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Zigbee Based Indoor Location Tracking System

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ABSTRACT: The objective of this paper is to develop a low cost, scalable indoor location positioning system which can be used to locate the position of moving object in indoor environment. Indoor location positioning system can be deployed in following applications: (a) In schools, to keep a track of children within school premises or to ping teacher remotely in case of emergency (b) In hospital, to identify the location of staff or patient (c) In automatic guided vehicle system etc. Earlier similar systems were developed using wireless technologies like RFID, WLAN and GPS, but each of the technology has its own limitation. RFID technology has limited range coverage. WLAN based location positioning system consumes high power and costs high for high range coverage. GPS system works fine in outdoor environment but gives poor performance in indoor environment. This paper portrays a novel low cost approach for 2D location monitoring system using ZigBee Technology in indoor environment. System uses location fingerprinting method for position estimation. This low cost embedded positioning system consists of low power 8 bit microcontroller, ZigBee module and laptop. K-closest neighbor calculation has been actualized for area estimation over an arrangement of radio area fingerprints gathered in a 2-D space.

KEYWORDS: Wireless Sensor Network, ZigBee, Location Fingerprinting , Embedded system

I. INTRODUCTION

In this approach, mesh network is formed between ZigBee nodes. ZigBee based network comprises of mainly three components (1) ZigBee Coordinator, (2) ZigBee Router and (3) ZigBee End Device. ZigBee coordinator and router device requires continuous power and good computation power, while end device can be a battery powered device requiring less computational power. In system setup ZigBee coordinator is stationary node connected to the PC or laptop over UART where one can track the location of the object. ZigBee routers are the stationary nodes which are placed at predefined locations on the floor. ZigBee routers are connected to microcontroller over UART interface. ZigBee end device are battery powered devices which acts as mobile node in our setup. They send periodic frames over the network.

Location fingerprinting method, two phases are involved (a) Training or Calibration phase (b) Estimation phase. In training phase, signal strength of mobile node with respect to reference nodes is measured at different grid points. In database, for each grid point its X,Y coordinate and signal strength value captured is maintained. Most of the time this captured Received Signal Strength (RSS) from each reference node fluctuates over the time, so it is required to take large no. of samples of radio fingerprints for each location and normalization of the captured RSS values before storing it into the fingerprint database. Hence for noise reduction, this phase is executed multiple times and average signal strength is stored in the database. Database of radio fingerprints in 3D space is created. (b) In estimation phase, run time mobile station's signal strength is tracked. Then it is compared with the values stored in fingerprint database

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created during training phase. K-closest neighbor algorithm will be used to estimate the position of mobile node. Figure 1 shows the research methodology.

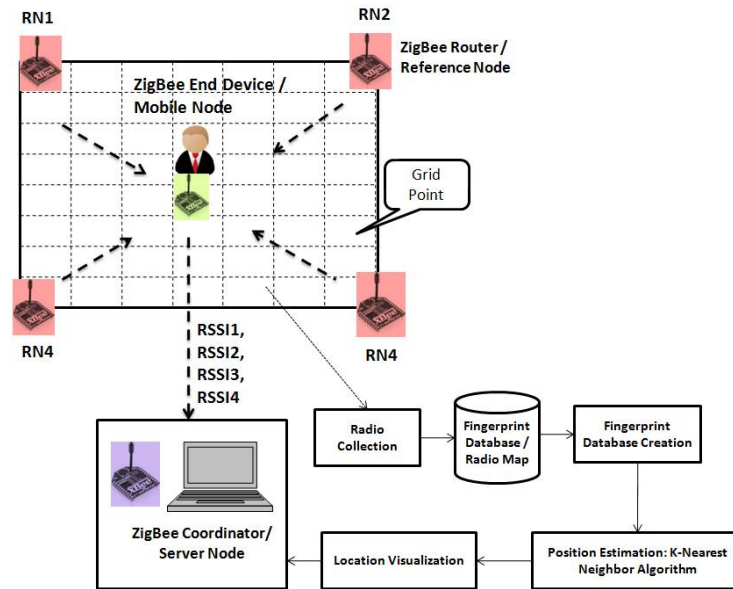


Figure 1: Research Methodology

II. IMPLEMENTATION METHOD

Proposed Model:

In this section firstly we will understand the system architecture components and how roles and responsibilities are divided among these components. For embedded part, XBEE Maxstream modules and PIC16LF1939 microcontroller were used.

