WSN based IoT Healthcare Application, Challenges and Solution: A Comprehensive Review

Suleiman Bello Mohammed
Department of Computer Science and Engineering
Seoul Nation University
Seoul, South Korea

Kilhung Lee*
Department of Computer Science and Engineering
Seoul Nation University, Seoul, South Korea
Email: khlee [AT] seoultech.ac.kr

Abstract—**Wireless sensor network (WSN) technology is mature enough to be used to improve the quality of life and is considered one of the important areas of research in the computer science and medical application industries. Popular medical systems provide a wealth of situation information and provide a mechanism to alert against strange situations with constant monitoring. This paper surveys an in-depth study of the significant benefits of the WSN application and discussed the major challenges in the healthcare system. In addition, we also provide some state-of-the-art examples along with design considerations such as discreetness, security, energy efficiency, scalability and a comprehensive analysis of the challenges of these systems. Finally, we surveyed some wireless technologies used in the healthcare system and discussed some existing research**

Keywords- Wireless sensor network, healthcare system, security, discreetness

I. INTRODUCTION

With the technological progress of low-power network systems and medical sensors, the emergence of Wireless Sensor Networks (WSN) in medical care has been observed in recent years. Growth in patients with chronic diseases and recent technological advances has influenced the idea of this paper to which wireless technology is applied to improve the patient situation [1]. In order to realize the maximum mobility and flexibility of ubiquitous healthcare, the design and size of sensor nodes used are taken into account when implementing hardware. Regarding medical care assistance, barcode technology that supports patient out of medication management is applied by capturing and decoding medicinal barcode using built-in camera of Android smartphone. It also reduces confusion, queuing and crowds at the hospital, provides more health care services, and focuses on patients who seriously and urgently need such services [2].

The rapid progress of technology, ease of use, and lower price of mobile devices contribute to major changes in today's lifestyle. Over the past decade, with the rapid development of wireless mobile and IoT technology, the ubiquitous coverage concept has grown in various areas of society. Initially, it has changed into a ubiquitous application so that many applications that could only be used in a fixed place can be wirelessly and flexibly used anytime and anywhere. For example, the ability to watch television programs and listen to songs on mobile phones, compared to the earlier times when these former entertainments were available at a fixed location where power can be supplied. The same trend is also observed in the medical field [3].

People have experienced the loss of loving beloved people due to chronic diseases such as heart disease, hypertension, diabetes, etc. are now increasingly aware of medical care. Long-term, high-quality drug treatment is necessary to keep it under control of chronic disease patients because the chronic disease has recurred over a long period of time. In this way, global medical costs are exploding increasing as the public's demand for improving the quality of medical care rises. As a result of this increased demand, medical personnel and appropriate medical infrastructure are lacking. Therefore, fundamental change is necessary to solve this problem.

WSNs fulfill promises to greatly improve and expand the quality of care in a wide range of settings and various parts of the population. For example, early system prototypes have demonstrated the possibility of WSN that enables early detection of clinical deterioration through hospital real-time patient monitoring [4], automatic first aid at large-scale disasters Electronic triage, improve the living environment of the elderly in a smart environment, enabling large-scale on-site investigations of human behavior and chronic diseases [5].

The structure of the rest of this paper is as follows; In Chapter 2, the service and application of healthcare system are discussed. Chapter 3 discusses challenges and security threats in healthcare system. In Chapter 4, we discuss and technologies and existing solutions. Finally, we conclude our research survey in Chapter 5.

II. SERVICE AND APPICATION

The IoT-based medical system applied to various fields including care of children and elderly patients to deepen their understanding of a wide range of topics. In this paper, we broadly classify the discussion in two aspects of service and application. The application is further divided into two groups: single condition and cluster condition group, as shown in Figure 1.

A. IoT Healthcare Services

IoT is expected to enable various medical services that each service provides a series of medical solutions. It is important to note that the general services and protocols required for the IoT framework may require minor changes due to proper functioning in the medical scenario. The following subsections contain various types of IoT healthcare services.

Internet of m-health: As discussed in [6], m-health is only mobile computing, medical sensor, and communication technology for medical services. In theory, m-IoT is familiar with the new health connection model which connects the evolving 4G network and 6LoWPAN for future Internet-based m-health care services. The use of m-IoT services are considered based on the likelihood of m-IoT for non-invasive detection of glucose levels, m-IoT architecture, problems, challenges, and implementation are described in [7].

