ZIGBEE BASED CHILD TRACKING IN INDOOR ENVIRONMENTS

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Abstract

Wireless sensor networks (WSNs) comes under a kind of ad-hoc networks where network nodes hold sensors on board and sense diverse factors around deployed region. WSN turns to be extremely popular owing to its diverse applications nature comprising cyber-physical systems, disaster relief, precision agriculture, rescue operation, healthcare and object tracking in terrestrial environment to examine physical factors of space applications, human and so on. Enormous applications utilize sensor nodes based location information as inherent features. This information is more essential to recognize spatial co-ordinates of data origination. Extensively, localization approaches are categorized into range free and range based approaches. In this busy world, it is difficult for the parents to control child movements in crowded places. There is a substantial risk that the child may get lost in the crowd. This has motivated to propose a solution to track the child movement in the crowded area like shopping mall, theatre, Play station etc. This proposed system helps to track the location of the child in In-Door environment using range-based localization technique. RSSI is a parameter used to estimate the child location and communicate its position to parents. Child and parents are considered as nodes, child would be wearing ZigBee and GSM modules which periodically sends signals to the parent node. If the child gets moved away from parent, then parent receive the accurate location of the child and track the children within a range. With the use of distance measurement, position of children will be computed, and location of child is informed to parents.

Keywords: ZigBee, Cyber-Physical Systems, RSSI, Parent node

I. Introduction

WSN is a generic network comprising of smaller sensor nodes (SNs) that may communicate with one another via wireless communication links. Every SN comprises of smaller memory, processing device, radio transceiver and battery for communication. These SNs may gather data, for instance, temperature, humidity and pressure, and carry out some local processing and transmit those data to corresponding neighborhood or beacon node. They are connected to central computer where major processing is carried out. Thus, information may be communicated from central computer to others as a part of huge network. WSN consist of sensor node, sensor field and sink node is shown in Fig 1.
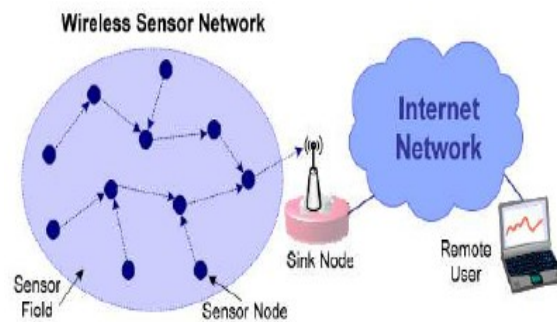

Fig. 1: Architecture of Wireless Sensor Network

WSNs are utilized in diverse applications in both commercial and industrial environments. WSN applications comprise habitat monitoring, object tracking, area monitoring, fire detection and traffic monitoring. Typical characteristics of SNs are smaller sized nodes, dynamic network topology, mobile nodes, harsh operating environments and restricted energy or power resources of nodes may be used effectually, as it is paced at those regions for certain years without available energy. In networking nodes are classifies as Settled nodes (S), Dumb nodes (D) and Beacon nodes (B).

Localization Techniques

There exist diverse localization approaches and accuracy requirements. Localization procedures are generally partitioned into two types [8]: Range free and Range based. The latter utilizes angle estimate or absolute distance estimate which is referred as network node may compute distance from nodes to beacons. It is a conventional approach to compute indoor location. These are Time based methods (ToA,TDoA),Received Signal Strength Indicator (RSSI),Triangulation and Maximum Likelihood (ML) and Angle-of-Arrival (AoA,DoA) estimation.

Received Signal Strength Indicator (RSSI)

RSSI approach is dependent on radio signal attenuates that increases exponentially in distance. Based on receiving power, distance may be computed by translation of power loss with theoretical model.

Time Based Methods (ToA, TDoA)

TDoA and ToA approaches may compute distance by translating propagation time among two nodes with considered signal propagation speed.

Angle-of-Arrival (AoA)

AoA is also termed as (Direction of Arrival) approach that computes position by geometric association with angle where signals are attained. TDoA, ToA and AoA approaches are attained typically by superior accuracy than RSSI approaches, as radio signal amplitude is influenced by environmental parameters.

