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M2M-based smart health service for human UI/UX using motion recognition

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Abstract Home networks currently dominated by human–object or human–human information production, exchange, processing, and paradigms are transitioning to machine to machine (M2M) due to the sudden introduction of embedded devices. Recently, due to the spread of IT equipment, more M2M-related devices are being used, and M2M-based projects are underway in various fields such as M2M-based u-city, u-port, u-work, u-traffic, etc. M2M has been applied in various fields, and u-healthcare is attracting attention in the M2M medical field. U-healthcare refers to technology in which ordinary patients can receive prescription services from experts by continuously monitoring changes in their health status during daily life at home based on wired and wireless communications infrastructures. In this paper, we propose an M2M-based smart health service for human UI/UX using motion recognition. Non-IP protocol, not TCP/IP protocol, has been used in sensor networks applied to M2M-based u-healthcare. However, sensors should be connected to the Internet in order to expand the use of services and facilitate management of the M2M-based sensor network. Therefore, we designed an M2M-based smart health service considering network mobility since data measured by the sensors should be transferred over the Internet. Unlike existing healthcare platforms, M2M-based smart health services have been developed for motion recognition as well as bio-information. Smart health services for motion recognition can sense four kinds of emotions, anger, sadness, neutrality, and joy, as well as stress using sensors. Further, they can measure the state of the individual by recognizing a user's respiratory and heart rates using an ECG sensor. In the existing medical environment, most medical information systems managing patient data use a centralized server structure. Using a fixed network, it is easy to collect and process limited data, but there are limits to processing a large amount of data collected from M2M devices in real-time. Generally, M2M communication used in u-healthcare consists of many networked devices and gateways. An M2M network may use standardized wireless technology based on the requirements of a particular device. Network mobility occurs when the connecting point changes according to the movement of any network, and the terminal can be connected without changing its address. If the terminal within the network communicates with any corresponding node, communication between the terminal and corresponding node should be continuously serviced without discontinuation. The method proposed in this paper can easily respond to dynamic changes in the wireless environment and conduct systematic management based on

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user's motion recognition using technology to support mobility among sensor nodes in M2M.

Keywords M2M · Smart healthcare · u-Healthcare · Telemedicine · Human UX/UI · Motion recognition

1 Introduction

Currently, the technology world is focusing on next generation Information & Communication Technology (ICT) infrastructure as a solution for urgent social and economic challenges as well as national key policy issues such as the global financial crisis, social polarization, job creation, climate change, energy savings, safe buildings, etc. As a result, the broadcast communication paradigm has greatly changed. Information collection and utilization techniques have been developed based on human-centered communications, but the communication area is being expanded to human–object, object–object, as well as human–human information production through convergence between different media. These techniques are called machine-to-machine (M2M), and intelligent convergence services that use M2M can send information through intelligent collection by applying sensor and communication functions to objects [1–5].

Recently, due to the spread of IT equipment, more M2M-related devices are being used, and M2M-based projects are underway in various fields such as M2M-based u-city, u-port, u-work, u-traffic, etc. In particular, there is increasing demand for health services due to a rapid increase in the number of elderly, rapid development of medical technology, increased competition among medical institutions, etc. This has led to additional consumer-oriented services that prioritize the expectations and desires of medical consumers in delivering health services. As a result, use of M2M technology is increasing in medical-related fields such as u-health, telemedicine, bio-sensor network, u-town, etc [6,7]. Telemedicine refers to technology in which ordinary patients can receive prescription services from experts by continuously monitoring changes in their health status during daily life at home based on wired and wireless communications infrastructures. The ultimate goal of telemedicine is to improve an individual's life by accumulating and providing lifelong personal health records such as PHR, EHR, and EMR [8,9]. Its goals are to allow individuals to receive healthcare services to ensure self-healthcare ability and continuously provide comprehensive services required for personalized healthcare. This can greatly alleviate increases in medical care costs due to an aging population and supplement the shortage of medical professionals by providing efficient medical services [10,11]. The basic technologies of telemedicine health are classified into bio-information recognition technology, transmission and gathering technology, as well as analysis and feedback technology [12,13]. Bio-information recognition technology periodically or continuously monitors various types of bio-information obtained from the human body, after which it processes and analyzes various biological signals related to health such as an individual's electrocardiogram, blood pressure, oxygen saturation, etc. Transmission and gathering technologies primarily process data by sending collected data through various devices to a PC or mobile phone using wired and wireless communication technologies. Analysis and feedback technologies include u-healthcare application service technologies in which the doctor remotely provides healthcare and medical services to the target patient. Data processed and analyzed using the above technologies detect the surrounding environmental information and send it to the health information server via a wired or wireless network in a synchronous or asynchronous manner [14–16]. Currently, a zigbee or UWB sensor communication protocol uses an interface system, and collected data between wireless medical devices and sensors are sent through wired and wireless technologies, including 3GPP, WLAN, etc. Data (wellness index) on health status and lifestyle are accumulated in a health information system, and related alarm, field diagnostic prescription (PoC), and simple recognition are sent to the user in an application service. In order to build a u-healthcare service system based on a variety of medical devices, the interface system and communication between feedback systems, which measure and manage the physical state of the patient, are highlighted as very important factors [17–19,35–38].