A) System Architecture Block Diagram:

Figure 1 represents the system architecture of proposed model. Main elements of the architecture are (a) Server, (b) Base Station/ Reference Node and (c) Client/Mobile Node.

- Server Node(SN): It is a laptop to which ZigBee network interface is provided. ZigBee coordinator device is connected to the server for ZigBee network connectivity over UART. Application developed on server will be used to calibrate the floor and to monitor the location of mobile node from central location. Location fingerprinting algorithm will be implemented on this node. PC based application will be developed using VB.NET.
- Base Station(BS)/Reference Node (RN): This element is made up of Low cost 8 bit microcontroller PIC16LF1939 and ZigBee Router Device. Microcontroller is interfaced to the ZigBee router device over UART. Application running on this microcontroller responds to the commands received from server over ZigBee network. It sends periodic frames to the client. More the no. of base stations, more accuracy could be achieved.
- Client/Mobile Node(MN): This element is made up of Low cost low power 8 bit microcontroller PIC16LF1939 and ZigBee End Device. Microcontroller is interfaced to the ZigBee router device over UART. Application running on this microcontroller calculates the Received Signal Strength (RSS) of reference node and sends it to the server node over ZigBee network. This device could go into the sleep and can be powered from battery source.

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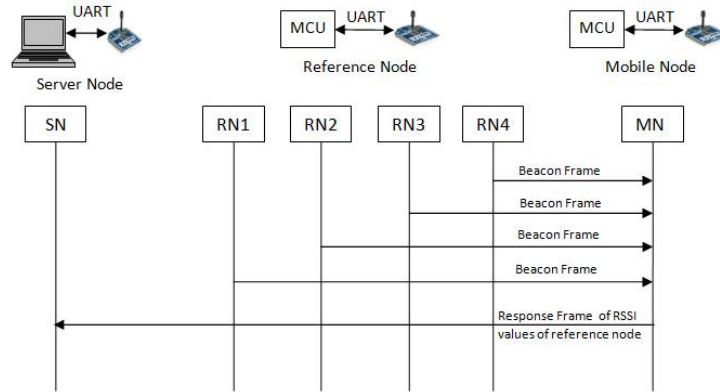


Figure 2: System architecture diagram

B] 2-D Radio Location Fingerprinting

Objective of the proposed design is to detect 2D location of an Mobile Node (MN) within indoor environment. This implementation requires following two phases.

1] Training Phase or Calibration Phase:

In this phase, indoor area where position system is to be deployed is calibrated. Following steps are performed in this phase.

1.1. Divide premises area where location of an object is to be tracked into the grid. Note down the (X_i, Y_i) coordinates of the grid the databases

1.2. At each grid point, measure the RSSI (Received Signal Strength Indicator) value of Reference Nodes (RN).

1.3. As RSSI at same location fluctuates with respect to time so take multiple samples for averaging the RSSI value.

1.4. Store the normalized RSSI values received from multiple reference nodes (RNs) into the fingerprint database with respect to grid point 2D coordinate.

Refer Figure 3 to understand the dataflow of training phase and Figure 3 to understand its high level software implementation flow.

