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Using Cloud-based IoT Technology for Wireless Medical Care Monitor System

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Abstract. This research was use IoT technology to detect the locations of medical care monitor to patient who move around indoors and outdoors; and, mobile physiological detect technique is associated to monitor the physiological patient on time. Through RFID, the operating system can assign medical care monitor personnel messages that is nearest to the patient at accident to perform medical care monitor system. Although the use wireless mobile device, it should to know that medical care monitor personnel to get medical message of the patient on time. Through integrate techniques as IoT technique, physiclogical monitor syatem technique and wireless mobile device, a set of medical care monitor system is designed in the research. Use this medical system, to develop a new system is to verify a useability of system. Through the medical care monitor system to develop in this research, the accident occurs, medical care monitor system can reach the patient at the accident place in the real time to reduce the delayed medical care.

Keywords: cloud based computing, Internet of Things (IoT), mobile device, medical care monitor system

1 Introduction

Wal-Mart of USA had announced that its 100 suppliers should attach RFID tag of EPC standard on the product paper carton and the wooden plate, eventually, it expected that all the suppliers should attach RFID tags on the product they supplied. Due to Wal-Mart's massive use of RFID technique to improve logistic management when RFID technique is still not mature and when the tag cost is still pretty higher, the hardware development and software application of RFID starts to catch people's attention [1-3].

In recent years, mobile devices have taken a significant role in improving the quality of people's life. In order to enhance the usability of those devices, more and more sensors have been built in. The current need of more than two days of tracking time can be reduced to within 20 minutes. Ton Yen General Hospital has used hospital contract history RFID tracking and control system to track and isolate possibly infected personnel quickly. The IoT medical care objects management system developed later on can perform access personnel control, medicine quantity and storage place management, medical object safety period monitoring, etc. The barcode and RFID technique to confirm the safety of blood transfusion. Barcode and RFID are used as identity confirmation job, that is, before blood transfusion, the blood type

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of the patient and the blood type of the blood that is about to be used will be double checked to ensure that medical care personnel will not transfuse wrong blood into patient's body [4]. RFID technique to record how many personnel and equipment appear in the operation room at certain time; the result can be used as reference for medical care history tracking [5].

The process of emergency medical care monitor, how to position one patient with an accident has become an important issue. Notwithstanding lots of positioning service and applications with positioning functions offered by modern electronic products such as mobile phone, PDA, GPS vehicle navigation system that have gradually become one portion of life, there are still some restrictions in applications of these positioning service, for instance, GPS for outdoor use only, and mobile phone with weakly precise positioning. With the IoT technology evolved to various feasible and prosperous applications gradually matured recently due to its features of long-distance detection with detected data containing positions, the concept of the positioning technology based on IoT expands applications of this technology beyond the conventional object identification only. Against this background, various RFID positioning methods continuously appear, for instance, using the positioning functions of RFID to assist users to find book collections [6] Installing RFID readers with the concept of RFID positioning technology in an operation room to decide qualifications of some staffs entering the operation room [7]. As a result of the RFID positioning methods applied to positioning of indoor objects or persons in general, these methods according to their precision [8]. The Smart Living Technology is a recent trend in which technology is applied to daily life to increase efficiency and affordability. The principle behind Smart Living Technology is that technology should be used to needs of human beings and to increase the quality of life by the power of human creativity. As such, intelligent Iot should be adopted to provide humans with full information to control an individual's personal environment. Wireless RFID technology can play a key role in enabling smart monitoring by allowing patients to make more informed choices and to connect RFID and reader to a coordinated APP system. The development of Smart Living Technology is based on the concept of user driven innovations [9].

2 Medical Care Monitor System

2.1 Triage in the Emergency Room

A complete emergency care system is composed of the pre-hospital emergency medical care and the post-hospital medical care. As to the pre-hospital emergency medical care, the firefighting department is responsible to first-moment rescues of the general public who have suffered from emergent injuries or diseases daily or in emergency cases and even delivery of patients to adequate hospitals, if necessary. For the case of one patient delivered into a hospital for emergency medical care, the first place, which one wounded or patient with an emergency accident is sent to, is the emergency department of one hospital.