In this paper, we propose an M2M-based smart health service for human UI/UX using motion recognition. The proposed M2M-based smart health service can be applied in a home healthcare environment and carry out motion recognition as well as bio-information collection, unlike existing healthcare platforms. The emotional state according to life patterns can be detected by measuring an individual's life pattern through motion recognition and by observing changes in a particular behavior over a long time. The residents of a home can manage their health and cope with emergency situations easily by using information collected from various sensors based on M2M technology. To obtain accurate data regardless of the situation, a smart health service was developed that can support mobility. Network mobility occurs when the connecting point changes according to the movement of any network, and the terminal can be connected without changing its address. If the terminal within the network communicates with any corresponding node, communication between the terminal and corresponding node should be continuously serviced without discontinuation. To this end, it was designed to have a mobility network protocol structure acting as the sensor network gateway, including route optimization, a multi-homing module for expanding address mapping table mobility network mapping with sensor net-

work nodes, QoS, security, light-weighted routing protocol with a sensor network, as well as internet routing.

The rest of this paper is organized as follows. Section 2 describes research related to the machine to machine (M2M) and M2M based health device. Section 3 describes the M2M based smart health service using motion recognition for human UI/UX. Conclusions are given in Section 4.

2 Related research

2.1 Machine to machine (M2M)

Recently, as wireless network, communication module and sensor etc. are spread, the growth of the relevant market is accelerating and M2M service seems to be more prevalent due to an increase in the service terminal such as smart phones, etc. and the introduction of the alternative network such as wifi etc. M2M is to expand human-centered information utilization approach of communication between human and human to communication between human to object, object to object and refers to the next-generation convergence infrastructure providing intelligent service by using a variety of media from the service based on conventional single media. M2M is functionally independent or convergent and can play a new convergent function with the development of communication technology such as 4G. Also, it is making the area of the new convergence service beyond the limits of human-centered communication. The development of ICT technology such as low communication costs between objects, embedded mobilization of all objects etc. is becoming the basis of rapid networking of a variety of objects. M2M was used in industrial facilities etc. in early days but is actively applied to mobile objects such as vehicle or person in recent years and M2M service market is growing in foreign countries due to the expansion of smart meter service and mandatory car communication module installation etc. Since almost all objects will be connected to the network in the future, it is expected to develop into to the center of intelligent service with the development of mobile communication technology and the evolution of the network and bring major changes to the direction of network policy implementation [20–23]. Machine to machine is used as M2M in ETSI, IoT in ITU-T and MTC in 3GPP depending on the institution of each country [24]. ETSI defines M2M as communication occurring among two or more objects not requiring direct human intervention and IEEE as information exchange occurring without human intervention between subscriber devices or information exchange between servers located in core-network via base station and subscriber device. Also, 3GPP uses M2M as the form of data communication in which one or more objects are involved not requiring human intervention and ITU-T uses it as global network-based structure connecting physical object and virtual object through data collection and communication functions as the network providing network connection even to all objects. In Korea, M2M is defined as 'service of mutually delivering information by collecting, processing, and handling it intelligently through objects by expanding and linking communication · broadcasting · internet infrastructure to areas between human-to-object, object-to-object and provides useful information and services for human from simple monitoring through sensors to failure and incident detection, asset management, customer usage information etc.

