Position Monitoring Care System for Senior Citizens - A study by the Chaoyang University of Technology Senior University Program

Chuan-Bi Lin
cblin@cyut.edu.tw

Jian-Ming Hong
s10330618@cyut.edu.tw

Hisn-Ying Liang
hyliang@cyut.edu.tw

Yung-Fa Huang
yfahuang@mail.cyut.edu.tw

Department of Information and Communication Engineering,
Chaoyang University of Technology, Taichung, Taiwan

Abstract

The aging population of Taiwan is increasing; however, despite gradually increasing acceptance of retirement homes, elderly people who retain their mobility may still decide to live at home. However, with Taiwan's decreasing birth rate as well as young men and women working outside home, there is no one at home that can look after the elderly. Some children encourage their elderly parents to attend community events so that they are not alone at home. Additionally, Taiwan suffers from a shortage of social workers. Consequently, the movement of mobile elderly people is neither monitored nor controlled.

For this reason, this study proposes a position monitoring care system developed at Chaoyang University of Technology's Senior University Program. The system employs radio-frequency identification (RFID) and determines location, as well as provides a web page, to monitor whether an elderly person is at a senior center or in a bathroom. Additionally, the system includes time settings that enable the web system to alert caregivers when an elderly person is in the bathroom for a long period of time. It can also provide push-notifications to the caregiver's smartphone application to enhance the safety of elderly people.

Keywords: Radio-frequency Identification, Senior Center, Location, Push-notifications

1. Introduction

As a result of the increasing functionality of radio-frequency identification (RFID) [1] positioning technology, it is being used in many areas such as store merchandise tracking, exhibition navigation, and personnel positioning [2]. Because of the increase in the aging population in Taiwan [3], we recommend employing a position monitoring system that uses RFID to track the movement and location of elderly people. Using this system will provide timely information pertaining to the location of elderly people in potentially dangerous areas and alert caregivers in order to improve the effectiveness of elderly care.

The Department of Golden-ager Industry Management of the Chaoyang University of Technology has established a senior center that provides elderly people the opportunity to attend activities, as well as providing students a practical work-study environment. However, the inability to control the movement of mobile senior citizens presents certain challenges to student caregivers, e.g., when senior citizens leave the center alone or spend time in the bathroom. These problems may occur spontaneously and caregivers may not be able to discover these problems in a timely manner. For

this reason, the design and implementation of a position monitoring system for elderly people has been proposed to provide timely notifications regarding the position of elderly people. The system uses RFID positioning technology to identify and monitor senior citizens, in addition to analyzing danger posed to senior citizens, by setting up a time-sensitive alert function for senior citizens in potentially dangerous locations. This system aims to improve the effectiveness of senior care.

2. Background knowledge and technology

This study will establish a senior citizen monitoring system to aid in locations or situations where caregivers are short-staffed. This section will describe common indoor positioning technology, compare the advantages and disadvantages of different indoor positioning technologies, as well as explain the reasons for choosing the indoor location and notification RFID technologies.

2.1 Indoor positioning technology

- **Infra-red Systems**

In 1992, the Olivetti Research Laboratory developed Active Badges, an indoor positioning system [4], which is the earliest iteration of such a system. Despite the high transfer rates of infra-red, transfer quality was easily affected by temperature changes as infrared is more susceptible to temperature changes compared to other light rays. Thus, the bandwidth of infrared emitted from environmental sources or other devices is limited. On top of these restrictions, infrared has a low penetration rate; it is easily blocked by obstructions, and its transmission distance is rarely more than 5 meters.

- **Wireless Local Area Network**

Triangulation, which involves wireless signal exchange between wireless devices and three wireless hotspots, allows determining the location of wireless devices. Despite the variation of response signal strength with the variation of the distance between wireless devices and hotspots, triangulation can provide relatively accurate positioning with the use of advanced differential evolution algorithms. Wi-Fi positioning is a relatively demanding wireless network; however, when wireless hotspots are more densely distributed, they provide more accurate positioning. This system uses a RADAR positioning system [5], developed by Microsoft Research Labs in 2000, for use within local-area wireless networks; however, this method has high financial and labor costs.

- **Bluetooth**

Bluetooth technology is easy to integrate into mobile devices. For this reason, this positioning technology is easily promoted and popularized. It is a low-power, short-range wireless transmission technology that allows terminal equipment to have a longer lifespan and measures signal strength in order to discover positions. Currently, Bluetooth technology is mainly used for small-scale positioning. Recently, Apple has vigorously promoted its iBeacon technology [6] that uses low-power Bluetooth to transmit a universally unique identifier to an application or operating system.

