The Development of Wireless Personnel Positioning in Internet of Things Based on ZigBee and Sensors

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Abstract

Internet of Things, also known as the sensor network, refers to the combination of the network formed by a variety of sensing devices, such as radio frequency identification devices, infrared sensors, global positioning systems, laser scanners and other devices with Internet. ZigBee technology is an emerging short-range, low-rate wireless network technology; it is a cross between technology and Bluetooth wireless markup of the technical proposals. The paper proposes the development of wireless personnel positioning in Internet of Things based on ZigBee and sensors.

Keywords: Internet of Things, ZigBee, Wireless Personnel Positioning, WSN

1. Introduction

ZigBee is an emerging short-range, low-rate wireless network technology, wireless sensor networks, and other occasions, a wide range of applications. ZigBee device power consumption and costs are low, so you can ensure that the ZigBee-based positioning system can achieve long accurate positioning at a lower price [1]. In addition, the ZigBee network integration support for mobile ad hoc networks, the whole system to build flexible, infrastructure construction less, to achieve the rapid deployment of the positioning system in a variety of complex environments. Positioning is an important supporting technology for the wireless sensor network (WSN) has a wide range of applications. ZigBee technology is a short-range, low power, low data rate; low-cost two-way wireless communication technology can be embedded into various devices, and support geo-targeting capabilities. ZigBee technology used in wireless sensor network is a focus of the present study, targeted research and application of technology has also been widespread concern.

Wide ranges of applications of wireless sensor are in order to the rapid development of positioning technology. TI has introduced a band hardware location engine targeting system on a chip (SoC) solutions CC243l 3 ~ 5 m positioning accuracy and resolution of 0.25 m can be achieved in typical applications, due to the lack of flexibility in positioning algorithms have been cured, resulting in its application [2]. On the other hand, the combination of software algorithms using common wireless transceiver device positioning has attracted widespread attention.

The Internet of Things is the object of identification, perception and intelligent processing capabilities, with the interconnect from the network of communications technology. Without human intervention to achieve synergy and interaction, it is aimed at providing people with the intelligence services. Internet of Things can be widely used in the monitoring of the various natural disasters, health care, electric field, the United States, Japan and other countries to invest heavily embarked on its technology, and established or are establishing a national perception center. At present, China is also to build their own sensor information center is no doubt that the Internet of Things is entering a period of rapid development with the development of the Internet of Things, sensor technology has received extensive attention and application, which constitutes the wireless sensor networks(WSN) can be connected to the physical world and digital world [3]. At present, the existing research work for environmental monitoring and protection, as well as discover and locate the source of the accident, aviation and aerospace placement control, the positioning of military targets and tracking in various applications, location information is critical to the monitoring activities of Things, though by the global positioning system GPS (global Position system) for positioning, but adapted to the unobstructed outdoor environment. And the user node is usually high energy consumption, large volume, high cost; you also need a fixed infrastructure.
As the duty cycle is very short, and send and receive information on low power consumption and sleep mode, the ZigBee technology can ensure that the two AA batteries for up to six months to two years of use, of course, different applications the power consumption is different.

Internet of Things, also known as the sensor network, refers to the combination of the network formed by a variety of sensing devices, such as radio frequency identification devices, infrared sensors, global positioning systems, laser scanners and other devices with Internet, and its purpose is to enable all items are able to remote sensing and control, combined with the Internet into a more intelligent system of production and living [4]. The Internet of Things is an extension of the Internet. As the forefront of the intersection of Things at the same time involving a variety of techniques of chips, sensors, embedded intelligence, wireless transmission and real-time data exchange.

Composed of wireless sensor networks (Wireless Sensor Network WSN) deployed near the observation environment of a large number of micro-cheap low-power sensor nodes, sensing, and data processing and wireless communication capabilities through the formation of multi-hop self-organizing wireless network systems. It is independent of the base station to mobile routers and other communications infrastructure, since a network of distributed protocols. Wireless sensor network through various integrated micro-sensor collaboration, real-time-aware acquisition and monitoring of various types of interest to research information and application information, information processing by the embedded system, and by random self-organizing wireless communication networks. Hop relay information transmitted to the user terminal.