Figure 1 shows the concept map of M2M. As shown in the concept map of M2M, as the relationship of collection and use of information is changed into the relationship between human and object, object and object and objects which are common in our daily life are intellectualized and exchange information via connected network, the state of an

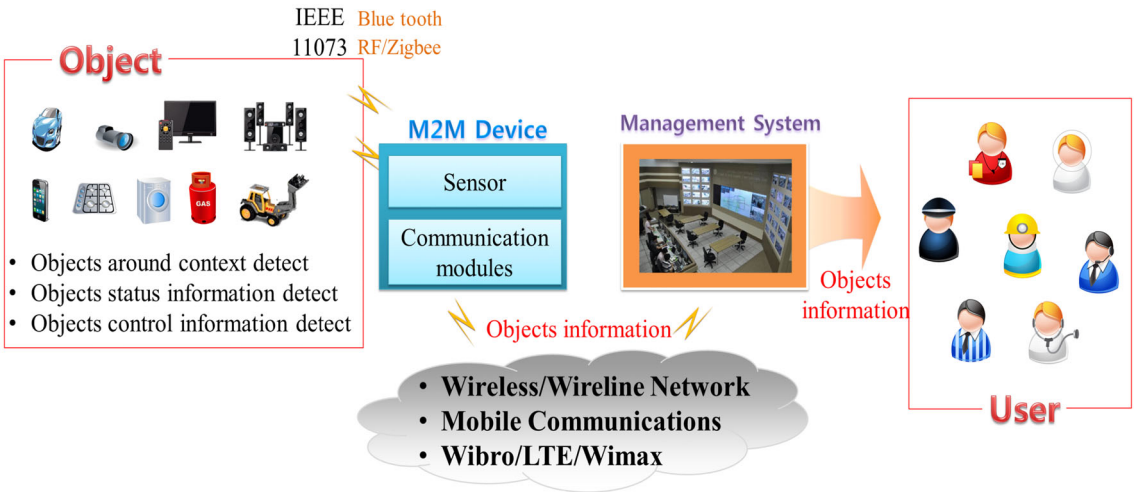


Fig. 1 M2M concept map

object can be identified, located, controlled and monitored from a far distance. The main technologies of M2M for this purpose include recognition technology, wired and wireless communication and network infrastructure technology, service interface technology. The recognition technology collects processes and manages information from the sensor and supports interface implementation for implementing information to service. In order to support object internet service between networks, wired and wireless communication and network infrastructure technology of short distance communication technology (WPAN, WLAN etc.), mobile communication technology (2G, 3G etc.) and wired communication technology (Ethernet, BcN etc.) etc. is needed. In order to provide object internet service to users, service interface technology of recognition, processing, storage, protection, authentication / authorization, open platform technology of information is needed [25–28,35–37].

M2M technology is widely used in the field of u-health service for solving social problems such as an increase in healthcare costs and decreased quality of life due to chronic diseases caused by changes in eating habits and aging phenomenon which are in progress worldwide. Bluetooth, short distance wireless communication technology is widely used in u-health service. Hospitals or homes, nursing homes developed independent u-health service by each company depending on serial port profile (SPP) profile, default transmission profile of bluetooth. However, the compatibility issue was raised because independent application is driven in different data types. To solve this problem, IEEE 11073 released health device rofile (HDP) standard. HDP manager gateway should meet various conditions required in various institutional or personal applications while sending and receiving messages with personal health device (PHDs) of various types and specifications. In order to reduce the inconvenience that patients with hypertension connect inconvenient equipment and enter blood pressure levels, u-health being recently progressed in domestic bit computers [29–32] self-developed HDP gateway supporting standard data transmission and introduced it to healthcare solution for utilization. Figure 2 shows the diagram of health gateway developed in the bit computer.

Health gateway was developed in software in the form of middleware within the service device of a mobile device. Service layer is present at the top of the health gateway in the service device and communication module is connected to communication module installed in the service device. HDP-enabled devices and SPP-enabled devices using health gateway are not affected by protocol or profile in service layer or service device through TCP/IP protocol as well as HDP and SPP profiles. Also, using distributable gateway can increase the convenience of the user because it automatically sends data measured by the user through PHD to the server.

