REACTOR BUILDING INDOOR WIRELESS NETWORK CHANNEL QUALITY ESTIMATION USING RSSI MEASUREMENT OF WIRELESS SENSOR NETWORK

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Abstract

Expanding wireless network reception inside reactor buildings (RB) and service wings (SW) has always been a technical challenge for operations service team. This is driven by the volume of metal equipment inside the Reactor Buildings (RB) that blocks and somehow shields the signal throughout the link.

In this study, to improve wireless reception inside the Reactor Building (RB), an experimental model using indoor localization mesh based on IEEE 802.15 is developed to implement a wireless sensor network.
This experimental model estimates the distance between different nodes by measuring the RSSI (Received Signal Strength Indicator)..Then by using triangulation and RSSI measurement, the validity of the estimation techniques is verified to simulate the physical environmental obstacles, which block the signal transmission.

Keywords
Reactor Building, Localization, RSSI, LQI, Service Wing, Vacuum Building

1. Introduction

Using 802.15 Ad-hoc wireless micro sensor network techniques enables network management features that can be applied in indoor localization model.
In this experiment, a mobile target broadcasts signals and the fixed nodes will receive the transmitted signals and route these data to a master node deployed for data collection.
These 802.15 sensors will control overall data communication from mobile to master node, providing information to estimate the links status and physical model of environmental obstacles. Large volume of obstacles in reactor building blocks signal transmission. 802.15 micro sensor network features will satisfy measured RSSI and LQI information to position the moving target and sensor locations. This calculation will be reversed to find the nodes line of sight in a triangular model. RSSI will mix LQI in a node triangular model to understand nature of the indoor environment and optimize the link with better position for sensors. Master node keeps a record of nodes locations in a local database for the purpose of reverse calculation.

Other industrial measurement methods are using ultrasound or lasers which provide high accuracy, but bigger devices and higher in terms of cost, and energy requirements. These methods considers as not suitable for sensor networks. A ready to launch, low configuration, and inexpensive RF based approach is suitable for this application. In such experimental method it is important to keep power consumption low to run the system for longer period of time. The other available options like 802.11 radios are not suitable for this application, as they are designed to work with high power equipments like PC and IPCs.
IEEE 802.15.4 for low transmission rate indoor wireless area is based on medium access control (MAC) and the physical layer (PHY) protocol for low-power devices. IEEE 802.15.4 is expected to be suitable for wireless sensor networks and is being offered in some products on the market. However, most past studies on localization systems carried out and proved the performance.
Basic studies on RSSI shows that the received signal strength indicator (RSSI) has a larger variation in terms of value because it is subject to the strong effects of fading or shadowing when the signal is facing obstacles. The models based on RSSI need more data collection than other methods to calculate the result more accurately.
Collecting the larger amount of data causes increase to overall sensor network traffic and energy consumption of sensors and normally decreases the lifetime of sensors.

Increasing the data collection time span has a negative impact to online operation. To overcome the mentioned problems and run the system in normal mode, same system that estimates the position of moving targets by measuring RSSI in sensor networks has been examined. Obtaining a three dimensions indoor environmental models with optimum load on master node to pick maximum sample in time period, will increase the number of sensor with a little slower data picking.

This experimental method provides an optimum method to decrease the amount of data collected by master node and extend the lifetime of the sensor networks, each node recognize the number of surrounding sensors and management software will decide received signal as a valid neighborhood node or not valid. Mobile target moves around and nodes switch the validity, then System will replace the invalid nodes with valid ones continuously to keep localizing the most valid node in present situation.

Figure1. Shows the distribution of wireless network antennas inside the reactor building, Service wings and can be used inside the vacuum building as well.

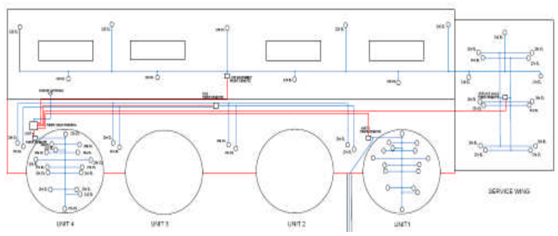

Figure 1 Antenna distribution inside reactor building

2. Localization system model

2.1. Localization in sensor network

This experimental sensor mesh will try to connect to mobile target and master node to estimate the line of sightless. The mobile target is a person with a mobile radio that broadcasts packets. Packet includes the mobile target's location information as the operator enters it using a keypad. Once the sensor receive it, measure RSSI, LQI and send the results to the master node, which calculates and simulates the environment blocking obstacles around the mobile target and sensor network at any checkpoint.

Sensor node placement

Sensor nodes will save their own position during the test. Their position information is saved in master node's database and they can retrieve this information anytime during the test.