Triangulation

Triangulation approach is utilized when node direction is computed indeed of distance alike of AoA systems. Nodes location is computed with trigonometric cosines and sines law. In this localization, compared to other techniques RSSI is the best to estimate the location because it does not need any extra hardware for processing and tracks the exact location. Received signal information is utilized to compute location information. It is extremely simpler approach however with least accuracy. All these procedures utilize reference node or anchor node. With competency to anchor node, all other nodes' location are evaluated.

IEEE 802.15.4/ZIGBEE

IEEE 802.15.4/Zigbee is depicted as a standardized communication protocol for Low-Rate Wireless Personal Area Networks (LR-WPAN).It was developed by ZigBee alliance to meet physical needs such as low data rate, low cost, cheap, ultra-low power consumption and easier installation, feasibility and extendable network, unlicensed radio bands utilization and network set-up and message routing integration. This will fulfil automation and remote-control fields based demands. IEEE 802.15.4 operates at three frequencies bands that are ISM 2.4GHZ, 868 MHZ and 915 MHZ respectively. These frequencies operate with 27 channels, in these 16 channels are for 10 channels, 2.4 GHz band are for 915 MHz band, and 1 channel is for 868 MHz band. The ZigBee depicts MAC and physical layer characteristics for LR-WPAN. Physical layer offers physical management service and physical data service and MAC sub-layer offers MAC management service and MAC data serviceas it deals with access to physical radio channel. ZigBee includes three device types that are End device, Coordinator and Router. Coordinator may choose channel for network. End device leaves or joins network and deals application packets. Router is cast off to determinefinest route to networkdestination as in Fig 2.
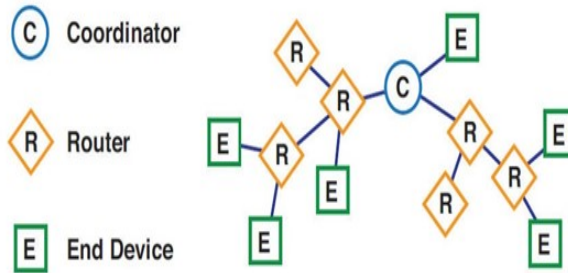
Fig.2: Zigbee Devices

In sensor network the message or data is routed from one to another node based on network topology. Zigbee topologies are classified as: star, tree, mesh. Star comprises of central node which is associated with all other nodes in SN. Messages are passed only via central node. Tree topology consists of top or root node with leaf or branch structure. In tree topology message are passed through top or root node, to reach its destination it travels up/down tree. Mesh looks like tree that is it has tree like structure. But the only difference is some leaves are directly linked with another and the messages travel across tree if correct route is accessibleas in Fig 3.
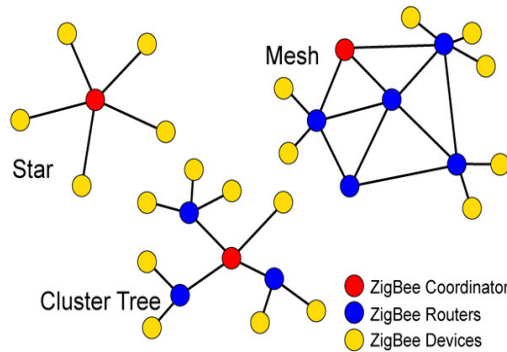

Fig.3: Zigbee topology

The paper is structured as follows: Section I introduces architecture of WSN, localization techniques and illustrates the topology of Zigbee topology. In Section II, various approaches for child tracking is explored and Section III highlights the proposed system. The architecture of the proposed system is dealt in SectionIV, list of modules are dealt in Section V. Results of the proposed system is illustrated and conclusion is presented in Section VI.

II. Literature Survey

In WSN, ultimate localization objective is to demonstrate target location with accuracy. Recently in many occasions' parents miss their children in the crowded indoor environment. Parents concerns about kidnapping probability of children. It is a major defect for parents to take care of their children's always. So, this project is

developed to take care of their children's in indoor environment like in the shopping mall, super market and theme park. The indoor environment tracking can be made using WI-FI, GPS and ZIGBEE etc.