2.2 M2M based health device

The largest HMO company in New York built HIP health plan that can the patient's condition in real time to provide the system that can order prescription drugs online if there is a problem in the health of patients registered in the sys-

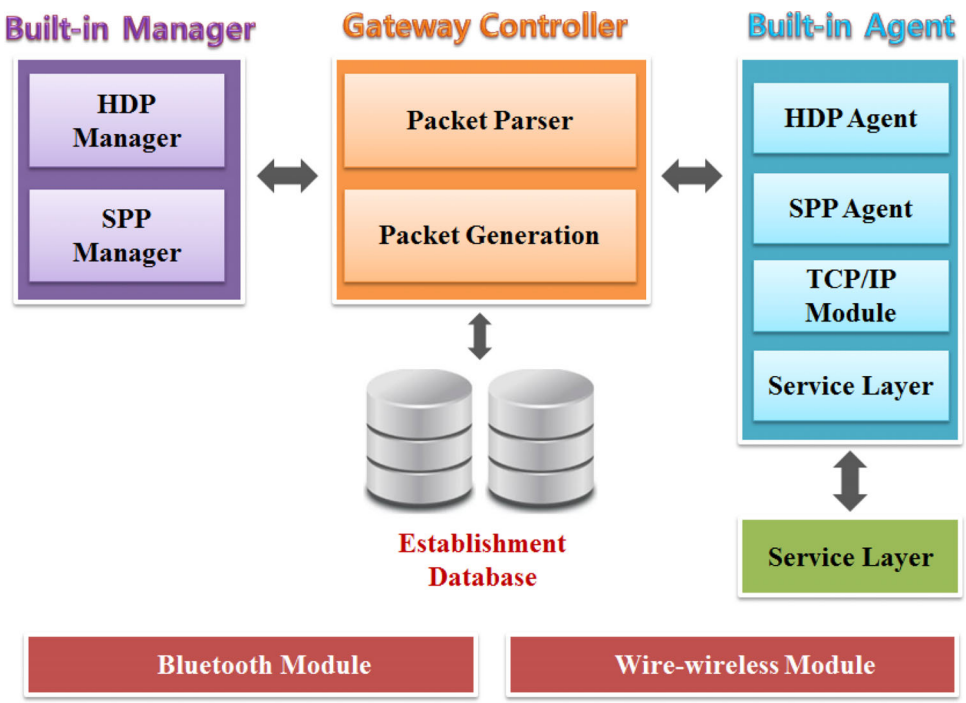


Fig. 2 Framework for home fixed gateway composition

Fig. 3 Vivologic of vivomentrics (www.vivometrics.com)

tem [33,34]. Health hero network is conducting health buddy trial service that the message equipment connected to the telephone is automatically on every morning to conduct question and answer and sends a visiting nurse if a problem is recognized in the answer or there is no answer. Vivometrics[1] in the US is providing the service that a doctor can check and feedback the user's status by using PDA with the sensor which can detect and measure more than 40 items related to body changes in a T-shirt. In order to implement this service, there is lifeshirt system including Vivologic soft-ware for analyzing, observing, reporting results and Fig. 3 shows the website of Vivometrics.

As internet and mobile environments are spread in recent years, app · web based health and wellness services are rapidly increasing, and u-healthcare service via mobile devices are actively being made. Smart phones, portable devices and related applications can be highly used as u-healthcare monitoring because they are mobile in a networked environment and support computing activities conducted by existing computers.

As the representative u-healthcare service, the sporting goods company Nike developed Nike + iPod sport kit[2] in association with Apple. It provides the service of measuring the user's walking situation with the sensor attached to the bottom of a left shoe and showing it in the display of iPod nano. Also, it provides the service of the user analyzing his walking history through Nike + experience website or comparing walking history to 50 and recommending music suitable for walking. Figure 4 shows the Nike + iPod sport kit service.