As the first place of accepting patients meeting accidents, the emergency room is one department specified to rescue those people with accidental injuries and acute diseases. Facing patients with different kinds of diseases or different levels of injuries at this place, physicians and the nursing staff must provide adequate treatments and care to patients within an ultra-short period. In the wake of one patient delivered into a hospital, the medical care personnel assigned in this hospital's emergency room will make a speed classification by categorizing patients according to the triage table and arrange one sequence of medical treatments for patients by the classified result following the triage.

As a result, the merits of the triage system covering excellent functions have to be remembered with the emergency medical care system developed; on the other hand, patients' illness conditions need to be considered when the medical care personnel is assigned to rescue patients, the dynamic performance of radio frequency identification (RFID) positioning system as the analysis target. The transmission from the static performance evaluation of RFID positioning system to the dynamic one is done. The Fisher information matrix and identification value are introduced to evaluate the dynamic positioning performance of RFID system. The positioning performance at the case of different paths, motion rates and number of reference tags could be evaluated by calculating the Fisher information matrix and identification value. The numerical simulation shows that motion paths and rate of target and the number of reference tags, could directly affect the positioning performance of RFID system. The findings also indicate that the selected motion path and rate of the target have a direct impact on the positioning performance. Furthermore, adjusting motion path of target close to the geometric center of reference tags

and reducing motion rate and acceleration appropriately could optimize the dynamic identification performance of RFID positioning system. This method provides a reference for improving the positioning performance and reducing the measurement error of RFID system [10-15, 17].

2.2 Monitor Current Situations for Care to Inpatients

Despite no monitoring devices securely installed on inpatients arranged in general wards or the medical care personnel disposed around these patients, a nursing station setup for wards in one section of a hospital, usually at a certain floor, is composed of several shift nurses submitting daily as well as emergency nursing service for inpatients. In part, accidental emergency events occurred within the general wards with a group of patients under care from the minority of nurses are inevitable sometimes. In such situations, some manners adopted for treatments of inpatients are described as follows: 1. Prevention is better than cure. Naturally, to provide an environment or care preventing inpatients from accidents is one optimal choice. As a result, precautions in connection with accidental events occurred frequently will be prepared by medical institutes. For example, as one accident most occurred on inpatients, tumble accounts for 70% of all accidents. Thus, most medical institutes formulate a series of regulations to prevent patients' tumble. 2. As to no medical care personnel accompanying patients at some places in one medical institute or private matters patients ask an environment for staying alone, the medical institute may install emergency bells around some specific areas for patients who can press bells to call for assists from the medical care personnel. 3, Compared with the medical care personnel, most general inpatients' family members staying in one hospital for caring patients, with long-term helpers for care of inpatients staying in one hospital may not meet demands in professional medical care for patients but still some kinds of effects to inform the medical care personnel for further treatments when patients have some problems [17-18]. Smart Living Environments for ageing well, and aims to build a dynamic pole for knowledge sharing in Internet of Things innovation for Smart Living Environments, acting as a bridge between initiatives that bring added value to healthy living. This workgroup should also identify and attempt to resolve market obstacles for IoT deployment in the Ageing Well domain. Driving Acceptance through market structuration, in increasing the acceptance of innovative IoT-based solutions for smart living environments for ageing well while impelling user needs and expanding the innovation coverage in the ageing well domain [16].

