Implementation of ZigBee Localization Using RSSI Location Cluster

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Abstract
This paper reports on an implementation of localization application using RSSI location cluster. In this system we developed both ZigBee embedded software on real devices and location monitoring software on laptop computer. To collect RSSI data from devices, we use RSSI location cluster, which is a communication interface defined by ZigBee’s standard, and determine position of a mobile user using location fingerprinting technique. The monitoring software is used for visualizing device’s location on a map. Moreover, it can control data collection process during the training phase and performs positioning algorithm. In other words, the software acts as a centralized processing unit of the location system. To evaluate the performance of the system, we use two location performance metrics which are the accuracy and the precision. The results reveal 0.77 meters of accuracy on average and approximately 90% of precision at approximately 3 meters.

Keywords
ZigBee, Localization, Location Fingerprinting, RSSI, Cluster Library

1. Introduction
Localization applications such as patient locating and tracking in healthcare domain are examples of emerging pervasive computing that can be provided by wireless sensor network (WSN) [1]. Over the past 10 years since the formation of ZigBee Alliance, ZigBee has been one of the world leading standards of low cost and low power WSN. Part of the ZigBee’s standard is dedicated to the localization framework, which is called ZigBee’s RSSI location cluster. ZigBee’s clusters are standardized communication interfaces defined between two devices, which consist of a set of attributes and commands [2]. The received signal strength indication (RSSI) is a RF channel’s quality parameter measured directly from the radio interface of ZigBee device that can be used to estimate a location of ZigBee device.

2. System Architecture and Experimental Setup

Figure 1 depicts an implementation of our location system that consists of location node, anchor nodes, and location gateway. Note that these nodes are defined in ZigBee’s telecom applications profile specification [5]. The anchor nodes are fixed and used as reference nodes to estimate the position of the mobile location node. The location gateway node is used to collect and relay RSSI information to the location monitoring software on the computer. The RSSI location cluster is defined in [2] to facilitate the exchange of RSSI between ZigBee devices and to report the RSSI to a centralized server that calculates a location of
mobile node using location fingerprinting technique [4]. In this work, the location estimation algorithm is based on the single nearest neighbour pattern classification. The RSSI pattern collected during the testing phase is compared to the location fingerprints in the database collected during the training phase. The position of a location fingerprint which has the shortest Euclidean distance with the RSSI pattern is returned as the estimated location.

To measure the localization performance of the system, we installed three anchor nodes at the corners of a grid of positions shown in Figure 2. The location gateway was placed at the lower right corner and also acts as another anchor node. The system was defined over the area of 4.2m x 7m. The location fingerprints were collected over 24 positions which were separated by 1.4m. Each location fingerprint is an average of 30 RSSI samples collected during the training phase. The tests were done 50 times per position on all 24 positions.

![Figure 2 Diagram of location system setup.](image)

3. Measurement Results

Figure 3 shows the graphical user interface (GUI) of the application which has a device list, a map of all devices and command menu. The software allows user to collect location fingerprints and estimate node position. When placing a floor plan picture as background image, the user can visualize the location of all devices. Figure 4 plots the performance results based on the error distance. At the accuracy (error distance) of 3m, the system has approximately 90% precision (cumulative frequency). Average accuracy is 0.77m.

![Figure 3 GUI of location application on computer](image)

![Figure 4 Localization performance of the system](image)

4. Conclusion and Future Works.

The localization application was implemented using the standardized communication interface called RSSI location cluster defined by ZigBee's specification. Preliminary results showed a promising localization performance; however, simple location estimation algorithm was deployed and limited measurement experiment were performed. The algorithm, the overall system improvement, and the extensive measurement experiment will be done in the future.

5. References