Fitbit of fitbit company provides hardware such as passometer, sleep meter, weighing machine etc. that can be interlocked with smartphones and the resulting management services. Fitbit helps to take in calories depending on the user's physical condition, eating habits and lifestyle for the purpose of weight control (weight increase/maintenance/decrease). Unlike typical calorie counting applications, it can automatically enter calories consumed depending on daily activity and show calorie consumption information based on the user's status and tracker by calculating the user's goal from 2 weeks ago and share information through SNS. Figure 5 shows the services of fitbit.

Map my fitness[3] is the application for aerobic workout training such as running, cycling, hiking etc. and allows the user to directly enter workout information or directly measure indoor / outdoor workout through GPS accelerator functions. Workout information (Position, speed, calories, etc.) entered or measured by the user is automatically updated in the website and can be analyzed through the workout graph. In particular, the user can compare the amount of practice with that of your friends around SNS and entertainment elements were added by recent release of map my dog walk App. Figure 6 shows map my fitness.

3 M2M-based smart health service using motion recognition for human UI/UX

3.1 Smart health service by motion recognition

Generally, M2M communication includes many networked devices and gateways. A gateway governs the connections

[1] Life shirt, http://www.vivometrics.com

[2] Nike + iPod sport kit service, https://secure-nikeplus.nike.com

[3] Map My Fitness, https://support.mapmyfitness.com

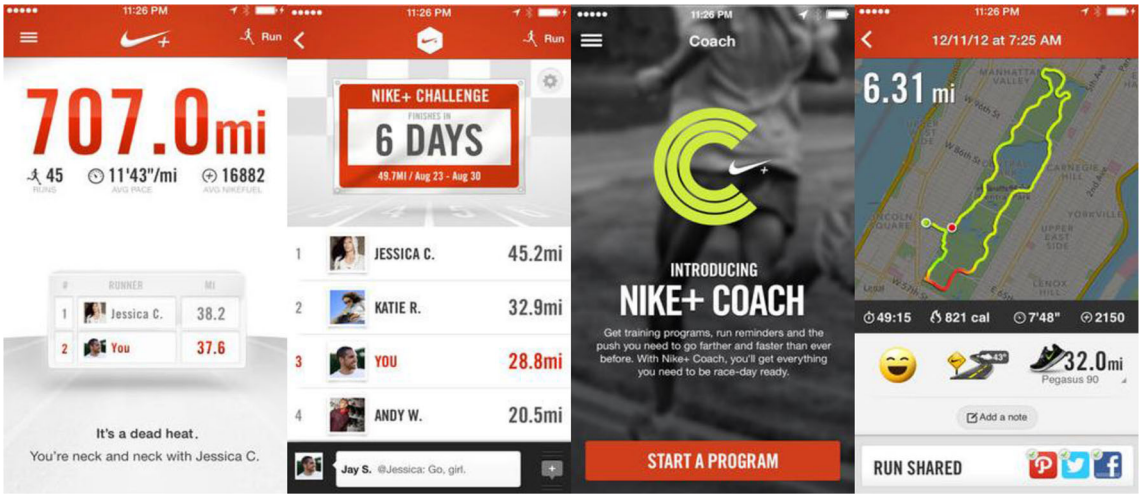
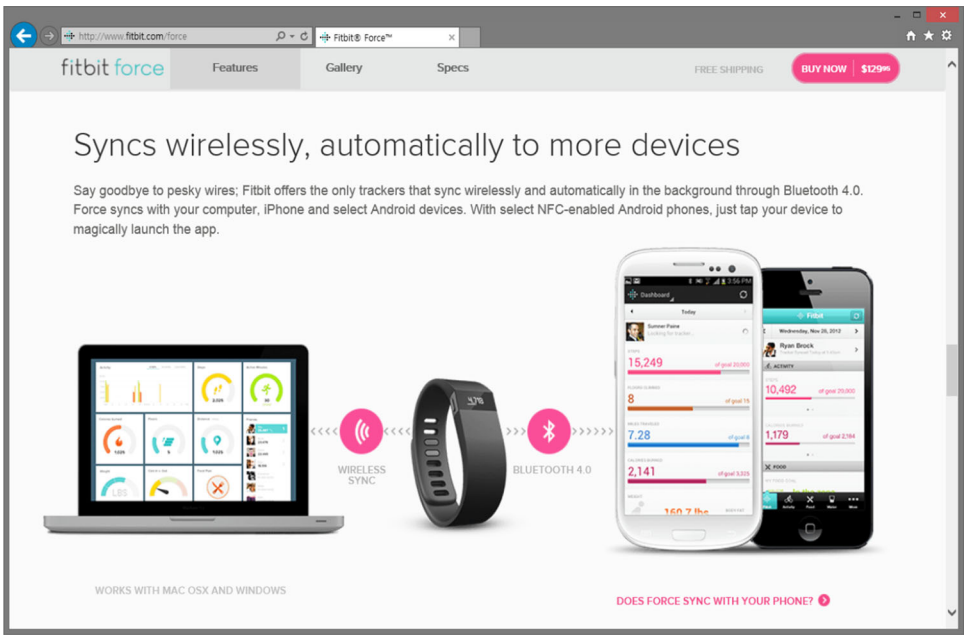


