Wireless Sensor Network Based Smart Community Security Service

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Abstract

This paper will present the first attempt to apply WSN on community security area. By III ZigBee Positioning System (IZPS), we have implemented a Smart Community Security System (SCSS) for a community. SCSS provides three main community security services, Emergency call service (ECS), Danger-Zone alarm service (DZS) and People Tracking Service (PTS). SCSS gives more active monitoring service than traditional community security monitoring service. SCSS also provides an easy way to build a security environment with ZigBee RF characteristics.

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General Terms

WSN, ZigBee, automated building, Community Security Service System

1. Introduction

Wireless Sensor Network (WSN) is a novel idea that deploys large scale of sensor nodes into environments and use RF to communicate and collect data from nodes. There are many applications of WSN that include monitoring, tracking, and controlling. Some of the specific applications are habitat monitoring, object tracking, fire detection, traffic monitoring, etc. [1]

ZigBee (IEEE 802.15.4) standard is for WSN and WPAN. The ZigBee 1.0 specification was ratified on December 14, 2004 and is available for members of the ZigBee Alliance. ZigBee network provides short-range, low-cost solution to realize WSN idea. [2][3]

We use III Zigbee Positioning System (IZPS) [4] as our positioning infrastructure. III Zigbee Positioning System is an area-based positioning system, which is different from coordination-based (or point-based) positioning based on result of location discovery. In each positioning sub-area (section), a Beacon device is deployed as the reference point of that section and the device broadcasts signals that assigned as the location information of that section. Badge is responsible for collecting location information around the user, and transmits the information back to server for determining user's location. The positioning algorithm calculates the location based on RSSI (Received Signal Strength Indicator) values gathered from beacons.

Basically, RSSI values are proportional to the distance between badge and beacons, the larger RSSI value should be received from the nearer beacon, without interference. Therefore, the location of beacon with maximum RSSI value can be assigned as the location of the badge and user. However, the interferences from devices, environment, and others RF signals are uncertainties in positioning. Some rules for obtaining stable RSSI values have to apply in position algorithm to ensure performance of positioning results. The rules are generated by practical measurement and testing, after all devices have been deployed.

The current results of location discovery, sections larger than $16m^2$ can be accurately determined, that means if two adjacent beacons are separated more than 4m, the positioning accuracy can reach 98% within 1~5 seconds. The response time depends on how serious the environment interferences and the signal drift are. In most cases, a new location result can be retrieved after 1~2 seconds when user enters new section.

On the other way, III IZPS positioning system can be divided into three parts, and are described as follows. The first part, is positioning information sensing, the related devices in this part are beacons and badges. Beacons are first placed in the interesting area to meet positioning requirements, and are used to provide location information for positioning. When badges receive signal from beacons, then the location information packets packed by badges are transmitted to nearest router of the zigbee networks. The second part is the routing issue in zigbee networks, which are constructed by routers and coordinator. The major task of these two devices is to gather badge's packets in the positioning area and to forward packets to server through coordinator by RS232 line. If coordinator cannot connect directly to server by RS232 line, then Ethernet is the best solution. In this case, a gateway that transfers serial signal to Ethernet packets is employed. Therefore, the positioning system can be utilized to serve to a large area positioning issues. The third part is the display terminal. The positioning results can transmit to any terminal device via Ethernet or WLAN. Hence, users can access the location services from any place if they can connect to the server.

In the remainder of this paper, we outline a system to build Smart Community Security Service with III ZigBee position, and briefly review related work (Section 2), and the overview of Smart Community Security Service System (Section 3), and System architecture (Section 4).Finally, We provide a summary, and discuss some future issues (Section 5).

2. Related Works

Many research systems already demonstrated how to locate personnel and use location information in campus, kids care, and home care area.

A project, called ActiveCampus, is done at University of California, San Diego, which provides an infrastructure that focuses on integrating location based services for academic communities. [5].

The study (Reference [6]) provides an outdoor kid's safety care context based architecture using space oriented concepts and contexts.

House_n [7] at Massachusetts Institute of Technology (MIT) explores to design Home and its related technologies, products, and services to evolve and to meet challenging opportunities of the future.

Smart homes [8] creates a numerous demonstrations for elders or people with health problems, providing assistive technologies and safety aids such as video-intercom system and motion sensors for lighting control, and emergency buttons for elders.