This paper describes the hardware and software design for wireless sensor positioning system, the positioning system can take advantage of the software method to achieve high positioning accuracy. Reduce the requirements on the positioning hardware. Wireless sensor positioning system maintained at a lower cost. From the actual test results show that: the positioning system is practical and easy to achieve. The paper proposes the development of wireless personnel positioning in Internet of Things based on ZigBee and sensors.

2. The research of wireless sensor networks

2.1. Wireless sensor network management technology

Network management is to control a complex computer network it has the highest efficiency and productivity of the process. The network management system typically includes data collection, data processing, and then submitted to the administrator for use in network operations. It may also include analysis of data and provide solutions, and further it can generate useful reports on the administrator to manage network. It has five aspects of failure management, configuration management, security management, performance management and billing management function.

The number of nodes in wireless sensor networks using random delivery method laid, the location of the node can not be predetermined; tissue formation through the wireless communications network in any time between the nodes; between nodes has strong collaboration capabilities through local data collection the data exchange between the pretreatment and the node to complete the global task [5]. Thus, wireless sensor networks is a central node distributed integrated monitoring, control and wireless communication network system, its own unique characteristics.

Characteristics of wireless sensor network management of wireless sensor networks different from the traditional network management [6]. The following describes the management needs of wireless sensor networks, wireless sensor network management model, and from several aspects of the model is a comparative analysis of obtained the development trend of the wireless sensor network model.

Management of wireless sensor networks is designed to provide an integrated management system to effectively monitor and control the remote environment or entity, with less energy consumption of network resource allocation, performance, fault, security and communications unified management and maintenance.

2.2. Overview of WSN data collection

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Wireless sensor networks, sensor nodes collect local perception data, to deal with these perception data will be useful information to the base station [7]. The wireless communication distance of the sensor nodes is relatively small, usually wireless sensor network is a multi-hop transmission to transmit data to the base station usually has to go through the middle of other sensor nodes forwarding. In wireless sensor networks, usually the sensor node is both a data generation node, a routing node; this is not the same with the traditional network. Base station to collect useful information from the wireless sensor networks, wireless satellite, Internet or other means to transfer this information to outside information systems, and results show the analytical processing of the information system to the user. According to different application requirements, and so on to monitor the regional real-time monitoring can also be data analysis and processing for research, as is shown by figure 1.

![Data collection node in the scheduling model](image)

**Figure 1.** Scheduling model based on node coverage and delay data collection Architecture

Scheduling, scheduling sensor nodes to the node and its perception range to form a cluster, the data collected with the sensor nodes in the cluster are interrelated, so, in order to save the network energy scheduling cluster nodes take turns to enter the work. To set up a cluster of sensor nodes, the data collection time is divided into time slices, each node in the cluster at a time the film is only a working state, and the remaining nodes in a dormant state, each data collection cycle, the node is active time (time slice size), if the length of each time slice is fixed, different clusters have different data collection cycle, the value of the cluster size as a proportion of the relationship between changes in scheduling a cluster, Sink node is randomly selected scheduling order, the scheduling information sent to the sensor nodes.

In view of the reduce energy consumption is the most important aspects to be considered in the design of wireless sensor networks, studies have shown that: routing protocols and MAC protocols for wireless communication module energy consumption plays a key influence. Therefore, the MAC layer and routing layer is a hot research field of wireless sensor networks [8].

Sensor network may include a large number of different types of sensors, sensor resources and communication resources, computing resources in the network is closely integrated with network management is also combined with sensor resource management, some scholars from the sensor management the angle of the corresponding algorithm.

### 3. Zigbee-based wireless sensor network positioning technology

#### 3.1. Introduction to ZigBee networks

Communication between the sensors of WSN sensor hardware platform is responsible for the transmission medium, the ZigBee as the main backbone, and supplemented with RFID to extend the range of applications. In accordance with the IEEE 802.15.4 defines ZigBee, the working frequency band can be divided between the general 2.4GHz of 868MHz in Europe and the U.S. 915MHz, the transmission distance of not more than 75 meters, the transmission rate between 20kbps ~ 250kbps. ZigBee chip in the transmission power consumption can be controlled at below 27 mA, the standby can be reduced to 0.3μA, low-power standby mode, use two batteries can drive as long as six months.