Community healthcare: In the community health monitoring, the concept of building a network is to cover the surrounding areas of the community. This could be an IoT-based network around a public hospital, a residential area, or a rural area. An energy efficient cooperative IoT platform for rural medical monitoring was proposed in [8]. The structure of community medical network can be seen as "virtual hospital." An occupant wellbeing data benefit platform based on a functional framework of a four-layer structure is being studied.

Wearable device access: Different kind of noninvasive sensors for various medical applications [9] specializing in WSN-based medical services are being developed. Apart from that, the wearable device can comprise a desired set of features suitable for the IoT architecture. An activity remote monitoring recognition method using wearable devices in presented in [10] and based on mobile device is proposed in [11].

Indirect emergency healthcare: There are numerous situations or circumstances in which medical problems are seriously involved, such as bad weather, transportation (aviation, ship, train, and vehicle) accidents, land collapse, fire and so on. In these specific situations, a dedicated service called Indirect Emergency Medicine (IEH) can provide a bundle of solutions such as data accessibility, notification of change, action after the accident, storage of records. For interested readers see [12] and [13] here.

Adverse drug reaction: ADR is injuries due to medication [14]. It may happen because of single dose or sequence of a double dose. IoT-based ADR is proposed in [15]. Here, the

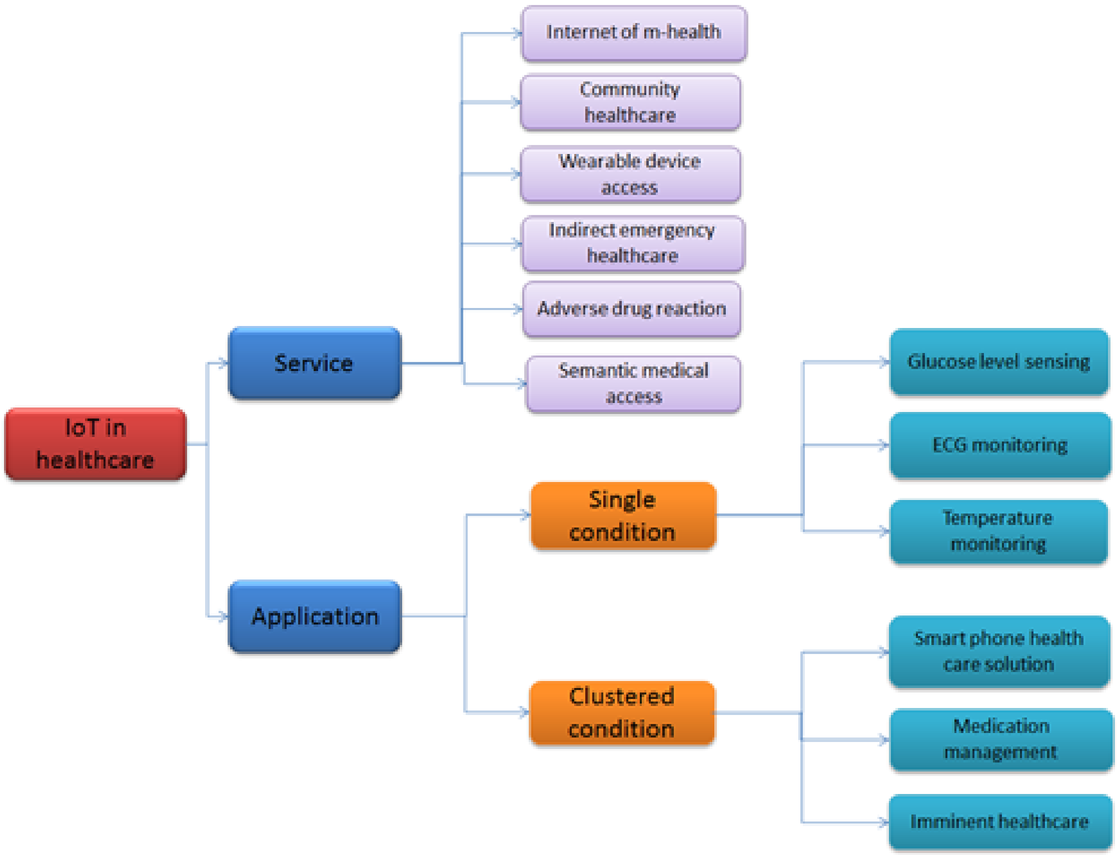

Figure 1. Application of IoT in healthcare

terminal of the patient identifies the medicine by the Barcode / NFC compatible device. IMedPack was developed as part of iMedBox to address ADR [14] using RFID and controlled delamination material (CDM) technology.