So, we try to use location information into community to provide extra services and benefits which makes the scenario a complete profile.

3. Smart Community Security System Overview

SCSS provides three main community security services, Emergency call service (ECS), Danger-Zone alarm service (DZS) and People Tracking Service (PTS). The detail descriptions are as follows:

3.1. Emergency call service (ECS)

Emergency call service provides resident to call a security guard in the community security control center, when an accident occurs, for example when an elder falls, so that guards in the security control center may provide an instant help. Figure 1 shows emergency call event in security control center monitor.

In Figure 1, the left menu shows where a badge is and how many badges in the community. In the bottom area, there are event lists of every badge. Apart from emergency call event, the bottom area also lists about entering danger-zone events. Various floor maps are shown in the other window and also provides details about which badge is active.

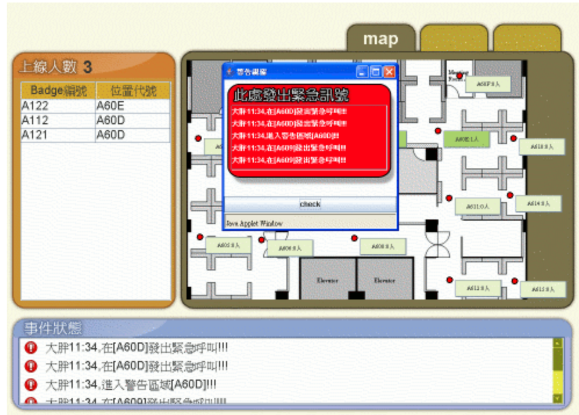

Figure 1. Emergency call event in the security control center monitor.

3.1. People Tracking Service (PTS)

People Tracking Service (PTS) provides a real-time tracking of particular person wearing a badge. This service is for family members only. But for private issue, security guard in control center cannot keep track information of other people apart from family members. Figure 2 shows tracking information in the family monitor.

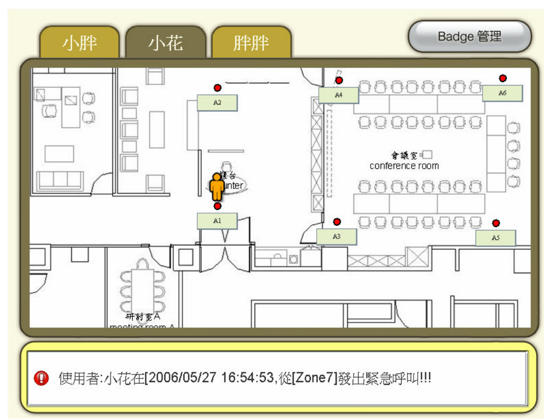

Figure 2. Tracking information in the family monitor.

3.3. Danger Zone Alarm Service

Dangerous Zone Alarm Service (DZS) provides a real-time alarm to family or guard when somebody enters a danger zone. For Example, parents often want their children to keep away from water, so parents can set water pool as danger zone. When kids run near pool, SCSS will inform parents.

4. System Architecture

We deploy Zigbee beacon and ZigBee gateway in public area in a community, such as garden, underground parking lot, etc. Figure 3 shows where beacons and gateways deploy.

Figure 3. Beacon and Gateway in the public Area

4.1. Hardware

Our System contains five basic devices – beacon, badge, router, coordinator, and gateway. Devices functions are stated below:

Beacon
A beacon is placed in the location discovery area and is used to provide location information. The signals are received by badges

Badge
Badge is a mobile device attached to user. It is used to gather beacon signals and forward the result packet to router or coordinator. The transmitting frequency is 3 packets per 2 seconds.

Router
A router is the component of zigbee networks. It is used to receive packets form badges, and forward them to coordinator.

Coordinator
A coordinator is the component of zigbee networks. It is used to receive packets form badges and routers, and forward them to gateway or server via RS232

Gateway
A gateway is the component of zigbee networks. It is used to transfer RS232 signals to Ethernet packets, and forward them to server.

4.2. Devices Deployment

We deploy 100 ZigBee Badges, 20 ZigBee Beacons, and 2 ZigBee Gateway in community pubic area, such as staircase, underground parking lot, and outdoor gardens.

4.3. Software

We use Java 1.5.0_06, and Tomcat 4.1 with Servlet 2.4 and JavaServer Pages 2.0 as our software environment.

