Path Loss Estimation & Deployment of Wireless Sensors Nodes in Typical War Ship

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***Abstract:*-Wireless sensor networks are tremendously used in war-ships to perform various monitoring tasks such as cargo monitoring, crew-passenger tracking, environmental measurements, monitoring abnormal operations or disorders of equipment , monitoring of dangerous regions for fire prevention, hull monitoring, surveillance for harbour protection. In the present work, a 109 m long, 12.8 m wide modern War Ship with 8 decks is considered. Path loss variations depending on the path loss exponent in different floors were found out using COST 231 model. The nodes are then deployed in different floors of the ship.**

Keywords- wireless sensor network; war ship communication; propagation path loss; node deployment; path loss exponent.

I. INTRODUCTION

The massive advances of micro electro mechanical systems (MEMS), computing, and communication technology have given rise to the emergence of massively distributed wireless sensor networks consisting of hundreds and thousands of nodes. Each node is able to sense the environment, perform simple computations and communicate with its other sensors or to the central unit. One way of deploying the sensor networks is to scatter the nodes throughout some region of interest. This makes the network topology random. Since there is no priori communication protocol, the network is adhoc. These networks are tremendously implemented to perform a number of tasks, ranging from environmental and natural habitat monitoring to home networking, medical applications and smart battlefields [1]. Wireless sensor networks are an emerging technology for monitoring the physical world.

In a sensor network application, large numbers of tiny sensor nodes may be deployed and collaborated to gather data from the environment [2]. Most applications in sensor networks rely on the knowledge of sensor positions. However, manual location entry results in high deployment cost and is unrealistic in large networks. Sensors collect information about the surrounding environment (sensor field) and they self-organize into a wireless ad hoc network in order to exchange sensed data and to connect with external sink nodes that issue queries to the network. Typical applications of sensor networks are environment sampling, monitoring disaster areas, health monitoring, surveillance, security, inventory management, and they have also been envisioned as an architectural support for applications of pervasive computing.

The models used in the WSN can be classified into theoretical and experimental models. The main experimental models are the Okumura-Hata, Cost231-Hata, and ITU-R model [3]. 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 in n quantitative description of the propagation environments. In addition to the height of T_X, and R_X, 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. COST231 non line off-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 COST231 model parameters to fit it to the measured data. Unfortunately, the COST231 model was developed based on measurements conducted in propagation environments that differ widely from the propagation environment in India. Largely, among all empirical models presented in literature, the COST231 model [4] is considered to be the most accurate and widely used model for outdoor-to-indoor coverage prediction [5]. Deploying sensor node at manual locations, considering the frequency 2.45 GHz is preferred [6] [7] [8]. This paper estimates the path loss for a war ship, whose length is 109m, height is 23m, breadth is 12.8m, and have 8 floors in all 8. It also analyses the node deployment in the warship.

II. ESTIMATION OF PATHLOSS

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. The three environments considered 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) which can be expressed in form,

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

$$L_{FS} = 32.44 + 20log(dkm) + n10log(FMhz)$$
(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, I = number of wall types, L_{wi} = loss of wall type I, L_f = loss between adjacent floors, b = empirical parameter and n= 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 the 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. 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. Moreover, the path loss exponent in the passenger deck is equal to 2.15[9] [10]. Furniture obstructing the visibility between Tx and Rx explains the larger value of n in the covered passenger deck [9] [10].

The studies made and are relevant to warship are as follows: - I=3, in ship it is considered three different types of wall, K_{wi} = 3, L_{w1} =3.4dB (light wall thickness <10cm), L_{w2} =6.9dB (heavy wall thickness >10cm), L_f= 18.3dB, K_f=8(in ship number of floor is 8), b = 0.46, f= 2.45 GHz and d=109 m [11].

Using the above parameters, path loss is estimated for the distance of 109m and plotted in Figure1. Here, the constant loss L_c is considered to be 0. It can be seen from the Figure1 that path loss increases with increasing the distance as expected. Increasing the value of n also increases the path loss.

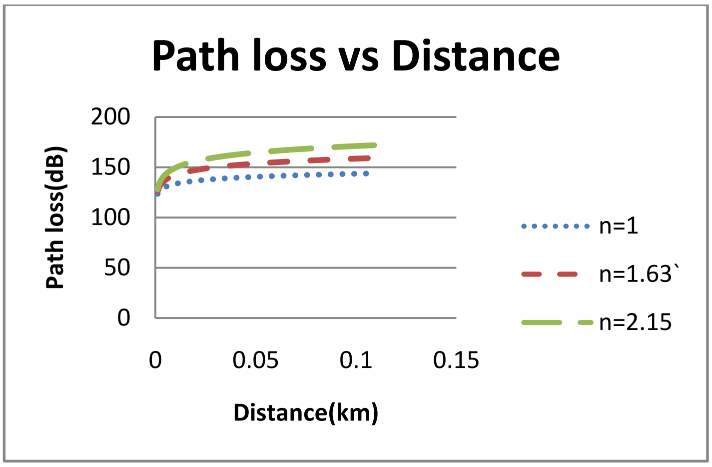

Figure1. Estimated path loss for different values of path loss exponent

III. DEPLOYMENT OF NODES

A war ship with 109m length, 23m height, 12.8m breadth and eight numbers of floors is considered here. Figure3 shows the node deployment and the layout of the ship. The nodes are placed in each deck to sense and communicate with each other even with the base station. The different deck to deck communication takes place through the staircase of each deck having height of 8 ft approx. The nodes are so placed to improve the internal communication such as for communication with the base station with minimum path loss of signal in spite of having noises, vibration at engine rooms and other parameters affecting the signal strength. Deploying more sensor nodes makes the internal communication with great accuracy.