2.3 Analyses of Medical Care Monitor System

The purpose of providing the first monitor care to emergency patients and ensuring their safety, a complete emergency care system is made up of pre-hospital and post-hospital emergency care. In this regard, most emergency care emphasizes rescues outside the hospital compared with rescues of inpatients with minor respect. To analyze current situations and relevant research for emergency care in one hospital. We employ the IoT indoor positioning technology as one basis, detect some feasible modifications in issues and methods, as regards the emergency care in the hospital, describing them as follows: 1. deficiency of the emergency medical care mechanism for general inpatients: assists to inpatient staying in general wards without adequate monitoring instruments and the medical care personnel accompanying them are slow or incomplete in case of accidents compared with those in the emergency room or the intensive care unit. 2. Inadequate control for positions of patients and the medical care personnel: With some accidents occurred, tracks of patients without limb disabilities or seriously controlled diseases and healthy medical care personnel cannot be controlled because of their free mobility without restrictions in the scope of activities. 3. Patients' emergency messages possibly unaccepted by the medical care personnel. In general, as a result of one hospital's monitoring instruments installed on some fixed location for reception of messages, The medical care personnel moving anywhere to take care of patients rather than constantly staying beside monitoring instruments may not receive emergency messages from patients [19, 23-24, 26-27]. As to one patient with emergency accidents, that the shorter time patients spend to wait the medical staff's rescue, the higher possibility they acquire for successful medical therapies. Due to one patient's movement far away from the medical care personnel who have duties for cure, precious time wasted on a journey is huge when an accident occurs [18, 25].

3 Analyses and Designs for the IoT Medical Care Monitor System

Considering the issue about emergency care mentioned in the previous section, we design one emergency medical care system for the medical care of inpatients by one method of integrating the RFID technology, wireless devices, and the technology of physiological signal suite. The entire system is composed of the following portions: RFID fundamental data management subsystem, RFID personnel's indoor positioning subsystem, emergency message processing subsystem, and medical care personnel's emergency message reception subsystem, as shown in Fig. 1. With combination of these four subsystems, the medical care personnel's cure is available to inpatients having the emergency events in the shortest period. Functions and operations for each subsystem is described as follows:

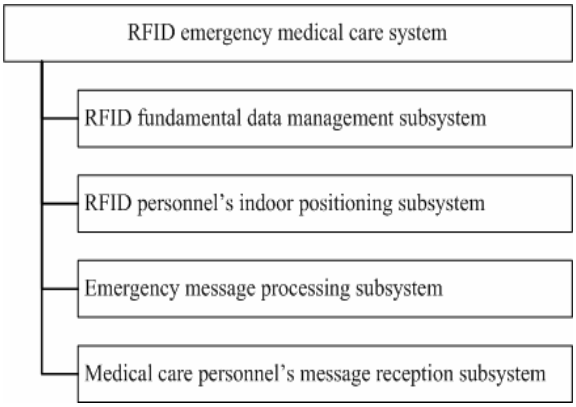

Fig. 1. The systematical structure of the IoT emergency medical care system

Considering the issue about emergency care mentioned in the previous section, we design one emergency medical care system for the medical care of inpatients by one method of integrating the RFID technology, wireless devices, and the technology of physiological signal suite. The entire system is composed of the following portions: RFID fundamental data management subsystem, RFID personnel's indoor positioning subsystem, emergency message processing subsystem, and medical care personnel's emergency message reception subsystem, as shown in Fig. 2. With combination of these four subsystems, the medical care personnel's cure is available to inpatients having the emergency events in the shortest period. Functions and operations for each subsystem is described as follows.

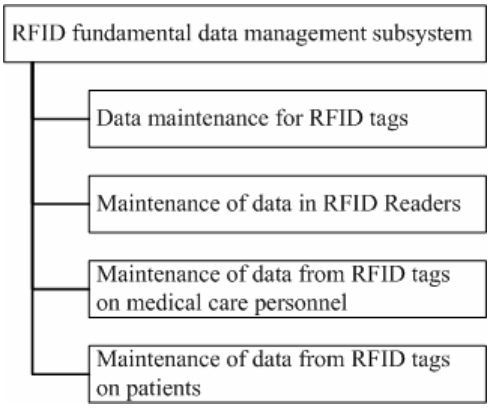

Fig. 2. The systematical structure of the IoT fundamental data management subsystem

3.1 IoT Fundamental Data Management Subsystem

With RFID tags detected, the transmitted information includes a patient's identity, a medical care personnel's identity, and people's positions as our requirement in this study. To this end, we need to maintain some basic corresponding data in the RFID fundamental data management system. These basic data is composed of four parts, as shown in Fig. 2 and explained as follows.