Fig. 4 Nike + iPod sport kit service

Fig. 5 Fitbit (www.Fitbit.com)



between devices, connections between M2M communication area, and other networks. M2M network uses a suitable standardized wireless technology based on the requirements of a particular device. In this paper, we propose an M2M-based smart health service using motion recognition for human UI/UX. Smart health service platform considering mobility can be mainly applied in a home healthcare environment. The residents in a home can manage their health and cope with emergency situations by using information collected from a variety of sensors based on M2M technology. To obtain accurate data regardless of the situation, M2M-based smart health service that can support mobility was designed. Unlike existing healthcare platforms, the smart health service has motion recognition as well as bio-information. Figure 7 shows the framework of a smart health service through motion recognition. It consists of an I/O device, detection module, application module, appraisal service, and web service. The I/O device can be configured with an EEG, ECG, GSR sensor, kinect, tablet, and smart phone and measure changes in the individual's brain nerves and heart depending on the situation through each sensor.

To provide a multi-modal interaction using a sensor in the detection module, four kinds of feelings, joy, surprise, sadness, and anger, as well as stress can be detected. The individual's state can be measured by recognizing the user's respiratory rate with the ECG sensor. The user's actions can be checked by using the kinect, and motion is sensed by interaction with the virtual object [35–38]. Emotional states can be detected by measuring an individual's life patterns and observing changes in a particular behavior over a long time