Data collection

Sensors will receive packet from mobile target, then measure and log RSSI/LQI into master database. The packet includes mobile target information, packet number and by reading the packet, a sensor gets the location of mobile target in marked checkpoint. Distance between sensor and mobile target will estimate and compare with information in master database, which is the location of both sensors and target. Master node will compare measured RSSI/LQI with desired value, which is saved in master database and will compensate the distance error and estimate better RSSI.

2.2 Effective data collection

Signal propagation characteristics will change depends on the environment. This experiment provides a flexible solution to give mobile target operator more free hands to send a packet out whenever is required by master. The number of data packets introduces certain degree of accuracy in the environment modeling. So, a user can decide about the number of data to be sent based on master node operator feedback. If the resultant accuracy is less than that required for the application, the user can easily increase the number of data packets. A sensor node receives a packet, if it is closer to the target than a certain distance and communication route is clear, but RSSI is weak then it is not in line of sight. Each sensor node measures the density by receiving packets from other nodes to announce their presence in each period of time.

The presence density around sensor is approximately determined by Eq. (1), where R is the communication range and M_i is the number of sensor nodes:

$$D = \frac{M_i}{\pi R^2} \quad (1)$$

By extracting above equation we will get Eq. (2):

$$D_i = R\sqrt{\frac{Z}{M_i}} \quad (2)$$

In this Eq, D_i depends on the presence density around sensor node i. Figure 2, shows RSSI measurement in sensor network.

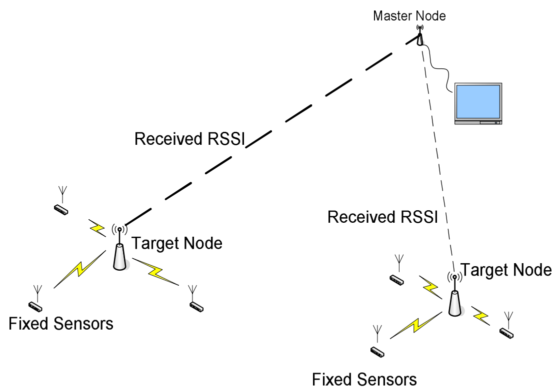

Figure 2 RSSI Measurement using sensor network

In Eq. (3), Z is the number of data to be sent. As Sensor node i send data, if the measured distance is less than actual to enable Master node to collect Z data, then that node mark as not in line of sight. The number of sensor nodes within D_i is depends on the density of sensors:

$$\frac{M_i}{\pi R^2} = \frac{Z}{\pi D_i^2} \quad (3)$$

3. Localization system

To test the experimental model described in the previous section, sensor mesh that performs communication based on the 802.15.4 standard, works with a sensor network management system and a wireless code programming package. The collected data will be sent to a Master node. Network management system also provides a feature to gather information about health and performance of sensors in the field. To watch for specific node performance and actions list, management system will provide an event logger for local and remote storages. This model is working based on single hop communication function and a packet transmitted from a certain node can be received by all other nodes that are located within the communication range. However, the other nodes out of communication range would be able to receive it though the sensor mesh. To make sure that a certain packet is received only by a specific node, each receiving node will check the sender MAC address in the packet. Its important to set the threshold value of RSSI in each sensor A node and then sensor node will decide to retransmit the received packet to master node only when the received signal from a mobile target is bigger then threshold and we can change the number of data to be collected in master node by changing this threshold value.

Figure 3, shows node distribution model for Reactor building, service wing and vacuum building in different levels.

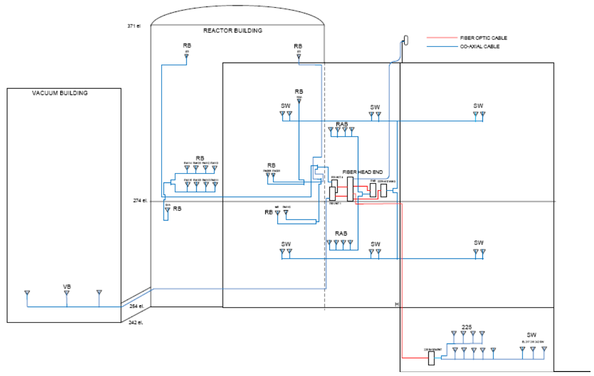

Figure 3 Node distributions inside reactor building

4. Conclusions

Sensor network in this experimental model will be implemented; using low power IEEE 802.15.4 devices with self-diagnostics, quick report back and a low power average network duty cycle of approximately 1%. Each node performs self check and self diagnostics. Using IEEE 802.15.4, benefits the system with link quality indicator (LQI), packet error rate (PER), and received signal strength indicator (RSSI). These additional features will help to estimate the most reliable communication route to the master node finding the clearest path through sensor mesh. Locating sensor nodes and establish a strong communication link regardless of environmental obstacles inside reactor building is an advantage of using this experimental model.

5. ACKNOWLEDGEMENT

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