Semantic medical access: The utilization of semantics and ontologies to share the huge amount of healthcare data and knowledge has been broadly considered. The wide capability of medicinal semantics and ontologies has gotten close consideration from designers of IoT-based social insurance applications. In [16], a semantic medical monitoring system based on the IoT sensor has been proposed. Several studies discuss semantic medical problems in the context of the IoT environment [17].

B. IoT Healthcare Application

IoT application is a deserve closer attention for IoT services. It can be noticed that services are utilized to create an application, while applications are specifically utilized by clients and patients. In this way, administrations are designer driven, while applications, client is driven. Notwithstanding applications shrouded in this area, different contraptions, wearable and other social insurance gadgets right now accessible in the market are talking about.

Glucose level sensing: Diabetes is a group of metabolic disorders that have high blood sugar levels over a delayed time. Blood sugar monitoring reveals individual blood glucose change patterns and helps plan for meals, activities, dosing times. An m-IoT arrangement strategy for real-time noninvasive glucose sensing is proposed in [18].

Electrocardiogram monitoring: Electrocardiogram monitoring, i.e. electrocardiogram recorded cardiac electrical activity, involves simple heart rate measurements and basic rhythm determination, as well as diagnosis of pleiotropic arrhythmias, myocardial ischemia and myocardial ischemia Extended QT interval [19]. In studies [20] and [21] explicitly discuss IoT-based ECG monitoring. In the application layer of the IoT network for ECG monitoring, there is a comprehensive detection algorithm for ECG signals.

Body Temperature Monitoring: Monitoring body temperature is an integral part of healthcare services administration, as body temperature is a decisive important sign of maintaining homeostasis. In [22] the author proposed a temperature management system based on home gateway which transmits the user's body temperature with the help of infrared detection over IoT.

Medication management: The problems of non-compliance in medicines are the problem of compliance in medicines or the dosage represents a serious threat to public health and causes enormous financial waste throughout the world. To address this problem, IoT offers several promising solutions. An intelligent packaging method for medicine boxes for pharmaceutical management based on IoT is presented in [23].

Imminent healthcare solutions: There is no explicit demonstration of the integration of these devices into the IoT network, but many other portable medical devices are available. In other words, it will take time for these devices to be integrated into the IoT function. More and more healthcare applications, devices, and cases address increased demand for IoT-based services worldwide. There are hemoglobin detection, peak expiratory flow, abnormal cell proliferation, cancer treatment, eye disease, skin infection, remote operation, etc. in the health care field where integration with IoT is imminent [24].

Healthcare solutions using smartphones: Late years have seen the rise of electronic gadgets with a cell phone controlled sensor, which highlights the ascent of smartphones as a driver of the IoT. A comprehensive review of healthcare applications for smartphones is provided systematically in [25]. This includes discussions on patient-oriented applications, general healthcare applications, medical education, training, information retrieval applications, etc.

III. CHALLENGES AND SECURITY THREATS

In this chapter, we present some challenges in WSN healthcare system as shown in figure 2 and discusses the security threats in IoT medical network.

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A. Hardware Level Challenges

Unobtrusiveness: Designing and developing sensor devices that can be installed without hindrance is still a major challenge. When a patient is necessary to carry a sensor attached to the body by a patient as a fall detection system described in [26] and FireLine [27], inconspicuousness becomes a big challenge for many other people. Because it is necessary to integrate different sensors into one solution, it becomes more difficult as with sensor units in LiveNet and PATHS.

Sensitivity and alignment: The sensitivity of the sensor device is imperative particularly important when the user wears the sensor in a harsh environment such as a fire situation or exercise. This sweat negatively affects the transducers of the sensor device and may cause a decrease in the sensitivity of the wearable body sensor or may require recalibration of the sensor.

Energy: One of the bottlenecks in sensor devices is batteries. In indoor situations, the rechargeable battery might be the cure now and again, though energizing the batteries might be difficult particularly for the elderly. Considering the possibility of forgetting to charge the batteries of some sensors, this is a serious problem to be solved.