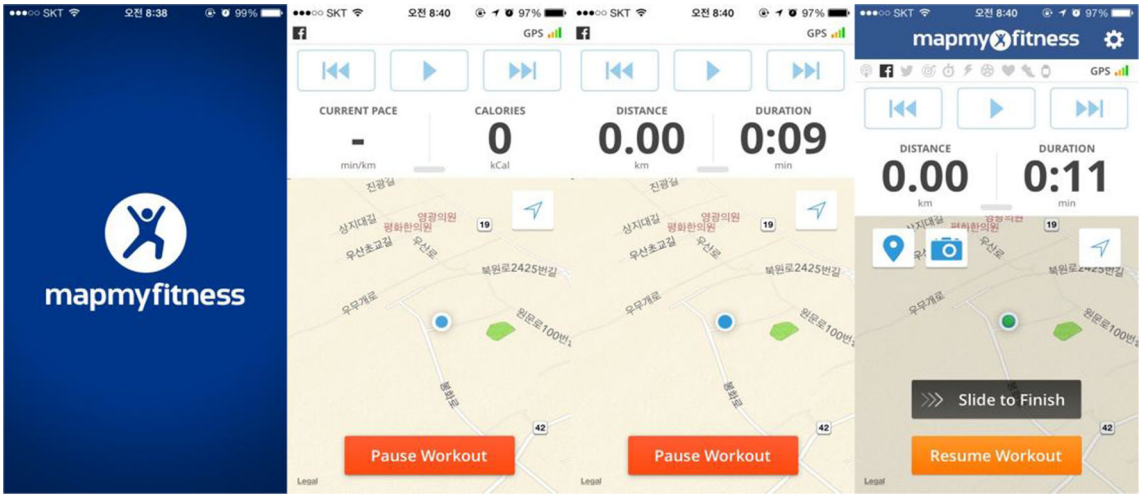


Fig. 6 Map my fitness

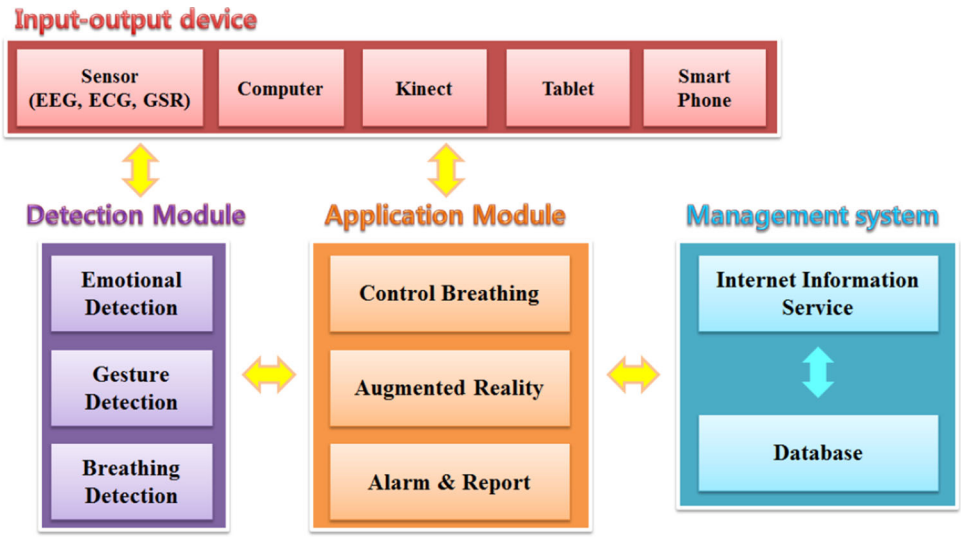


Fig. 7 Framework of smart health service using motion recognition

through motion recognition. The application module offers feedback depending on the state or quantity of motion of the user based on information entered from the I/O device or detection module. Accurate data can be provided by collecting bio-information and by building a web server and integrated management system. Currently, bio-information can be collected by configuring M2M-based healthcare WBAN and by attaching various sensors to each part of the human body to measure bio-signals such as blood pressure, pulse, electrocardiogram, etc. M2M-based healthcare WBAN consists of a sensor, actuator, and communication module and is connected to a wireless network. The device of this basic unit is attached to the human body and has the mobility of the network unit while moving with people. M2M-based healthcare WBAN includes mobility mobile devices. Figure 8 shows an overview of a smart health service by motion recognition.

Data measured by the sensor and collected by the mobility device of WBAN is sent to the end system corresponding to the destination through a broadband router, etc. This end system may be a healthcare service provider or wireless service provider. Data measured here are stored in a web-based system, promptly sent to the provider, and then monitored by a person in charge in the medical agency. Communication between each component within the M2M-based WBAN is classified as either internal or external body area network (BAN) communication via a mobility mobile device and can be monitored remotely. While internal BAN communication is based on 6LoWPAN technology, external BAN communication uses IPv6-based wireless Internet. The sensor configuring WBAN collects data, which are converted into electrical signals and then sent through amplification, control, and digitization processes. Healthcare WBAN sensors include a self-supporting sensor and front-end supporting sensor. A self-supporting sensor has a power supply device as well as amplification, control, figure conversion, and communication devices. Sensors are the independent building blocks