Wi-Fi Based Child Tracking

The child tracking using WI-FI is based on Blue soft's Aero Scout System is real-time location system which is appropriatelypositioned at Wi-Fi and Aero Scout's -based active RFID tags. Here, park guests may provide Aero Scout Wi-Fi Tags with wristband as children may wear it inside park [XII]. If child seems to be separated, parents may transfer text message (i.e., SMS) from mobile phone and acquire automated response about accurate child location. This motivatesthe integration of RFID technology with WSN for tracking in smaller-scale children's park.However with RFID there are numerous disadvantages like:

- RFID technology is harder to understand
- It is less reliable.

GPS Based Child Tracking

It anticipates an Android dependent solution to offer parents to observe their children over real time environment. In recent times, mobile phones are attached with location services competencies for facilitating devices' geographic location in real time. The anticipated solution considers location services benefits offered by mobile phone as most children may carry mobile. Mobile application utilizes SMS and GPS services to determine Android mobile phones. It facilitates parents to sense their children location over real time map. System comprises of two sides, parent side and child side. The significant duty of parent side is to generate location request based SMS to child's device to attain child location. However, in child side, the responsibility is to respond with GPS location based on request from parents'. Solution anticipated in this work is to consider benefits over rich characteristics provided by Android smart phones.

System architecture comprises of two components, GSM telephony services or GPS satellite. The anticipated system is based on two essential services, location and telephony. Therefore, eradicating the internet connection need or dedicated server as depicted in Fig 4.

Fig. 4: Child tracking architecture using GPS

In parents' side, android phone is utilized by parents, where SMS is cast off for communicating with children using GPS[IV]. However, children side acts as a client system. Client side is also android smart phone, however owned by child to be identified. Child side utilizes SMS for transmission with parents and location services, network or GPS to acquire children location in coordinates form. In child side, location services and telephony are facilitated and ends on running child side system for performing functions. This system has many drawbacks like, it needs internet connectivity always, GPS will not work well in the In-door environment and the children should always carry a mobile phone along with them.

III.   Proposed System

In this busy world, it is difficult for the parents to control child movement's in crowded places. There is a substantial risk that the child may get lost in the crowd. This has motivated to propose a solution to track the child movement in the crowded area like shopping mall, theatre, Play station etc. The proposed system helps to track the location of the child in In-Door environment using range based localization technique. RSSI is a parameter used to estimate the child location and communicate its position to parents. Child and parents are considered as nodes, child would be wearing Zigbee and GSM modules which periodically sends signals to the parent node. Through RSS, distance is estimated.

Localization Phase

The localization of mobile devices can be done by using WSN by evaluating RSSI. There are diverse environmental conditions that influence RSSI values to compute device position. Even though device seems to be motionless, RSSI values acquired may vary at anytime considerably, by varying environmental conditions. System functionality comprises two essential factors: localization and calibration[VI]. Requested node's location is computed in central server, and distributed to network. Central processing server facilitates complex algorithm implementation, while ZigBee network facilitates gathering signal level values and similarly it is utilized to

offer data to central server for localization computation. When blind node requires localization, system carry out calibration, thereforeenvironmental changes are measured in localization phase, and therefore making system accurate and robust.

There exist two kinds of system nodes, reference and blind nodes. Former is configured as ZR and generate route messages, network scope is larger. Blind nodes are configured as ZED as it assists nodes to locate, however it may be configured as ZR too. This isessential to execute cooperative localization, where blind node whose position is known (as it is estimated previously), works as reference node, that reports system with signal levels that is attained from another blind nodeto be located. Former is deployed in entire scenario and corresponding position is known.

Blind nodes are located once,however, there is no coordinator node associated with PC where anticipated centralized positioning algorithm functions. Coordinator is accountable for maintaining and initiation of network, as messages are exchanged to computer where it is processed. Asthese nodes possess computational limitations, energy and system performance will be increased.