Zigbee for its features and cost advantages of the network topology can be used as the intermediary of the Wi-Fi and RFID. The ZigBee Smart Energy 2.0 standard is already integrated and Wi-Fi, and
further application in the field of home smart grid (Smart Grid) to expand the scope of the integration of wireless sensor networks [9]. ZigBee can combine the strengths of RFID identification, in order to achieve materials management, tracking and positioning purpose. ZigBee + RFID tag costs than passive, but remain a long transmission distance (hands-free), adjust the hazardous area sensing range, can transmit temperature data, can be people and goods location management. The most important thing is, RFID + the ZigBee can simultaneously monitor a large number of labels.

Wireless positioning system develop CC2430/CC2431 precision mesh networks based on ZigBee protocol stack. 0.25M accurate wireless positioning resolution can be achieved based on the use of the environment can be achieved 1-5 m positioning error, and fully support efforts to improve the anti-collision mechanism of the ZigBee network and the network topology[10]. The positioning of the system node will automatically calculate the exact location of display monitoring unit, the integrated use with any PC, PDA and other mobile terminals and other equipment and any SCM system. 3-12 reference node, constitute one of the biggest area of 64X64 meters wireless positioning network. 802.15.4/ZigBee wireless communication standard between the reference node, maintaining wireless contact can be achieved through the PC software to configure the wireless parameters of the reference node.

WSN sensor nodes (Sensor Node) of the wireless gateway (Wireless Gateway), PC / of NB, and data processing centers (Data Server). WSN by with communication capability, cloth was built in the living surroundings tiny sensors, sensing physical or chemical change of the target, the use of ad hoc networks (Mesh/Ad- Hoc Network) the information passed to another a sensor, then the information is transferred to the Wireless Gateway, and then the data passed to the vicinity of the PC / NB, and then transfer data to the Internet, allows users to remotely monitor control target changes in information, and make related coping as a sensor network.

3.2. WSN positioning node hardware based on ZiGBEE design

Positioning node hardware is designed framework. The hardware design is divided into two parts: the wireless communication module design and the design of wireless test modules. Wireless communication module providing an interface for wireless data between nodes, it is a node in the core part[11]. Wireless test module via the RS232 serial converter circuit data transmission between the PC and the coordinator node.

Locators can communicate with each other to deliver a wireless signal to form a network of wireless monitoring, personnel wherever they go, its near the locator label to send wireless signals can be received. Personnel locator card (label) sent information to the control center computer, the computer screen showing the current location of the staff, as is shown by figure2.

![Figure 2. Z-Pos Positioning System Architecture](image)

Compared with the Bluetooth, it is in order to ZigBee highly scalable. ZigBee data transmission module is similar to the mobile network base stations, wireless network platform is a wireless module can be up to 65000, the entire network within a ZigBee network module can communicate with each other, each network node distance of 75m from the standard infinite expansion. CDMA network or GSM network and mobile communication, ZigBee network established for the automated control of data transmission, so it must have simple, easy to use, reliable, low prices. The mobile communications network for voice communications, the value of each base station is generally more expensive, the
price of each ZigBee "base station" only one percent of the mobile base station to the thousandth. Each ZigBee network nodes not only in itself can be used as the monitoring object, for example, the sensor it is connected directly to the data collection and monitoring, can also automatically transfer the data passed over by other network nodes. In addition, the child nodes of ZigBee network nodes also within the scope of their coverage, and more commitment to the network information transfer tasks isolation wireless connection.

Sense of intellectual ZigBee (CC2430 / 1) Professional Development Kit is the design and development of wireless network technology based on IEEE 802.15.4 and ZigBee standards, is a sense of intellectual team of engineers with TI chip characteristics with many manufacturers technical features designed to a high cost systems.

Zigbee can be up to 65,000 wireless data transmission module consisting of a wireless data transmission network platform in the entire network within a Zigbee network data transmission module can communicate with each other, the distance between each network node can unlimited expansion of the standard of 75m.

CDMA network or GSM network and mobile communication, Zigbee network is established for the industrial field automation and control data transmission, and therefore, it must be simple, easy to use, reliable, low prices. The mobile communications network for voice communications and establish the value of each base station is generally more than one million yuan, while each Zigbee "base station" but less than 1000 Yuan. Each Zigbee network nodes not only in itself can be used as a monitor object, for example, the sensor it is connected directly to the data collection and monitoring, can also automatically transfer the data passed over by other network nodes. In addition, a Zigbee network node (FFD) can be within the scope of their coverage, and more does not assume network information transfer tasks orphaned child node (RFD) wireless connection.