Data acquisition efficiency: Due to the high rate of data collection, the design of an effective data processing technology is very important in medical systems. In some cases, a 3-lead electrocardiogram may be insufficient to identify heart disease, and a single 3-axis accelerometer may not be able to classify all human activity.

B. Physical Layer Challenges

Error resilience and reliability: Because the wireless sensor device has low transmitted power and small antenna size, the signal-to-noise ratio (SNR) decreases, the bit error rate increases and the reliable coverage area decreases. However, reliable data transfer in medical monitoring systems is essential.

Interoperability: The reconciliation of various sensing devices operating at different frequencies causes interoperability problems. Communication between various devices occupies multiple bands and uses numerous protocols. This situation can cause interference between various devices, especially within unlicensed industrial, scientific and medical (ISM) radio bands.

Bandwidth: The transmission bandwidth available for data communication for WBAN is relatively low. For new sensor node the bandwidth capacity is 250 Kbps but the duty cycling mechanism is applied to reduce power consumption and it results in reducing of the actual available bandwidth. For 10% duty cycle is operated be sensor node it results that data transmission is 10% of the time. This situation can cause difficulties, especially when there is a huge amount of data as in the case of transmission of diagnostic medical image data requiring a capacity of maximum Mbit / s level

C. Others layer Challenges

MAC layer challenges: In addition to WSN's periodic MAC layer challenges such as energy efficiency, there is a challenging problem specific to healthcare monitoring. First of all, we need to consider the quality of service (QoS) requirements of emergency traffic for medical monitoring applications.

Network layer challenges: Delay Optimization and Energy Recognition Routing protocols are the most important unresolved research topics for wireless sensor network applications for medical monitoring. Convergent traffic inherent in the wireless sensor network can cause a choke effect at the node close to the base station. For this reason, we need to develop a load-balancing routing protocol.

Transport layer challenges: Because healthcare applications handle life-critical data, lost frames and packets can cause alarm situations to be completely missed or misunderstood. Therefore, reliable data delivery is necessary. Some reliability mechanisms are present at different layers, e.g. Automatic Repeat Request (ARQ) at the MAC layer, but critical WSN applications such as healthcare monitoring require an end-to-end reliability mechanism [28]. For medical application reliability, we may need either a packet level or event level solution.

Application layer challenges: In the application layer, one of the most difficult tasks is to create useful information to organize the data and grow in knowledge. The application layer on the top surface is expected to have an adjustment mission as well. In this specific circumstance, the organization of the medical, ambient sensor, and other context data must be maintained by this layer.