GSM Module

GSM is mobile communication modem stands for global system for mobile communication. It is a digital and open cellular technology for transmitting data services and voicethat operates on 850MHz, 900MHz, 1800MHz and 1900MHz frequency bands. It was developed as digital system with time division multiple access (TDMA) for communication. Itdigitizes and reduces data, and sends to channel with two diverse client data streamsin own time slot. Digital system possesses an ability to hold 64 kb to 120 Mbps. In this proposed work, the GSM is cast off for transmitting location of the child to parents mobile. The GSM will be attached with the ZIGBEE device wearied by the child. The other ZIGBEE devices will locate the spot of the child and it passes the location to the parent.

IV. Architecture

This system is based on RSSI technique; even there prevails diverse signal measurement. It may add system complexity and it is expensive. However, it is a parameter that is acquired from messages exchanged among ZigBee.There exists two phases: calibration and localization phase is in Fig 5.
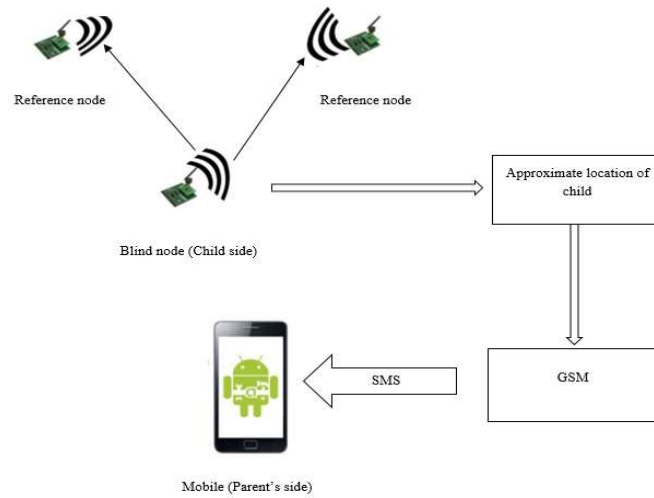
Fig. 5: Architecture diagram

In calibration process, system computes message RSSI that every reference node transmits to others from fixed location. Relationship among RSSI and geometric distance between every referenceare considered. In ZigBee, there are 3 nodes, coordinator, routers and end devices. In coordinator, prediction commences from network and receives every message to process it in PC, reference nodes functions as router devices and blind nodes also holds router profile. Nodes transmit messages to others, therefore RSSI values requireonly positioning system. Reference node transmits 8 messages blast to other reference node. To validate RSSI value, mean value is with 8 messages. Same condition occurs in localization phase, where blind node transmits 8 messages blast and RSSI mean values are calculated. In Localization, system measures RSSI of messages that every reference node transmits to others from fixed position. Relationship among geometric distance and RSSI of all references are considered. This may have four reference nodes for communication with one another thatcomputes RSSI value. To locate blind node location (child), ZIGBEE communicates with child with reference nodes and recognizes location by validating reference node in shortest distance.Once the location of the child is taken, it should be communicated with the parent. For communication, the GSM module is being used. The GSM module will be attached with the XBEE device wearied by the child. The GSM module collects the information about the location of the child and transfer that information in the form of message to the parent mobile.

V. List of Modules

- Distance/angle estimation
- Position computation
- GSM module

Distance/Angle Estimation:

This component is responsible for estimating information about the distances and/or angles between two nodes. This information will be used by the other components of the localization system.

Position Computation:

It is accountable for node's position computationbased on information available that concernsthe reference nodes position and distances/angles. It is an essential localization system component. It describes how information available is manipulated to facilitate or all WSN nodes for estimatingits positions.

GSM Module:

GSM module is communication device. It is cast off to broadcast message of child position to parent via SMS is provided in Fig 6.
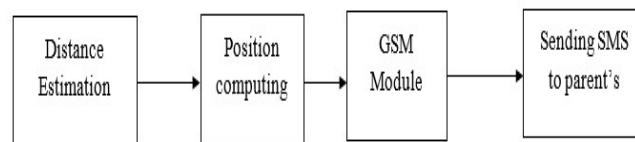

Fig. 6: Modules of localization

Distance/Angle Estimation

Distance/angle computation comprises distance or angle reorganizationamong two nodes.This computationcomprises of essential localization systems components, as it isutilized by position and localization components. Various approaches are cast off to compute this information. Some areextremely accurate, however with superior costs (energy, hardware and processor resources), whilst others are least accurate however available already overSNs. In following sections,some essential techniques arecast off by localization to evaluate distances/angles.