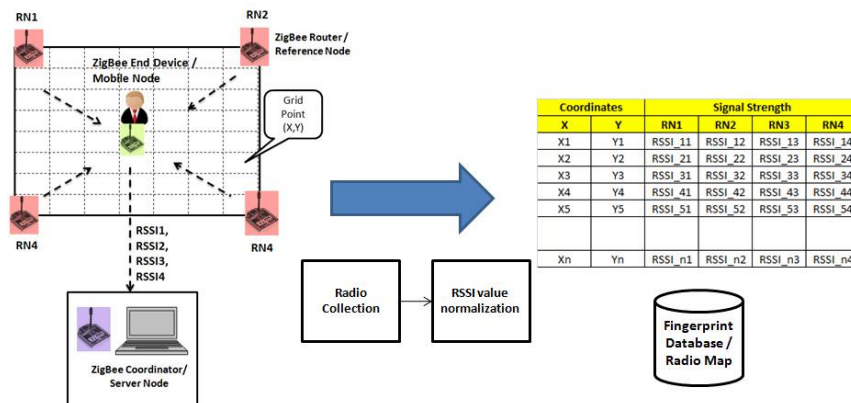


Figure 3: Data flow diagram for Training Phase

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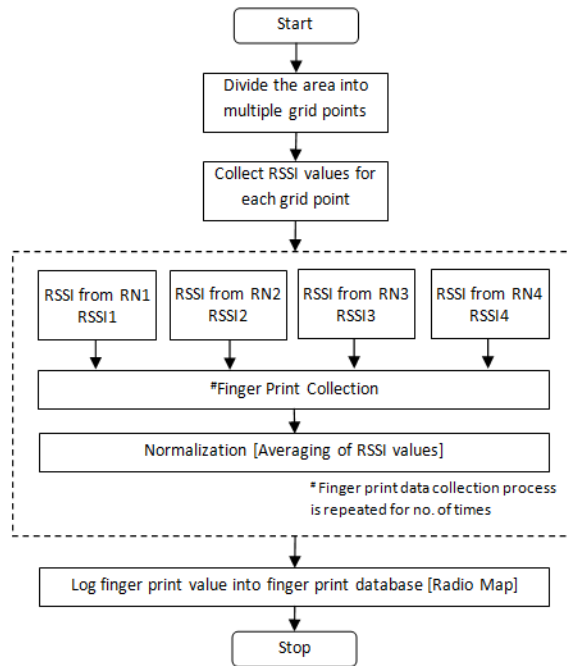


Figure 4: High level software architecture for Training Phase

2] Location Estimation Phase:

In estimation phase, software running on remote laptop system will track the position of object by comparing the RSSI values received run time with those stored in the fingerprint database. GUI developed on the laptop will show the movement of mobile node across the floor. VB.NET software is used for the development of GUI for location monitoring system. Steps followed in location estimation phase are,

- 2.1. Get the RSSI values of reference nodes.
- 2.2. By using K- closest neighbor algorithm estimate the location of a mobile node within area.
- 2.3. Show the location of a mobile node on PC based monitoring software.

Refer Figure 5 to understand the dataflow of training phase and Figure 6 to understand its high level software implementation flow.

