor Networks (WSNs) have gained worldwide attention in recent years, particularly with the proliferation of Micro-Electro-Mechanical Systems (MEMS) technology which has facilitated the development of smart sensors. Smart sensors are small devices composed of one or more sensors, a memory, a processor, a power supply and a radio unit. A wireless sensor network (WSN) commonly consists of a large number of sensor nodes that are densely deployed either inside the phenomena or very close to it. It can sense physical phenomena (e.g., temperature, pressure, etc.) or detect from its surroundings, process and store them, and finally provide these data to users, upon either demand or event detection. They can sense the environment, measure and send data wirelessly to control unit for further processing and decisions. For the deployment of wireless sensor network in warship for various security issues systems, the path loss prediction models are very important and have been studied for a long time. These models can be classified into theoretical and experimental models [1]. The main experimental models are the Okumura-Hata, Cost231-Hata, and ITU-R model [2]. The problem of these models is that these prediction expressions are based on the qualitative propagation environments such as urban, suburban, and open areas. The Cost231 is a result of the effort to use n quantitative description of the propagation environments. In addition to the height of T, and R, antennas, the quasi-uniform building height and width of suet are considered in this model. In spite of the development of numerous empirical path loss prediction models so far, the generalization of these models to any environment is still questionable. They are suitable for either particular areas (urban, suburbs, rural *etc.*), or specific cell radius (Macro cell, Microcell, Pico cell)[3]. To overcome this drawback, the empirical models' parameters can be adjusted or tuned according to a targeted environment. The propagation model tuning must optimize the model parameters in order to achieve minimal error between predicted and measured signal strength. This will make the model more accurate for received wireless signal predictions. COST 231 non line of-sight form superiority over the other empirical models has provoked us to select and adjust this model to our target environment. The model reports the relation between the path losses measured in various areas and its parameters such as frequency, distance, base station (BS), and mobile station (MS) antenna heights. A typical application involves taking measurements of the path loss in the target environment and then tuning the COST 231 model parameters to fit it to the measured data. Unfortunately, the COST 231 model was developed based on measurements conducted in propagation environments that differ widely from the propagation environment in India. A lot of research has been carried for modeling the outdoor-to-indoor scenario and several prediction models have been proposed in this regard. Empirical models which are analytical equations designed out of extensive filed measurements require less input information and provide reasonable accuracy and computational efficiency[4]. On the other hand deterministic models which are resulting from theory rather than experience are less computationally efficient and provide better accuracy at the cost of requiring detailed input information about the propagation environment [5]. Largely, among all empirical models presented in literature, the COST231 model [6] is considered to be the most accurate and widely used model for outdoor-to-indoor coverage prediction [7]. WLAN received signal strength based location estimation techniques are promising for their low cost and ease of deployment. Deploying sensor node at random locations and considering the frequency 2.45 GHz [8][9][10].

Ships constitute an important part of modern systems and are widely used in armed conflicts and commercial purposes such as fishing and transporting passengers and cargos apart from surveillance. The effective protection of vast near-coast sea surfaces and busy harbor areas from intrusions of unauthorized marine vessels, such as pirates' smugglers or, illegal fishermen is particularly challenging [11]. Wireless sensor network used in external application of ship as intrusion detection, under water communication to detect the submarine with the help of sensor, internal navigation administration, to detect environment, device status for avoiding unwanted accidents and Surface to surface detection of enemies. Wireless sensor networks are used in intelligent hull monitoring system to reduce the risk of structural failure spills into the sea and damage to cargo and to improve passenger safety and comfort. WSN requirement is also there in the main engine room of a real ship.

2. Estimation of Signal Strength

The multi-wall model gives the path loss as the free space loss added with losses introduced by the walls and floors penetrated by the direct path between the transmitter and the receiver. It has been observed that the total floor loss is a non-linear function of the number of penetrated floors. This characteristic is taken into account by introducing an empirical factor b. The three considered environments in this case are: the engine room, the parking and the passenger deck. Measurement results are used to determine the relation between the path loss and the distance between nodes in each environment. Average path loss for a separation distance d between the transmitter and the receiver is expressed as a function of distance by using the multi-wall model (MWM) can then be expressed in form [12][13].

$$L = L_{FS} + L_c + \sum_{i=1}^{I} K_{wi} L_{wi} + K_f^{\left[\frac{K_f+2}{K_f+1} - b\right]} L_f \tag{1}$$

$$L_{FS} = 32.44 + 20log(dkm) + n10log\ (FMhz) \tag{2}$$

Where, $L_{FS=}$ Free space loss between transmitter and receiver, $L_{c=}$ Constant loss, $K_{wi=}$ Number of penetrated walls of type *i*, K_f= number of penetrated floors, here I considered as 8 (in ship number of floors is 8), I = number of wall types, here I considered as 2(as in ship I have found maximum two different types of wall made of different types material), L_{wi}= loss of wall type *i*, L_f = loss between adjacent floors,b = empirical parameter

n=is the path loss exponent, which indicates the rate at which the path loss increases with distance.