4.4. Software Architecture

In the software architecture, we adapt III Smart Control Center as framework. III Smart Control Center support Location based service, providing real-time position of badges, and we implement Emergency call service, people tracking service, danger-zone alarm service into Smart Control Center Framework.

When three above events occur, Smart Control Center provides three ways to remind residents, through MMS, SMS, and E-mail.

At the same time, the monitor of Control Center shows relative information to inform the security guard in case of accidents.

Smart Control Center Framework receives badge location data from coordinator through serial port.

In the web application, there are four components, resident setting module, resident applet, control center applet, and control center database backup module. Resident setting module is a set of JSP pages for setting information of ECS, PTS, and DAS. Resident Applet shows information of family members wear badge, such as location of children. This applet will be shown in each family. Control Center Applet shows all ECS, PTS, and DAS information of badges in whole community. Smart Community Security System (SCSS) Software architecture is shown in the figure (Fig 4) below.

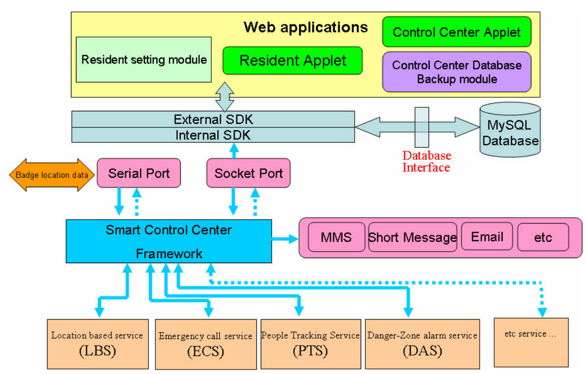

Figure 4. SCSS Software Architecture

5. Summary and Future work

In this paper, we address an overview of SCSS. SCSS provides three Service to community, Emergency call service (ECS), Danger-Zone alarm service (DZS) and People Tracking Service (PTS). With RF characteristic of ZigBee, RF makes the building industry easy to deployment smart security environment. Our system, Smart Community Security System (SCSS), gives more active, easier deployment than traditional community security monitoring service.

In fact, since the early 1990's, many related works have been focused on how to acquire, refine, and use location context information. Until now, there are many location-sensing methods proposed. Generally speaking, explicit or implicit methods of localization are those that most traditional location-sensing systems rely on. The designed localization method in this paper belongs to explicit one. In this explicit location method, the user must wear or carry a device which is used to locate them. In our location-sensing system, a user must carry a "badge". On the other hand, those location methods that belong to implicit ones do not be equipped with any device for a user. In the future, we are interested in taking use of this kind of implicit location methods to enhance our system. Sound source location will be used in the future works. That is, a sound source location method which locates sound events in the monitoring environment using microphone arrays will be utilized.

A Sound Source Location (SSL) system determines the location of sound sources, which are based on the audio signals received by an array of microphones at different known positions in the monitoring environment. In our future works, the designed location system will take use of the sounds to track members in a monitoring area. When acquiring the location of sounds, this also will be helpful for some kind of context aware computing, such as speaker identification. However, the current SSL research works still have some main challenges for deploying this [9]. These main challenges are "Background noise", "Reverberation (echoes)", "Broadband", "Intermittency and Movement" and "Multiple Simultaneous Sound". Based on the current development location system, our future development system hopes that these general challenges mentioned above can be overcome. That is, we will construct a multi-modal approach to determine the spatial position of the user. In this multimodal approach, it will result in more significantly improved performance in spatial location than the current location system using only badge-carrying methods. Also, by means of combining with the SSL methods, this location system will additionally be able of detecting speaker activity and determining the speaker's identity. For this additional application of the speaker identification, we will classify the users in a monitoring environment such as in a meeting using the acoustic speech features of speakers. That is, the speaker identification technique is implemented by analyzing the short-time spectrum of the spoken phrases. Besides, the Gaussian Mixture Model (GMM) has been proven to be a good choice to capture the speaker's information, and our future system will hires this kind of model to do the works of the speaker's classification.

The long-term objective of our project is to create a system which is cognizant of the users. The designed system will acquire speaker IDs and relative location of the user or active speaker. Based on these extracted information, numerous important applications such as human posture inference and modeling of human behaviors will be able to be developed in this future system.

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