3.2 Data Maintenance for RFID Tags

Two RFID technologies used for the RFID emergency medical care system are the personnel's identity recognition technology with short-distance RFIDs, and the indoor positioning technology with long-distance RFIDs [15-16]. As a result of different radio frequencies for RFID tags in both technologies. The methods.making the system recognize identification codes from RFID tags detected by both RFID readers. As one identical person who is required to wear two types of RFID tags with district classifications. That is summarized as the following three points: 1 Customized RFID tags: even though each RFID tag directly purchased on the market only supports one RFID frequency. RFID tag based on the current technology can be designed and manufactured into a device of receiving and emitting distinct frequency signals received by each of different-frequency RFID readers reading the same RFID identification codes. 2. Unification of identification codes from two types of RFID tags: Based on a fact that identification codes from a certain RFID tag can be modified, unification of two purchased RFID tags with different specifications makes two RFID tags eventfully deliver identical identification codes. 3. Maintenance of data corresponding to identification codes from two types of RFID tags with distinct specifications: Maintenance of one data sheet for corresponding identification codes from both tags. Through this data sheet with both identification codes corresponded each other, both codes can be transferred to one consistent identification code to recognize the person with the RFID tag. As such, one data maintenance operation for RFID tags as a manner to maintain correct data from tags for users must be setup in the RFID fundamental data management subsystem. The operations should cover the following items at least :(1) Addition of data from RFID tags; (2) Deletion of data from RFID tags [7, 9, 20].

RFID positioning system, for the correct operational RFID positioning system, the RFID position data to record detailed positions of all readers have to be setup. As such, detected signals form RFID tags can be transferred to positions in the RFID reader [1-2, 17].

The medical care personnel provide cure to patient, the message processing system, picking up the medical care personnel one patient in a real time.

The purposes of giving RFID tags worn by the medical staff : 1. Registration in one portable computer for the identity recognition technology with short-distance RFIDs; 2. Detection of long-distance RFID tags on the medical care personnel as determination of actual positions for the RFID indoor positioning technology.

There are two reasons of wearing RFID tags on patients: 1. Detection of long-distance RFID tags on patients as determination of their positions for the RFID indoor positioning technology; 2. Recognition of one patient's identity by the medical care personnel at real time. In one medical institute, carry and non-carry of RFID tags lead to constant maintenance of data regarding RFID tags on patients because patients,.

3.3 IoT Personnel's indoor Positioning Subsystem

As shown in Fig. 3 flow chart of the IoT personnel's indoor positioning system.

To investigate related distance between patients and the medical care personnel, this system can detect positions of persons. Because of constant changes of positions of mobile objects, patients and the medical care personnel, at different time, the system, deliberating the relative distance between both parties, will arrange the adequate medical care personnel possibly arriving at the target in the shortest period to assist this patient with emergency accidents.

(1) Emergency message processing subsystem

As to one medical institute's some accidental events requiring the medical care personnel's assist forthwith, the adequate medical care personnel must acquire messages at the first moment and arrive beside the patient quickly. Against this background, one specific subsystem processing various messages and delivering them to those who need messages received makes the medical staff rescue the patient with incidents in the shortest period.