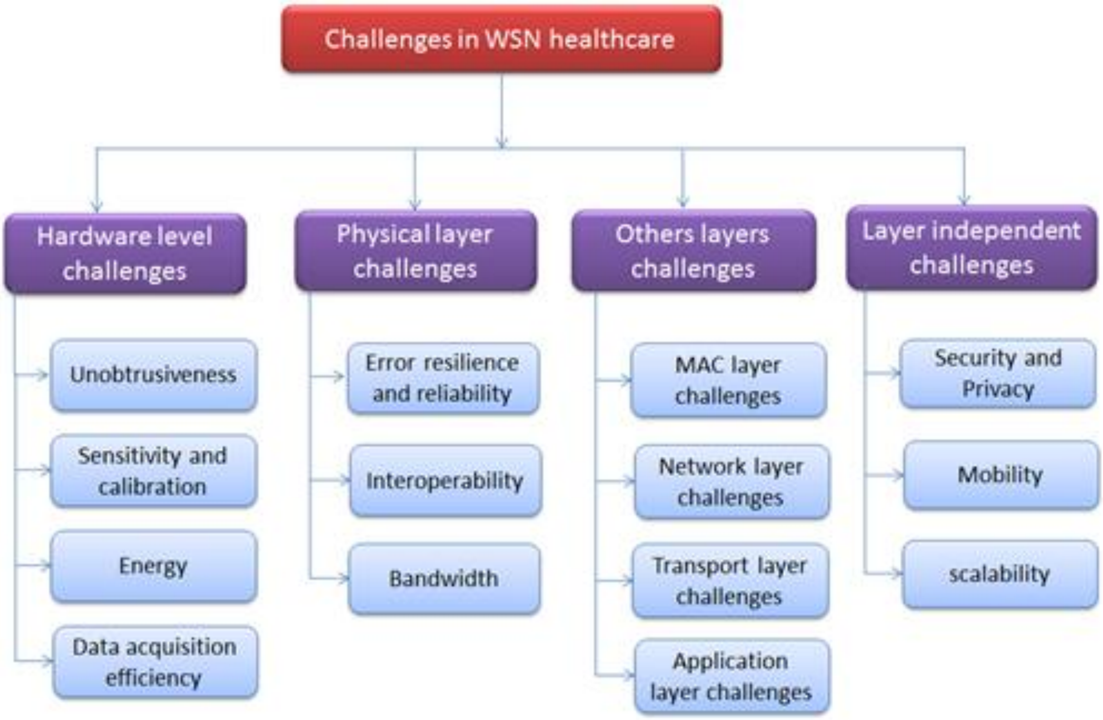

Figure 2. Challenges in WSN healthcare system

D. Layer Independent Challenges

There are some tasks not directly related to a specific layer or directly related to all layers. These challenges and related tips on solutions are described in the next subsection.

Security and privacy: The basic system security requirements are confidentiality, data integrity, availability, accountability and access control. In order to guarantee these security requirements encryption methods can be used that cause the problem of developing an efficient key management protocol.

Srinivasan et al. presented the fact that wireless communication is encrypted, it points out privacy leak called Fingerprint and Timing-based snooping (FAT) attack in wireless sensor system [29]. This privacy flaw allows an attacker to monitor people's ADL with only two pieces of information: timestamp and fingerprint of each wireless message.

Mobility: The purpose of health monitoring is that the people live independent lives with high quality of medical services. Using different sensors and sensor networks for this purpose is not new [30]. Nevertheless, the advent of WSNs has allowed the development of applications that guarantee and promote the mobility of users.

Ease of deployment and scalability: As with convenience, development of a popular type system for easy to deploy is also indispensable and an important issue. As the number of patients and caregivers increases, scalable and easily deployable applications that can support multiple receivers are very important. In general to observe the healthcare systems, it is generally necessary to simultaneously use multiple sensor devices, communication devices, and software. With these various components, the ease of introduction should be considered.

E. Security Threats

Security violation in sensor network healthcare applications is a major concern. Most security-related issues in the sensor network healthcare application are similar to those of the WSN application environment. Security problems can be divided into two major levels: system security and information security.

The author of [31] classified attacks and threats into two parts: active and passive. Passive attacks can occur while routing data packets in the system. An attacker could change the destination of a packet or inconsistent routing. An attacker can also steal health data by eavesdropping wireless communication media. Active threats are more harmful than passive counterparts. Criminals may know the user's location by eavesdropping. This could lead to life-threatening situations.

Frank kargal et al. [32] refers in detail to attacks on health monitoring. Eavesdropping and tampering with medical data, impersonation of alarm of medical data, denial of service, tracking user's location and activity, physical device tampering, disturbing attacks and so on. A malicious person may use that information for harmful activities. Some of the activities are as follows:

Data modification: An attacker can delete or replace some or all of the eavesdropped information and send the changed information back to the original recipient to achieve fraudulent purposes. Health data is essential. Changing them can result in system failure, causing disasters to people.

Impersonation Attack: If an attacker eavesdrops on the identification information of a wireless sensor node, it can use it to cheat other nodes.

Eavesdropping: Because of the open function of the wireless channel used in the sensor network, any partner can intercept wireless communication between wireless nodes freely and easily. Data stalling may be used for malicious acts.

Reproduction: An attacker can eavesdrop on valid information and retransmit it to the original recipient after a while and achieve the same purpose in another case.