- **Frequency Identification**

A system that uses radio waves to transmit identifying information has many applications. RFID is an advanced wireless identification

technology, which can use microchip "labels" with unique ID numbers on merchandise to identify, track, and confirm the status of goods through a connected computer system. The system uses a radio scanner to monitor the status of each chip, identify, track, sort, and confirm various items such as people, cars, or other goods. SpotON, an indoor RFID positioning system proposed in 2000 [7], pioneered the use of active RFID indoor positioning systems. Its positioning technology employs, at its core, a 16-degree signal reception method, an aggregating algorithm to determine signal strength, and a signal strength regression model to estimate signal propagation distance and location.

2.2 Comparing indoor positioning technologies

The focus of this study is on cost considerations and releasing caregivers from frequent battery replacement and charging requirements of location identification systems. In these respects, the RFID system stands out: its average battery consumption is only 3–7 μA, and its battery life is more than one year. When Bluetooth systems are in rest mode, the power consumption of such systems is only 1 μA, and during transmission of instant messages, the power consumed is only 15 μA. A comparison of Bluetooth and RFID systems shows that Bluetooth systems are more suited for short-range locations (less than 1 m) and are more susceptible to interference. For this reason, this study will use RFID as the transmission technology for the positioning system.

3. System Structure

The use of RFID to assist caregivers in monitoring senior citizens is aimed at strengthening the integrity and security of the provision of care. By wearing an active RFID tag, senior citizens located in an activity area equipped with RFID readers and positioning devices are easily identified and located. Depending on the different activity environments, activity areas are divided into indoor and outdoor RFID activity areas.

Indoor RFID activity area: Indoor RFID monitoring is primarily aimed at allowing personnel to identify whether senior citizens are currently in a monitoring area and to prevent them from escaping caretaker supervision. The system prevents senior citizens from escaping caretaker supervision by alerting staff that an elderly person has left the monitoring area and providing the individual's departure time and current location.

Outdoor RFID activity area: Outdoor RFID monitoring is aimed at potentially dangerous locations such as bathrooms and staircases. The areas are designed to prevent senior citizens from spending an unduly long period of time in outdoor areas without the knowledge of caregivers. In such areas, the system works by immediately alerting caregivers when an elderly individual spends more than a certain amount of time in the monitored potentially dangerous area.

In order to improve the aforementioned question summaries and research goals, this system proposes several functional requirements for designing the architecture of an RFID positioning system:

- **Ability to locate the elderly**

By using an RFID tag worn by elderly individuals and transferring data to positioning devices, RFID readers should be able to determine the current location of an elderly

individual.

◆ **Ability to identify the elderly**

Each senior citizen should wear a unique tag that can be read to identify and provide information on the wearer to the caregiving staff.

◆ **Ability to issue alerts**

When a senior citizen spends an unduly long period of time outside the monitoring area, or in a potentially dangerous area, the system should immediately alert the caregivers.

◆ **The system should be reusable and include the ability to modify data**

As senior citizens will be occasionally added to or removed from the system, caregivers should be able to update the system, modify data, and continue to use the equipment of seniors who are no longer active in the program.

3.1 Warning Tips

In order to prevent accidents while caregivers are unaware of the location of senior citizens, this study establishes three types of alert functions to notify caregivers. They are a marquee, Google Cloud Messaging (GCM), and Email. Multiple alert systems should reduce the likelihood of accidents, and improve the convenience and quality of the system.

◆ **Google Cloud Messaging (GCM)**

GCM[8] is a free service that can allow staff to send messages on a variety of platforms (Android, iOS, and Chrome). For example, a server can send messages directly to a single device or a group of devices, or an application on a device can send data directly to a server or devices within its group.

◆ **Email**

As smartphone applications are quite popular, when an email is received, the application can alert caregivers through a vibration or alert sound.

◆ **Marquee**

The webpage connected to the system will have a marquee with dynamic updates. When a senior citizen is outside the control area for a longer period of time, the marquee will be immediately updated. A large screen for monitoring will enable easy discovery when a senior citizen leaves. an indoor area.

3.2 Architecture element

This study proposes an RFID-based position monitoring system architecture with an integrated client side, server side and equipment side, as shown in figure (1).

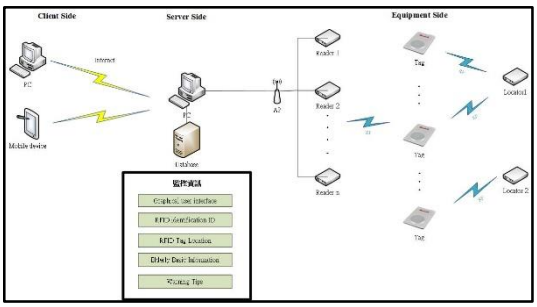

Figure (1): Core architecture diagram

On the equipment side, a reader, tag, and locater use standard RFID communication to transmit messages. All individuals whom the staffs wish to monitor wear the tag, which sends packets to the backend reader. Additionally, tags can receive position packets sent by the locator. After entering the tag location into the packet, it returns the packet to the backend reader. The reader will receive the packet information sent by tags at regular intervals; this information includes the tag ID, locator position, and emergency notifications, as shown in figures (2) and (3).