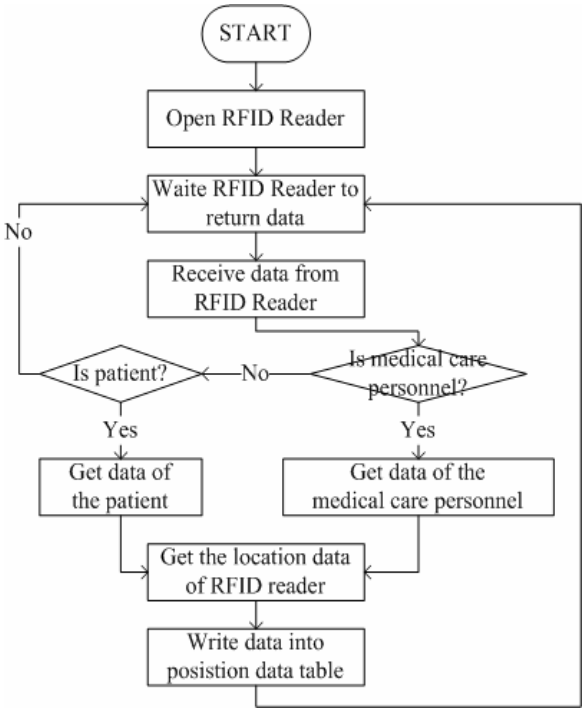

Fig. 3. The flow chart for execution of programs in the IoT personnel's indoor positioning system

As a result, this subsystem is one pivot of operating the entire RFID emergency care system. As shown in Fig. 4, the concept for operation of this system is composed of: 1. Reception of emergency messages from all sources: monitoring of physiological signal suite, messages from various physiological detection instruments, pressed emergency buttons installed around one medical institute or physiological signal suite, and new messages on PDAs triggered by the medical care personnel. 2. Inquiry & reception of positioning information from RFID personnel's indoor positioning subsystem; 3. Selection of one physician at the shortest distance from the patient for rescues on the spot; 4. Delivery of emergency information to the selected doctor; 5. Maintenance of emergency event lists for the whole medical institute to ensure a complete implementation for each event.

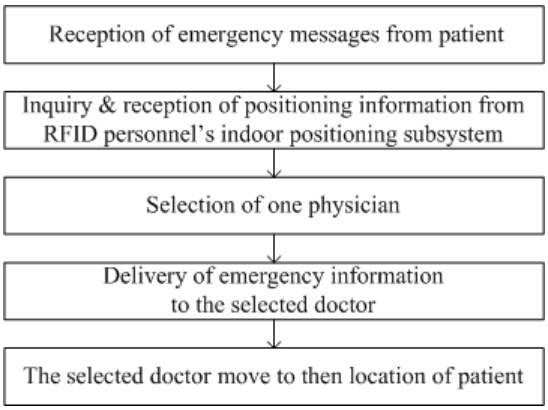

Fig. 4. The concept for the emergency message processing

With emergency messages from one patient received by the system, positions of the patient as well as all medical care personnel will be inquired via the RFID indoor positioning subsystem first. For the purpose of the medical care personnel's reception of real-time information, messages with the patient's position will be forwarded to the portable computer of this medical care personnel with warning messages indicated on his (her) PDA via the wireless network after identities and positions of the medical care personnel and the patient are confirmed. Finally, the medical care personnel will move to this patient, conducting the first aid after recognizing the patients' identity via the RFID reader on the portable computer.

(2) Reception of messages about one patient's calling for help

For one patient's emergency rescue event delivered to the medical care personnel via the system, there are following possibilities: 1. One patient's abnormal physiological signals detected by conventional medical equipment: the patient's any physiological abnormality will trigger warning messages from monitoring instruments that attract the medical care personnel out of the nursing station for immediate treatments of that patient. 2. One patient's abnormal physiological signal detected by the advanced smart physiological signal suite: A patient wearing the physiological signal detection suite developed by lots of research institutes has not to undergo restrictions of activities on one bed only but freely move inside one hospital with his physiological signals constantly monitored and signals for emergency rescues emitted from the physiological signal suite detecting. 3. Re-emission of emergency messages from the medical care personnel receiving the first message: In such a situation, triggering of one emergency event from the medical care personnel who is responsible for this event may derive from this staff's original tasks.