In addition, the attacker, therefore the threat, may be both internal and external. Since an external attacker is not part of the system, it is difficult to deter. The main purpose of these attacks is to steal precious personal data

TABLE I. WSN TECHNOLOGY CANDIDATES FOR PERSISTENT HEALTHCARE SYSTEMS

Technology	**Data rate**	**Candidate subsystem**	**Cell radius**	**Frequency band**
IEEE 802.11g/WiFi	54 Mbps	BAN/PAN	50–60 m	2.4 GHz
IEEE 802.11n/WiFi	54 Mbps	BAN/PAN	50–60 m	2.4 GHz
ETSI HiperMAN	WAN	25 Mbps	2–4 km	<11 GHz
IEEE 802.22	WAN	18 Mbps	40 km	54–862 MHz
IEEE 802.16e/WiMAX	WAN	30 Mbps	Up to 7080 km	2–6 GHz
WiBro	WAN	18 Mbps	1 km	2.3–2.4 GHz

IV. TECHNOLOGIES AND SOLUTION

A. Technologies

To provide global coverage, existing and new broadband networks need to be integrated into pervasive healthcare solutions. Technology of application and service infrastructure is also possible to discuss with remote experts such as part of medical shortage without marine Luca Catarinucci et al. [33] proposed a smart hospital system using hybrid sensing network and CoAP)/IPv6 protocol. Sanaz Rahimi Moosavi et al. [36] provide vessel and technology infrastructure satellite and high altitude platform provide services for disaster area quickly and easily. Table 1 summarizes the characteristics of mobile network technologies and candidate wireless connectivity [37].

B. Existing researches in healthcare system

In the field of healthcare, applications of the sensor network are research and deployments throughout the world. This section presents some existing research on WSN based healthcare system. Pei-Cheng Hii et al. [34] researched and analyzed of ECG wave form in real time coverage of WSN. Joao Caldeira et al's research [35] provided a mobility support for the body sensor network using link quality indicator. Sasan Adibi et al. discussed the challenges and issues related with m-health [38].
authentication and authorization in distributed smart e-health gateway and protect by DoS attack. Moreover, Surabhi Juneja et al. [39] surveyed the application of WSNs in the healthcare system.

TABLE II. SUMMARY OF EXISTING SCHEME ON WSN BASED HEALTHCARE SYSTEM

Reference	Existing scheme	Basic theory	Description	Other feature
[32]	Ubiquitous Healthcare Solution on an Android Mobile Device	ARM processor, QR Barcode Generator, Android™	observe and analyze ECG waveforms from wearable ECG devices in real time under the coverage of WSN and exploitation of WSN in healthcare can substitute the complicated wired technology, moving healthcare away from a fixed location setting.	Achieves self-monitoring, flexibility, mobility and real-time heart rate analysis.
[33]	Mobility Solutions for Body Sensor Networks on HealthCare	6LoWPAN, link quality indicator (LQI)	It can always be connected to back-end healthcare providers and a gateway to the Internet to provide mobility support for the BSN.	Continuous monitoring on hospitals, detect any anomaly in the patient health status.
[34]	A review on mobile health solution	Bluetooth low energy, ZigBee, eHealth	Discusses the challenges related to mHealth realization and provides a brief discussion about the medical research.	Reviews healthcare industry and their underlying link technologies.
[35]	IoT-based Smart Healthcare Systems Architecture	(CoAP)/IPv6, hybrid sensing network, REST web service	Propose a smart hospital system (SHS), which relies on different, yet complementary, technologies, specifically RFID, WSN, and smart mobile through a constrained application protocol.	Ultra-Low-Power HSN has been implemented and identification and tracking of patients, nursing staff, and biomedical device.
[36]	Secure Architecture for IoT-Based Healthcare	DTLS handshake protocol, CC2538 module,	Authentication and authorization are done by distributed smart e-health gateway. It utilizes a more secure key management scheme for securing the architecture.	Impact of DoS attack is reduced, reduces communication overhead, and communication latency
[37]	Healthcare Analysis via Wireless Sensor Network	-----------	Paper studies the application of WSNs in the healthcare system and address how WSN concepts are integrated into our computer program.	Cancer Detection, Artificial Retina, Glucose Level Monitoring, Heart Rate Monitoring

V. CONCLUSION

There was growing interest in the development of academic and industry technical solutions to tackle the problem of health care provision. It was difficult to accurately forecast the future in every field, but the population of the world's aging population will be in a new environment that will provide services to everyone who needs the healthcare industry and reduce the cost of healthcare services. From the medical point of view of the WSN, we provided an analysis of these challenges. In this paper, we also attempted raising concerns about social importance such as privacy and security in the medical environment. Moreover, this paper summarized some wireless technologies used in pervasive healthcare system and suggested some existing solutions

ACKNOWLEDGMENT

This study was supported by the Research Program funded by the SeoulTech(Seoul National University of Science and Technology).

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