ID Structure(11Byte)										
0	1	2	3	4	5	6	7	8	9	10
Locator_ID		Data			Type	ID				Status

Composition	Position	Explanation
Logo header	10 Byte	Locator Address,2Bytes,Address range 0~0xFFFF,0xFFFF is Broadcast address, 0xFFFF representatives have been triggered Locator
Data	Byte 2~4	Tag Data
Type	Byte 5	Distinguish the type of tag
ID	Byte 6~9	Tag ID
Status	Byte 10	Each bit represents a state

Figure (2): Packet format

The processing center of the system is at the server end, and it is composed of a database and middleware. The bridge between the database and equipment side is formed by the middleware and wireless base-station communication systems. The main function of the middleware is to receive packets returned by tags worn by senior citizens, analyze the packet data, and store it in the back end database. The wireless base station or access point (AP) provides a means for communication between mobile devices in the monitoring system. The AP can also provide the staff with a means of monitoring, system management, and data acquisition via a desktop computer or handheld device.

On the client end, caregivers can use the webpage or the smartphone application to check the daily attendance of senior citizens, as well as their current status and location.

On the equipment side, readers are provided with an external IP. Through external IP addresses on the same network segment, packet information can be returned to the middleware after being received by the AP. Using the network access translator installed on the AP, information can be transferred to the middleware of a designated port. Our system also includes a web version interface to provide a convenient method for caregivers and family members to check the status of an elderly individual. The web interface can include a historical record because packet data will be stored in the database. Readers receive information every 2 s, and therefore, the software element stores this information in the database every 2 s; the database is saved in file format. During the 2-month test, the database received 2 million pieces of data. As the web page had difficulty in retrieving information from such a large database, the database was limited to 1 million pieces of data consequently. Therefore, when the database exceeded this figure, it was emptied.

3.3 Middleware element

The middleware designed in this study comprised of three parts: an application interface, a data processing interface, and an element interface. Its functional block diagram is shown in figure (3).

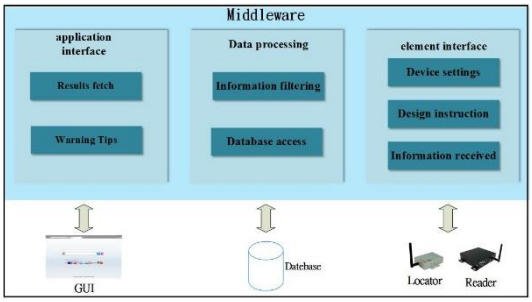

Figure (3): Middleware structure

In the application interface, the graphical user interface (GUI) regularly collects the status sent by the tags worn by senior citizens, and generates emergency alerts. In the event of an alert, it will prompt caregivers to check on the situation.

Data processing is separated into two functions:

◆ **Information filtering**

This step sorts the information sent from tags into two categories: control area and activity area. It transforms the data into useful information.

◆ **Database access**

Database access uses web service to allow updating and editing information regarding senior citizens, as well as searching position history. Database access provides information such as senior citizen ID or information on a senior citizen's personal caregiver.

The most important function of the element interface is setting the coverage area. As the positioning equipment may cover areas of different sizes, the element interface allows for setting coverage area in accordance with these dimensions. In addition to receiving the data packets returned by tags, it also transfers these to the backend after parsing. The element interface is shown in figure (4).

Figure (4): Middleware

Many location management elements have been included within the location monitoring system for the benefit of caregivers such as a graphical user interface that allows users to use a browser to operate, monitor positions, and edit information. As soon as a senior citizen enters a monitored area, caregivers can immediately use RFID to determine their position and determine the length of time spent in that area. RFIDs have the special characteristics of providing contact-less information transfer as well as transparency of information. They can improve access control and identity verification, and help in avoiding situations where the location of a senior citizen is not known. RFID tag positioning uses the RFID locator to determine the current position of the wearer. Basic senior information management provides caregivers the ability to update, edit, and delete information.

4. Experiment results and discussion

4.1 System implementation

In accordance with the structure shown in figure (1), we developed an application for an RFID position monitoring system. Implementation details, site planning, and system integration are explained below:

The hardware of the system consists of a server, a personal computer, a wireless router, three RFID readers, three RFID locators, and sixteen RFID tags.

The main purpose of the personal computer is to receive the information packets sent from tags to readers, and to store this information on the server's database.