(3) Inquiries of positions of one patient and all medical care personnel

A new event in the queue of the emergency events discovered by the emergency message subsystem will trigger this step. Prior to selecting the adequate medical care personnel for rescues on the spot, positions of this patient and all medical care personnel must be realized by the system. Against this background, information with regard to positions of the patient and all medical care personnel will be required from the previously mentioned RFID indoor positioning system. As a system constantly detecting all persons' positions, the RFID indoor positioning system has one database providing records as regards their detailed positions that can be inquired.

(4) Selection of the adequate medical care personnel

A patient's emergency status, the first priority considered by the system is time as the major consideration to decide the medical care personnel be picked up to arrive at the destination within the shortest interval. Thus, the current work status of the originally adequate medical care personnel must be one factor considered by the system. As to the difference for seriousness between both tasks, we depend on classifications by the triage that the medical care personnel rescuing a Level 1 wounded should not receive a lower-priority emergency message. The procedure of selecting the medical care personnel by the system is shown as Fig. 5.

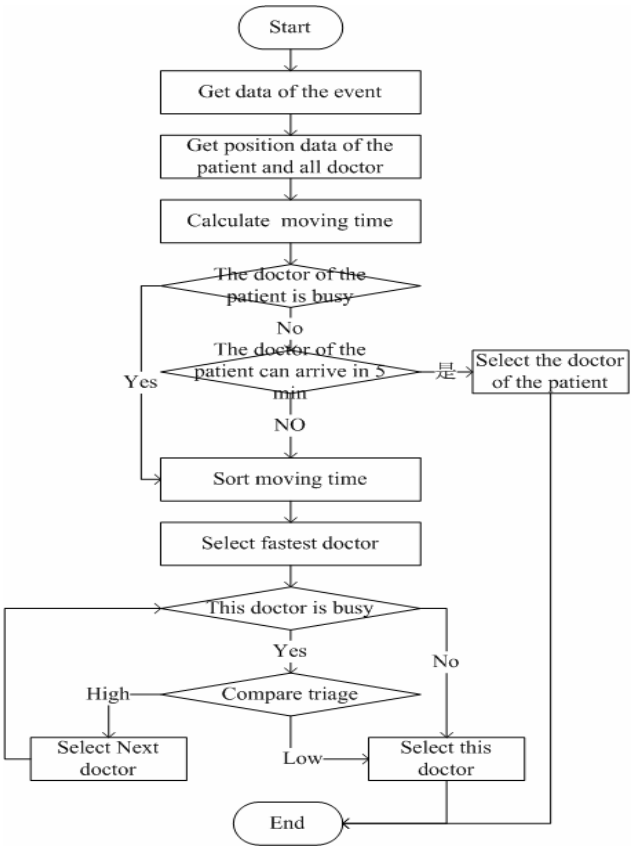

Fig. 5. The flow chart of picking up the medical care monitor personnel

(5) Delivery of Emergency Messages to the Medical Care Monitor Personnel

With the medical care personnel selected, he (she) needs to receive the emergency messages via one portable computer providing a channel to get one patient's information in this study. Furthermore, the computer program inside one PDA linking the server constantly inquires and receives messages shown on the screen with warning messages indicated.

(6) Start of Rescues after Arrival of the Medical Care Personnel beside one Patient

While arriving at the destination, the medical care personnel will start rescues to the patient. For the sake of ensuring the system being aware of the patient rescued, the medical care personnel arriving at the scene should detect the patient's tag to recognize his (her) identity by using one RFID reader. With the patient's identity confirmed, the system may mark this level of message as "in process" to avoid messages constantly delivered.