RSSI is cast off to compute distance among two nodes dependent on signal strengthattainedfrom another node. Hypothetically, signal strength is inversely proportional to squared distance, and termed as radio propagation which isutilized to transform signal strength to distance. Moreover, in real-world scenarios, this indicator is extremely identified with obstacles, noises and antenna types that arecomplex to mathematically design it. Here, it is usual to perform system calibration, where RSSI values and distances are computedwith time in over controlled circumstances.

Position Computation

Whennode possesses appropriate information regarding angles and positions, it may evaluate own position with one amongst thesetechniques. Numerous approaches are utilized to evaluate nodes' position. Theseapproaches comprisemultilateration, trilateration,probabilistic approaches, triangulation,bounding

box, and central position. Selection of these approaches is to use final localization system performance. Choices arebased on available information and processor's restrictions.

Trilateration is considered as intuitive and basic approach. This technique evaluates node's position via three circles intersection. To compute trilateration based position, node has to recognize three reference nodes position and distance from other nodes. Bounding box approach is anticipated in squares indeed of circles as in trilateration to bind probable nodes position. Last error is higher than trilateration, evaluating squares interestwithleast processor resources than computing circles intersection. Angles based triangulation information is utilized indeed of distances. Position evaluation isperformed remotely by node itself. This algorithm is posse's essentiallocalization system components. This component depicts how information associated with positions and distances is manipulated to facilitateallWSN nodes to compute its positions. Thisis classified as: without or with infrastructure,centralized or distributed position, absolute or relative positioning, outdoor or indoor scenarios and multi or single hop.

GSM Module

GSM is mobile communication modem stands for global system for mobile communication. It is a digital and open cellular technology for transmitting data services and voicethat operates on 850MHz, 900MHz, 1800MHz and 1900MHz frequency bands. It was developed as digital system with time division multiple access (TDMA) for communication. It digitizes and reduces data, and sends to channel with two diverseclient data streamsin own time slot. Digital system possesses an ability to hold 64 kb to 120 Mbps.

In this the GSM is used for transmitting the location of the child to the parents mobile. The GSM will be attached with the ZIGBEE device wearied by the child. It passes the location of the child to the parent.

VI. Result and Discussion

At first, XBEE will be attached in a fixed position in Shopping Mall, in every room. XBEE attached with the GSM module will be wearied by the child. Fig.7 and Fig. 8 show the whole connection of this project, where one XBEE will be connected to the fixed position and another XBEE will be wearied by the child, after estimating the distance, it will send the SMS to the parent. Both the XBEE and GSM are connected to the Arduino for transmitting and receiving data.

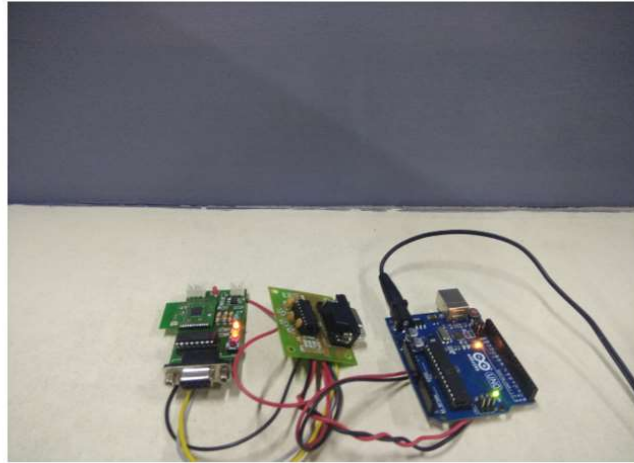# COMPONENTS INSTALLED IN INDOOR ENVIRONMENT