Node deployment facilitates safe and uninterrupted communication. Each deck consists of various compartments i.e. the bottom deck comprises engine and fuel compartments, the upper decks comprise s of cargo, parked vehicles, control room etc. Watertight the doors when closed can cause severe degradation of communication (~20dB). Devices in each compartment will form a WSN cluster. Each cluster communicates with the neighbouring clusters via gateways and the backbone network. Propagation study should be done before the deployment of a WSN to determine the placement of the sensor nodes on shipboard such as diffraction tests with respect to obstacles in the cargo decks, intradeck and interdeck communication tests, analysis of the link quality on each deck, between decks and also in the cargo/container decks. In a node deployment, sensor nodes are judiciously placed on the different decks, relay nodes are placed in the stairways between decks in order to maintain the connectivity between floors, and gateways are employed to connect with Ethernet or Wi-Fi.

In order to maintain the continuity of network connection there is a need for duplication of vital nodes to prevent any kind of discontinuity for node deployment. Obstructions can be alleviated by inserting intervening nodes and exploiting the multi-hop capabilities. Connectivity in the presence of watertight doors can be ensured by placing nodes on both sides of the door. For instance, 30th node of deck1 and 21st node of deck2 have been installed on both side of the water tight door. The engine room of the ship is so designed that partly belongs to deck 4 & 3. The engine room of the ship is so designed that partly belongs to deck 4 & 3. This room is separated by a bulkhead and a watertight door which have both a big glass window. Connectivity between the decks can be achieved by placing relay nodes in stairways .Backbone of gateways are sparsely placed among the different decks in positions where Ethernet or Wi-Fi can be available so as to cope with latency and disconnection issues [12]. It is shown in figure2 that the gateways are interconnected in the given network to facilitate the above issues.

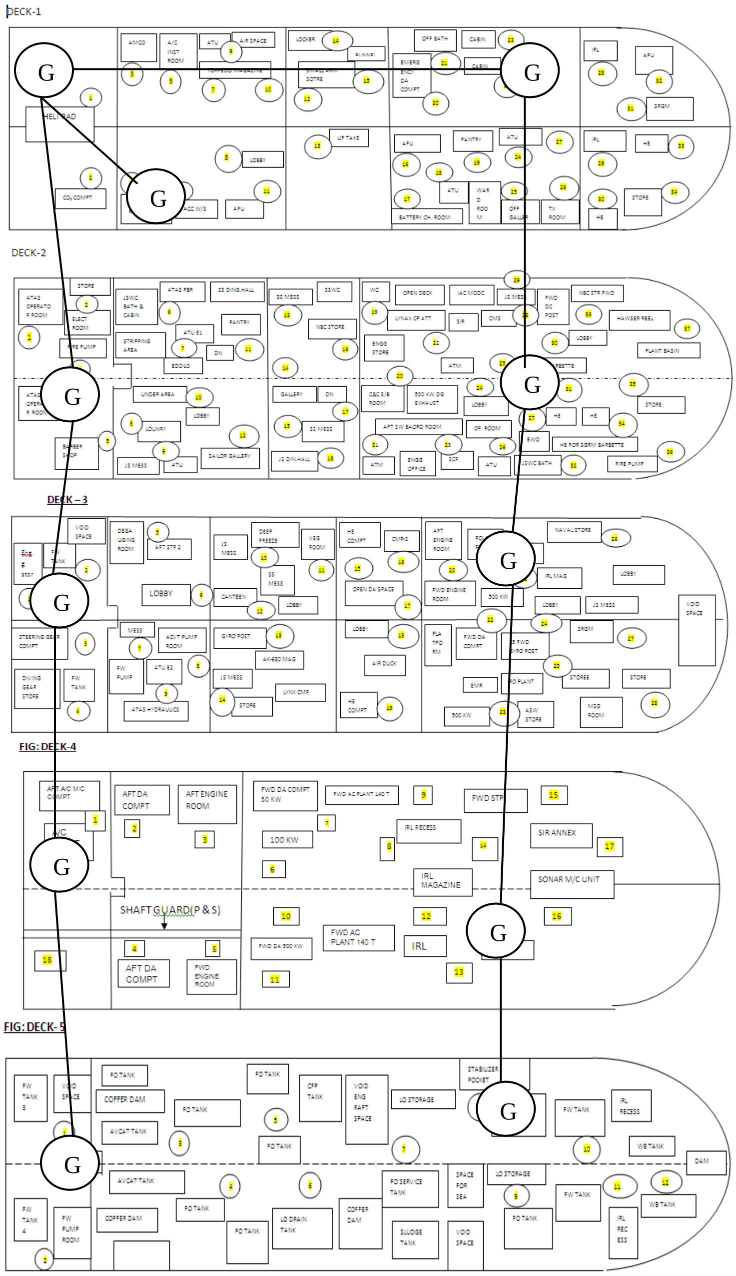

Figure2: The node deployment and the layout of the different floor of the warship.

CONCLUSION

Path loss models for indoor propagation are investigated for multiwall configuration. Path loss for a war ship environment is estimated using COST 231 models for different floors of the ship. It is seen that path loss varies from floor to floor based on the propagation environment and hence path loss exponent. We have then studied the architecture and floor plan of the ship. We have deployed nodes in different floors of the warship. Special attention was given to the development of the shipboard sensor nodes because this equipment must resist against moving machinery, vibrations and radio emissions form a very harsh environment for wireless communications.

Future work includes estimation of signal in different node locations and proposing some energy efficient routing.

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