(7) Medical Care Personnel's Message Reception Subsystem

In this study, the portable mobile computer with one RFID reader installed is adopted as a tool of receiving messages for the medical care personnel. To this end, this portable mobile computer should have the following functions:

(8) Confirmation and Record for the Identity of the Medical Care Personnel Completing Registration

Because the portable mobile computer, as unregistered hardware, cannot judge any medical care personnel using this equipment, the identity recognition function via the medical care personnel's registration identifies a user, making the system decide the destination of messages delivered. Additionally, to save costs for purchases of some equipment, the medical care personnel preparing to use the equipment enter the registration process recording their identities because they take rest alternately and work in shifts.

(9) Reception and Warning of Emergency Messages

With the medical care personnel registering the portable mobile computer successfully, the system will activate one constantly executing process to check the database for any message designated to some certain registered medical care personnel and read these messages into the portable mobile computer that the medical care personnel are able to realize their own duties via this mobile device. As one kind of active equipment, the system detecting some tasks required to implement forthwith will send one warning message indicated on one pop-up control box with sounds as well as vibration.

(10) Delivery of New Emergency Messages

With one new emergency accident informed to the medical care personnel, he (she) has to make a decision to deliver emergency messages by considering his (her) current tasks. In addition, while executing tasks, the medical care personnel having requirements of assistants for the current work can deliver messages collecting necessary manpower.

(11) Recognition of One Patient's Identity

The medical care personnel arriving beside one patient can identify his (her) identity via the RFID tag on the patient confirmed as the target requiring rescues. With that patient recognized as the target for rescues, the system will mark this patient in the list as "under rescues".

4 Implementation System and Efficiency Analysis

4.1 Developed Environment and Tools for the System

This system is divided into four major potions where PDAs are prepared as one environment for data maintenance and reception of messages delivered to the medical care personnel. As to the emergency event processing system, the computer program is designed as one constantly executing service program displayed with Windows interfaces for the purpose of convenience in explanation and exhibition of effects & functions. As a result of deficiency in experimental equipment regarding long-distance RFIDs, our positioning system integrates the well-developed RFID medical care personnel & patient positioning system with emergency messages from the well-developed smart physiological signal suite incorporated for the purpose of system integration in this study.

As shown in Fig. 6, for the whole systematical environment is composed of two mainframes and one PDA. For this system, one mainframe is taken as the database mainframe and another as the application programming mainframe including the emergency message processing system and the data maintenance system. To cover functions of message reception for the medical care personnel into the RFID emergency

medical care system, which is setup as the fundamental data maintenance function in this prototype system, PDA is equipped with the RFID reader. As one major channel for reception of the RFID positioning information, e.g., positions of the medical care personnel and patients, the RFID positioning system mainframe also deliver abnormal emergency messages detected by physiological suite.

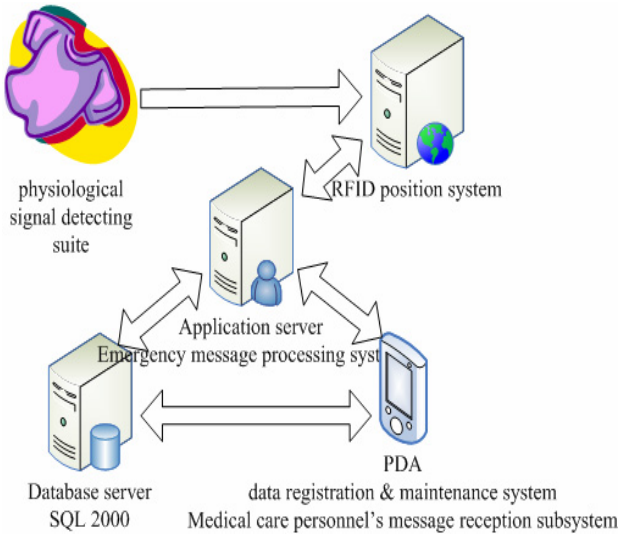

Fig. 6. The systematical environment and structure for the IoT medical care monitor system