Fig. 7: Components installed in Indoor environment
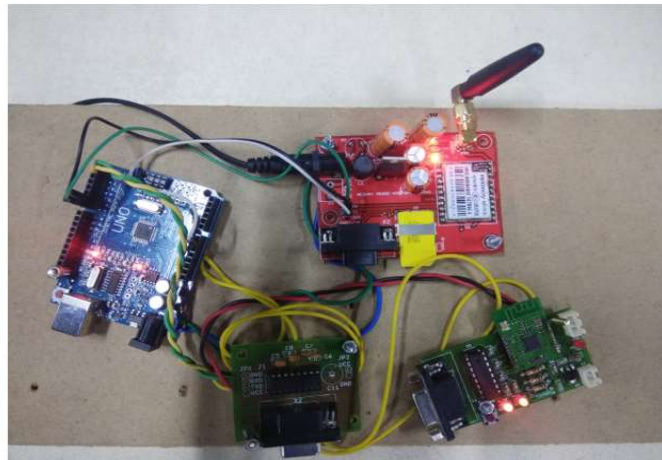
CHILD WEARABLE DEVICE

Fig. 8: Child wearable device

Distance Estimation

When the child moves away from the parent, the XBEE wearied by the child will communicate with the fixed position XBEE in the shopping mall and estimate the distance between them using RSSI value as shown in Fig 9.

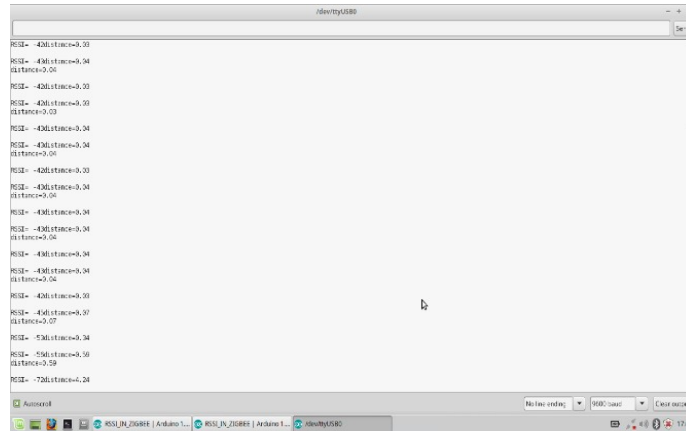**Fig. 9:** RSSI Value

Once the distance is estimated, it will notify the location of the child using the GSM module connected with the XBEE wearied by the child.

Sending Message to Parent's

The parents phone number will already be registered in the XBEE. The distance from the fixed XBEE to the child will be given as the message to the parent as shown in Fig 10. XBEE is fixed in the fun station in shopping mall in the fixed position, once the child walks away, the distance is sent as SMS to parent.
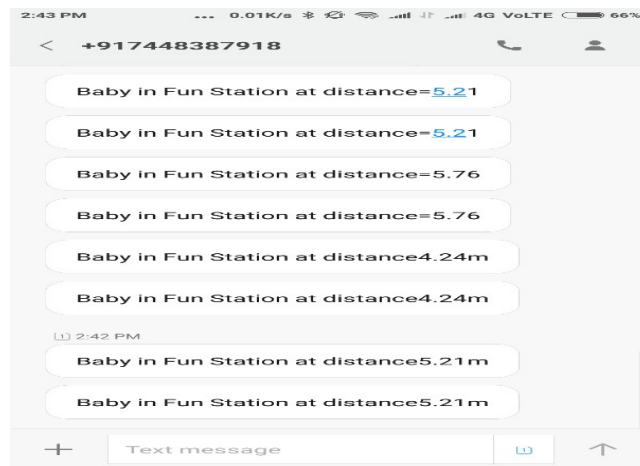

Fig.10: Message Received by the Parent

VII.   Conclusion

WSN is flexible and extremely possess superior features like High sensing fidelity, fault tolerance, low cost. In this proposed system the ZIGBEE is used as a location estimator in the indoor environment. This system is used to identify the

location of a child when it gets lost in indoor environment like the super market or the shopping mall. Parents would be intimated about the child location using GSM module. The proposed method has acquired promising outcomes, as indoor positioning systems are far to provide superior outcomes; they needhuge pre-processing and does not consider environmental changes automatically. There is another consideration that needs to be taken care of, the ZIGBEE device used in this project has a limited distance range of hundred meters. While using it in large indoor environment like the shopping mall, there is a need for placing many ZIGBEE devices around it which increases the cost.

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