RFID readers should be located in each senior activity area, hallway, and any potentially dangerous area. Each reader is given a unique IP address, which uses the internet to send data packets to the backend software. RFID locators are placed in the activity area and potentially dangerous areas to determine the time spent by senior citizens in these locations. RFID tags are worn by senior citizens, and each senior citizen is

assigned a unique identification number.

4.2 Site planning

The Chaoyang University of Technology Senior Center served as headquarters for developing and implementing the RFID position monitoring system proposed in this study. The dimensions of the senior center are shown in figure (5). In this study, three readers were installed on the walls of three different areas, and were primarily responsible for receiving the information packets relayed by the RFID tags worn by senior citizens. RFID locators were separated between two locators, which were installed in bathrooms to determine the period of time spent there by senior citizens. In addition, a RFID locator was located in the activity area. The server was located in the activity area such that caregivers could conveniently check the location of senior citizens.

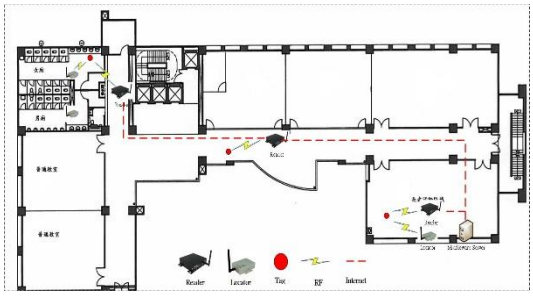

Figure (5): Site plan blueprint

4.3 System software design

When senior citizens arrive at the senior center, caregivers will activate their RFID tags, which will begin to send data packets. Then, caregivers will turn on the backend middleware to receive these packets, which will be simultaneously saved in the backend server through the database of the associated webpage. By analyzing this received data, the application will determine the daily attendance of senior citizens, as well as their current status and location. It will also calculate the time spent by a senior in a given location, and as shown in figure (6), if a senior spends a longer period of time than the preset time limit in a dangerous location, it will immediately send an email, GCM push notification, and update the website marquee to alert staff regarding the potential danger.

Figure (6): Website monitoring page

Because elderly people tend to walk at different speeds, and use the restroom for varying durations, caregivers can use the webpage to customize the time limit for each senior citizen Core processes are shown in figure (7).

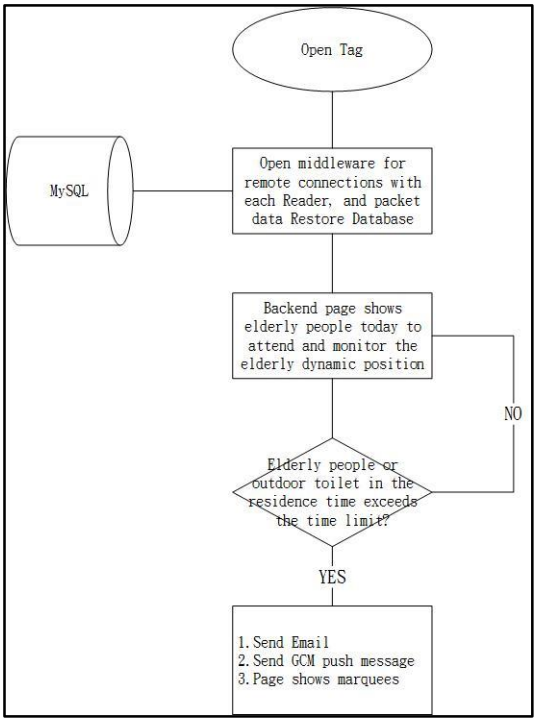

Figure (7): System structure flowchart

5. Conclusion

As people grow older and frail, they must make certain difficult lifestyle choices, including selecting a type of senior care institution. Often, the style of care offered by these institutions cannot guarantee the level of safety that senior citizens inherently require. Taiwan's network of elderly care facilities suffers from a shortage of caregivers. Therefore, the design and implementation of the RFID position monitoring system is presented in this paper with the goal of supporting overworked caregivers on whom the elderly depend on a daily basis. Based on the decision-making abilities of the system, caregivers will be alerted of potential danger when senior citizens spend an unusually long time in a potentially hazardous area, providing caregivers the opportunity to provide assistance and avoid serious accidents. The senior citizen position monitoring system proposed in this study can be effective in monitoring the current status of elderly people when they go out in their daily lives, and therefore has definite practical functionality.

In order to improve and complete the system, we hope to continue collecting and analyzing data to achieve a more accurate representation of activities performed by senior citizens, and the normal periods of time spent by senior citizens in various areas. This will allow the system to provide more precise alerts to caregivers, thereby increasing the efficiency and quality of care.

6. Acknowledgements

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