Some preliminary conclusions may be drawn from the values of n. The path loss exponent is equal to 1 in the engine room of warship. This result can be explained by the presence of metallic walls and ceiling and the absence of significant radio leakage between the engine room and the neighborhood (the access between the engine room and the parking was closed during measurements). The transmitted energy is then kept within the engine room. The engine room is then similar to a reverberant chamber. Moreover, the path loss exponent in the parking is equal to 1.61 which is lower than the free space path loss exponent. This result is explained by the guiding effect of metallic walls and ceiling. However, the difference between the engine room and the parking exponents is explained by the presence of glass windows in the parking walls which allow EM leakage for radio waves. The transmitted energy is not kept inside the parking like in the engine room where the walls are completely metallic. Furniture obstructing the visibility between Tx and Rx explains the larger value of n in the covered passenger deck. Moreover, the path loss exponent in the passenger deck is equal to 2.15[14].

Here, we considered the following values -

$L_{w1=}$3.4dB, $L_{w2=}$6.9dB, L_f= 18.3dB, L_f= 18.3dB, b = .46, F= 2.45 GHz.

A war ship is considered with 109m length, 23m height, 12.8m breadth and eight numbers of floors. Using the above parameters, path loss is estimated for the distance of 1m to 109m and plotted in Figure 1. Here, the constant loss L_c is considered to be 0. It can be seen from the Figure 1 that the path loss increases with increasing the distance as expected. Increasing the value of n also increases the path loss.

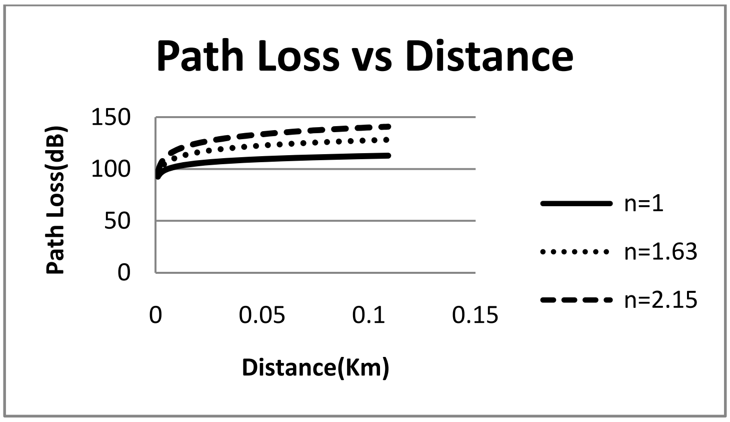

Figure 1: Path Loss estimation for ship for different values of path loss exponent.

In this paper we have considered the transmitted power as P_t = 34.77 dBm [15] and estimated signal strength are plotted in Figure 2.

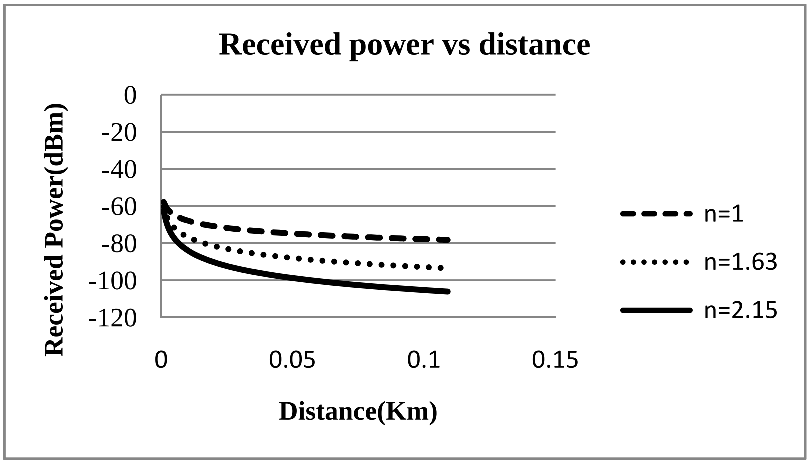

Figure 2: Received signal estimation for a ship for different values of path loss exponent.

3. Conclusion

In this paper, we studied COST 231 indoor propagation path loss model and estimated signal strength in a WSN for three different values of path loss exponent in the parking, engine room and passenger room of 5 different decks of a 109 meter long war ship. It is seen that the signal strength varies depending on the propagation environment and structure of the floors. Special attention must be given to the development of the shipboard sensor nodes because this equipment must resist against hostile environmental conditions in the engine rooms such as temperature, humidity, vibration etc. Future scope includes estimating signal strength in exact node locations and finding out optimum transmission path.

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