3.3. ZigBee wireless network technology in Internet of Things

Internet of Things is a very large network, it is inclusive, involving all walks of life, and its essence is to make everything connected through the network to achieve many of the super-intelligent application. This is the infinite vision of a people a better future, and to achieve it will have to down to earth from the basics [12]. The sensor network is to build the Internet of Things basic network sensor as the perceived front-end to detect and collect the signal, then a variety of wired and wireless communication technology for the exchange of equipment between communication. And optical fiber, ADSL, 3G and Wi-Fi networking, the main artery, while the last 100 meters of the short-distance access is achieved through short-range wireless communications technology, Zigbee is considered the most suitable sensor network access side of the wireless communication technology, as is shown by figure3.

Figure 3. Structural model of ZigBee wireless network technology in Internet of Things

Overall Internet of Things platform called sensor network, and families in a variety of gateways, sensors, cameras and other terminal through Zigbee access to the platform, and then access the Internet via 3G, Wi-Fi. Home users can directly use mobile phones connected to the gateway via Wi-Fi to control the home of a variety of sensor terminals, not at home when the through registry sensor network portal using a mobile phone or computer to easily view and control a variety of sensors at
home terminal[13]. In this spectrum, it is 3G and Wi-Fi networking artery, while ZigBee is to connect the sensor terminal capillaries.

4. Wireless personnel positioning in internet of things based on zigbee and sensors

A large number of ZigBee-based wireless user application will use the best design of IEEE802.15.4 compliance SoC silicon devices, which can reduce the cost and design complexity of applications, without taking into account the technical specifications of the IEEE802.15.4 / ZigBee technology. Real SoC solutions that integrate all functions (such as a wireless transceiver, data processing unit, memory and user application function) to single silicon chip, functional, cost and significantly faster superiority [14]. To achieve low power performance with dedicated on-chip functions internal to minimize overhead. Minimum system BOM, smaller footprint and fewer components, it is simpler assembly and testing, as well as easy and reliable design low manufacturing costs and fast-listed features.

ZigBee is suitable for a large number of applications, including industrial monitoring and control, family, and building automation, sensor networks, medical and automotive programs. ZigBee wireless technology is built on the IEEE 802.15.4 standard, designed to provide economic, standardized, and flexible wireless network to provide low-power, low to moderate data rate control and monitoring applications, reliability, work together, and security support. The ZigBee Alliance also provides interoperability and conformance testing specifications. The ZigBee network layer, it is responsible for device discovery and network configuration, and supports three network topologies (star, tree and mesh).

Wireless Sensor Positioning System SCADA software and location-related features include two categories: positioning project management, and positioning information processing. Positioning project management to complete the reference coordinates of the nodes load the targeted area diagram and configuration information [15]. Positioning information processing is completed the data acquisition, data processing functions. Specifically, the positioning project management needs to include the following three aspects: 1) load the floor plan of the targeted area, the user-specified target scenes to choose the schematic diagram of the targeted area of bmp, jpg, gif format; 2) configure the reference node information, user configuration in the project, the reference node and set the reference point, marked the location of the reference node in the targeted area diagram; 3) save and modify the project, to save and modify the project information at any time.

ZigBee technology is an emerging short-range, low-rate wireless network technology; it is a cross between technology and Bluetooth wireless markup of the technical proposals. ZigBee, based on IEEE 802.15.4, IEEE wireless personal area network (Personal Area Network PAN) Working Group on a standard known as IEEE 802.15.4 (ZigBee) technology standard. ZigBee technology with low power consumption, time is short, network capacity and security advantages, have a unique advantage in the short-range, low power, wireless communication, ZigBee technology applied to a small range of control and automation based on wireless communication areas, as is shown by figure4.

Figure 4. Structural model of ZigBee wireless network technology in Internet of Things
This paper describes the hardware and software design for wireless sensor positioning system, the positioning system can take advantage of the software method to achieve high positioning accuracy. Reduce the requirements on the positioning hardware. Wireless sensor positioning system maintained at a lower cost. From the actual test results show that: the positioning system is practical and easy to achieve.