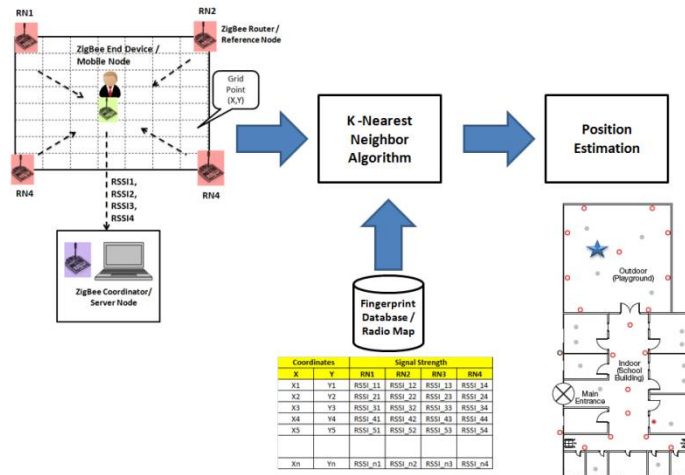


Figure 5: Data Flow Diagram for Estimation Phase

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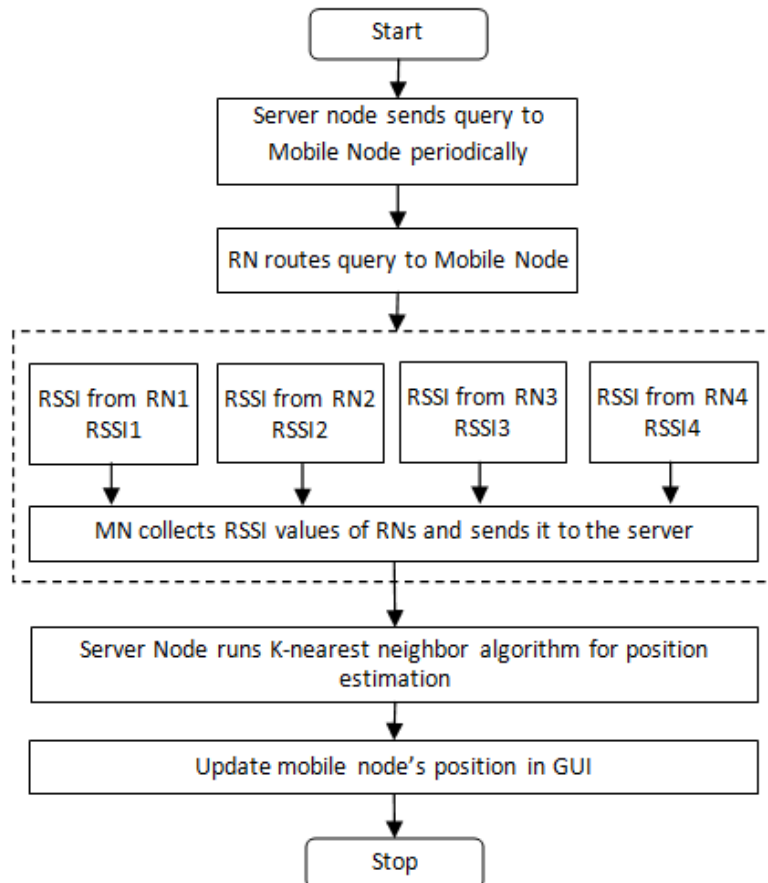


Figure 6: High level software architecture for estimation phase

The fingerprinting approach comprises of a setup or information gathering process in which, the sign qualities at each fixed sensor hub are measured and put away. Every record has the organization of $\{x, y, \text{RSSI}_i\}$, where (x, y) is the grid position in the 2-D space, and RSSI_i is the gotten signal quality in dBm at the i -th fixed hub. N , the aggregate number of fixed reference nodes. To lessen the impacts brought about by commotions and way misfortune, each RSSI_i is the normal of different estimations gathered over a period. The gathering of all estimations shapes a 2-D radio sign quality framework that comprises of the highlighted signal qualities, or fingerprint, at each tested position. Taking after the setup procedure, a portable sensor hub might be confined utilizing the sign qualities measured at each fixed hub. For confining a portable sensor hub, the calculation looks the 2-D radio grid gathered in the information accumulation stage, and discovers the fingerprint that best matches the sign qualities watched. That is, the versatile hub contrasts the watched signal vitality and the recorded, and picks the area (x, y) that minimizes the Euclidean separation as the area gauge. This strategy is additionally alluded to as closest neighbor technique. A slight variation of the procedure includes finding the k closest neighbors in sign space, and averaging their directions to get the area gauge. The accompanying clarifies the strides taken for the setup and area estimation forms utilizing fingerprinting strategy.

III. CONCLUSIONS

Paper has presented a low cost approach for indoor location positioning system to track location of moving object in indoor environment. Mesh networking capability of ZigBee network helps to make network scalable and allows increase the coverage area of location positioning system. Due to low power consumption, and small form factor, mobile nodes can be developed on battery powered embedded platform. Such low cost indoor location positioning



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system can be deployed in schools for keeping a track of children within school premises or to ping teacher remotely in case of emergency or in hospitals to ping a doctor in case of emergency.

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