4.2 Comparisons between the Current Medical Care and the IoT Emergency Care Monitor System

As to the relevant research for the current medical care mechanism, we have comparison with the IoT care monitor system offered in this study, as shown in Table 1, and further instructions as follows:

Table 1. Comparison between current medical care and IoT medical care monitor system

	Current medical care	IoT medical care monitor system
Monitoring of one patient's physiological status	Monitor a patient's physiological status via fixed physiological monitoring instruments.	Physiological signal suite to monitor one patient's physiological status.
Notices of one patient's emergency status	Install emergency buttons for patients' usage or depend on staff accompanied.	Monitoring via physiological signal suite with emergency buttons on it for one patient.
Control of people's tracks	No proper control.	Control positions of the medical care patients anytime via the RFID positioning technology.

(1) Monitoring for Patients' Physiological Status

As a result of seriousness of patients, the emergency room or the intensive care unit will be equipped with monitoring instruments based on the current method for monitoring of inpatients' physiological status. However, these monitoring instruments may not be installed for inpatients in general wards and the medical care personnel or careers deployed in wards may not accompany patients, either. In this study, patients wearing physiological signal suite can be monitored by the system anytime in any place even though there is no any staff accompanying them.

(2) Notices for Patients' Emergency Status

Suffering from abnormal physiological conditions or any emergency accident, one inpatient needs to press one emergency button around him according to the current method. In the unlikely event that one patient has no emergency button around or cannot press that button by himself because of his physiological factors, the accompanied staff or other people passing through are the only helpers to inform the medical care personnel. In case of no assist from anybody unfortunately except for those cases previously mentioned, that patient will be trapped into a plight of no help. With the physiological suite

mentioned in this study, physiological abnormalities of one patient staying at any location will be detected by the system and the aid button designed on the suite submits another channel of one patient's calling for help.

(6) Reception of Emergency Messages

While one patient's emergency event, it will be detected by the medical care personnel via monitoring pictures in the nursing station; this message will be lost by the medical care personnel who are not beside the monitoring pictures. Alternatively, one person perceiving any abnormality of one patient directly seeks the adequate medical care personnel for medical treatments; however, this method may cause waste in time owing to no finding of the medical care personnel. In this study, all medical care personnel wearing mobile devices will receive patients' emergency messages anytime in any place.

(7) Efficiency Analyses

With the RFID positioning and the identity recognition as major technologies, the IoT emergency medical care monitor system developed in this study integrates physiological signal suite and wireless mobile devices and guarantees that patients who have problems anytime in any place are able to receive rescues in the shortest period. As shown in Table 2, the efficiency as regards this system is described.

Table 2. Efficiency analysis of the IoT emergency medical care monitor system

Conventional method	IoT medical care monitor system
Uncertain control of one patient's physiological status	Control of one patient's physiological status anytime
Difficult tracking of one patient's positions	Control of one patient's position anytime
Possibly longer wait of one patient	Reduction of one patient's wait for rescues
A patient's emergency messages uncertainly received by the medical care personnel	A patient's emergency messages received by the medical care personnel anytime
Medical care uncertainly received by one patient	Guarantee of medical care to one patient anytime

5 Conclusion and Future Work

In this paper, we offer one hospital emergency medical care system by integrating several technologies such as RFID identity recognition, RFID positioning, and mobile communications to ensure the medical care personnel's immediate cure to general inpatients within one hospital. Contributions of this study can be summarized as follows:

- Based on the RFID technology, one hospital emergency care system incorporating physiological signal suite as well as wireless mobile devices is offered to ensure the medical care personnel's immediate care to general inpatients that have emergency accidents in hospital.
- Cooperating with other organizations researching the RFID technology applied in the medical industry, we can design one system with complete coverage of medical care to all inpatients without any dead space regarding medical care in one hospital.
- The systematical structure can be setup to other medical care institutes like the senior citizens' care center as their emergency medical care system.

However, there is still some future work to do. The future research focuses on improving the efficiency of IoT Personnel's indoor Positioning Subsystem.

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