Positioning is an important supporting technology for the wireless sensor network (WSN) has a wide range of applications [16]. ZigBee technology is a short-range, low power, low data rate; low-cost two-way wireless communication technology can be embedded into various devices, and support geo-targeting capabilities. ZigBee technology used in wireless sensor network is a focus of the present study, targeted research and application of technology has also been widespread concern.

Radio frequency identification cards from time to time reported to their own state information, including temperature, voltage; when the power shortage of radio frequency identification card (wrist and waist style can set the power shortage threshold voltage matching battery life, such as working voltage less than 2.0V alarm status. The threshold voltage can be dynamically set), the system platform can be automatically prompted to replace the battery. At the same time, wireless identification card indicating the lack of electricity; the power shortage alarm status, the wireless tag can be guaranteed at least the normal work for more than 10 days.

A program is dependent on the integrated radio transceiver (PHY functionality, under certain circumstances, a small part of the MAC) and contains a combination of MAC, network, application layer microcontrollers (MCUs). In this approach, it is scalable and easy to modify the ZigBee system to meet the wide range of applications. In such allocation, you can select the RF transceiver and the MCU completely suitable for the application requirements and previous experience in the design or existing hardware / software platform. A large number of ZigBee-based wireless user application will use the best design of IEEE802.15.4 compliance SoC silicon devices, which can reduce the cost and design complexity of applications, without taking into account the technical specifications of the IEEE802.15.4 / ZigBee technology.

The entire control and management within the central data acquisition system as a network node, and set up a wireless local area network (the network in general can cover a radius of several kilometers range) through this network, each read and write Locator and other terminal equipment and control center of the computer together. It comes from a variety of signals, each read and writes locator acquisition to transfer to the control center computer, and control center issued various directives transfer to reading and writing locator, and other information displayed or broadcast equipment.

The positioning of the basic steps of an unknown node is the distance measurement (unknown node to the node of the calibration), coordinate calculation. Distance measurement commonly used method: TOA (Time of Arrival), by computing the signal propagation time, distance measurement, the TDOA (Time Difference, ranging through the recorded signal propagation time difference of Arrival); the RSSI (Received Signal Strength Indicator) to accept the signal strength ranging; AOA (Angle of Arrival) signal propagation angle distance measurement. The system using JENNIC - 5139 module, only the RSSI ranging method does not require additional hardware, but the ranging method based on the signal to emphasize vulnerable to the interference of the signal multipart, reflection, etc., to reduce the measurement accuracy. Calculate the coordinate location algorithm: triangulation, triangular positioning method, maximum likelihood estimation method, centurion, and so on. If you directly use the above location algorithm to locate, RSSI-based ranging can not be satisfied with the measurement accuracy. The positioning mechanism of the system is to establish a database of full roadway RSSI ranging and mixing mechanism of the centric algorithm to achieve personnel positioning.

ZigBee protocol stack to build a mesh network real-time location system is a new, very challenging task, wireless Long as the pioneer of this industry, with strong technology can help the user needs, including: design of the new features of the wireless node(including the additional variety of sensors) or the development of wireless network monitoring, remote control, wireless location networks, ZigBee wireless network communications, wireless dragon communication will fully provide these services.

5. Summary

Composed of wireless sensor networks (Wireless Sensor Network WSN) deployed near the observation environment of a large number of micro-cheap low-power sensor nodes, sensing, data
processing and wireless communication capabilities through the formation of multi-hop self-organizing wireless network systems. The paper proposes the development of wireless personnel positioning in Internet of Things based on ZigBee and sensors.

The Internet of Things refers to the sensing devices through a variety of information, such as sensors, radio frequency identification (RFID) technology, global positioning systems, infrared sensors, laser scanners, gas sensors and other devices and techniques, real-time acquisition of any need to monitor, combine to form a vast network of connections, interactive objects or processes, collecting their sound, light, heat, electricity, mechanics, chemistry, biology, location information of a variety of needs, and the Internet. Its purpose is to achieve things and things, things and people, all of the items connected to the network to facilitate the identification, management and control. The sensor network as the material collected information terminal tool, just like the Internet of Things "eyes", "nose" and "ears", these collection tools different standards, has seriously hampered the development of things.

6. References