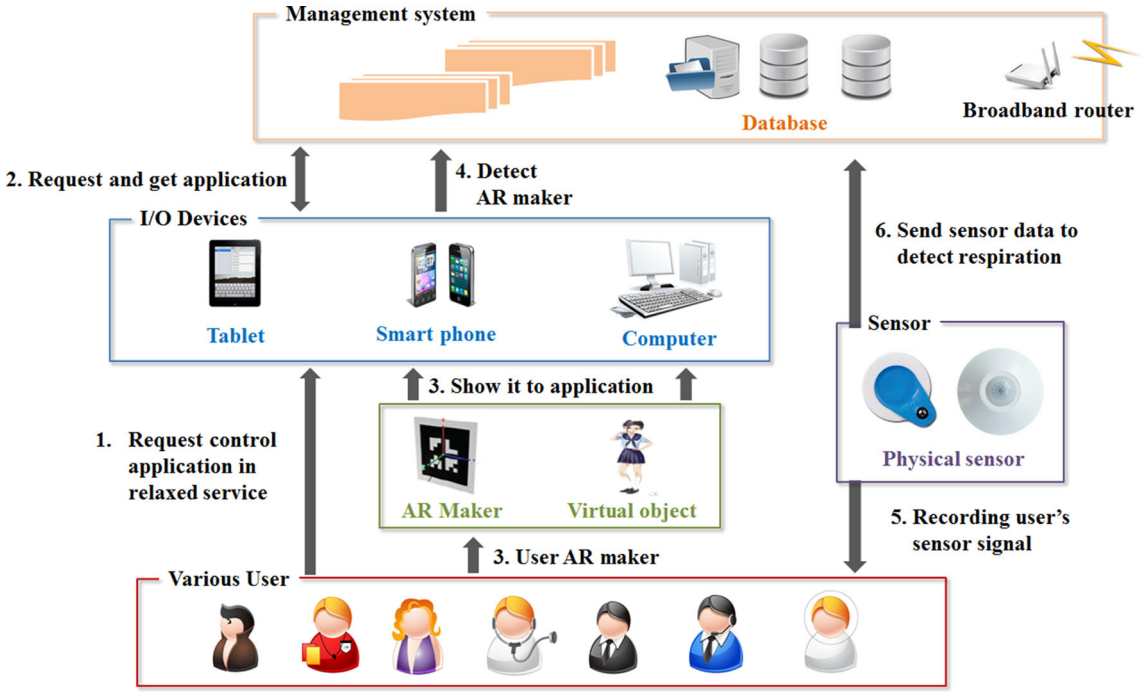


Fig. 8 Overview of smart health service by motion recognition

of WBAN and healthcare WBAN with available advanced settings. A front-end supporting sensor shares a power supply device and data collection device. A mobility device is a terminal not a communication module that processes only routing functions, and the information from the sensor modes can go through a mobility device. Its limitation is that communication is only possible when the user carries a mobile device.

3.2 M2M-based smart health service

A motion recognition M2M-based smart health service consists of a sensor and actuator service, an internal and external BAN communication provider, and a smart health service layer. Internal and external BAN communication providers possess communication services offered by internal and external BAN communication networks, respectively. The proposed service can be shown as the structure divided into physical location and implemented function. Figure 9 shows the framework of the M2M-based smart health service.

A smart health service layer integrates internal and external BAN communication providers. Application of the service can be a simple viewer showing WBAN data as a graph of the complex. A mobility device containing the network mobility protocol and external BAN (Network Mobility Home Agent) receives or sends physical information such as blood pressure, ECG, and pulse to the internal BAN supporting the mobility of the 6LoWPAN unit. Figure 10 shows an example of the M2M-based smart health service.

A user at home communicates with a mobility device via a network mobility home agent. A network mobility home agent is a device that interconnects or relays a wired or wireless home network along with the xDSL, cable, and FTTH. An outside user communicates with a mobility device through an access router, which is a core device that connects the local area network (LAN). Equipment for reading receives the address from the transmitted information and specifies the most appropriate communication path to the communication network. This acts as a wired or wireless router with combined functions of a wired router and wireless LAN switch. A M2M-based smart health service monitors body area, personal area, local area, and offers various services through smooth communications. A body area network builds a biomedical sensor network inside, above, and around the human body, and these sensors collect and send bio-signals such as blood pressure, EEG, amount of oxygen saturation, pulse, temperature, and heart rate. Bio-information data are stored in the body area sub gateway (SGW) for remote access, after which they are periodically and automatically sent to remote hospitals, doctors, and nursing homes. To provide a body area service, M2M communication is sent in the BAN. Communication herein consists of BAN inner communication between sensors within the body as well as BAN outer communication between BAN and the contact point. A personal area network targets short-range heterogeneous networks in the smart health service. Communication consists of Bluetooth, IETF 6Low-PAN, Wi-Fi, and wireless HART. Zigbee, which is mainly used in per-

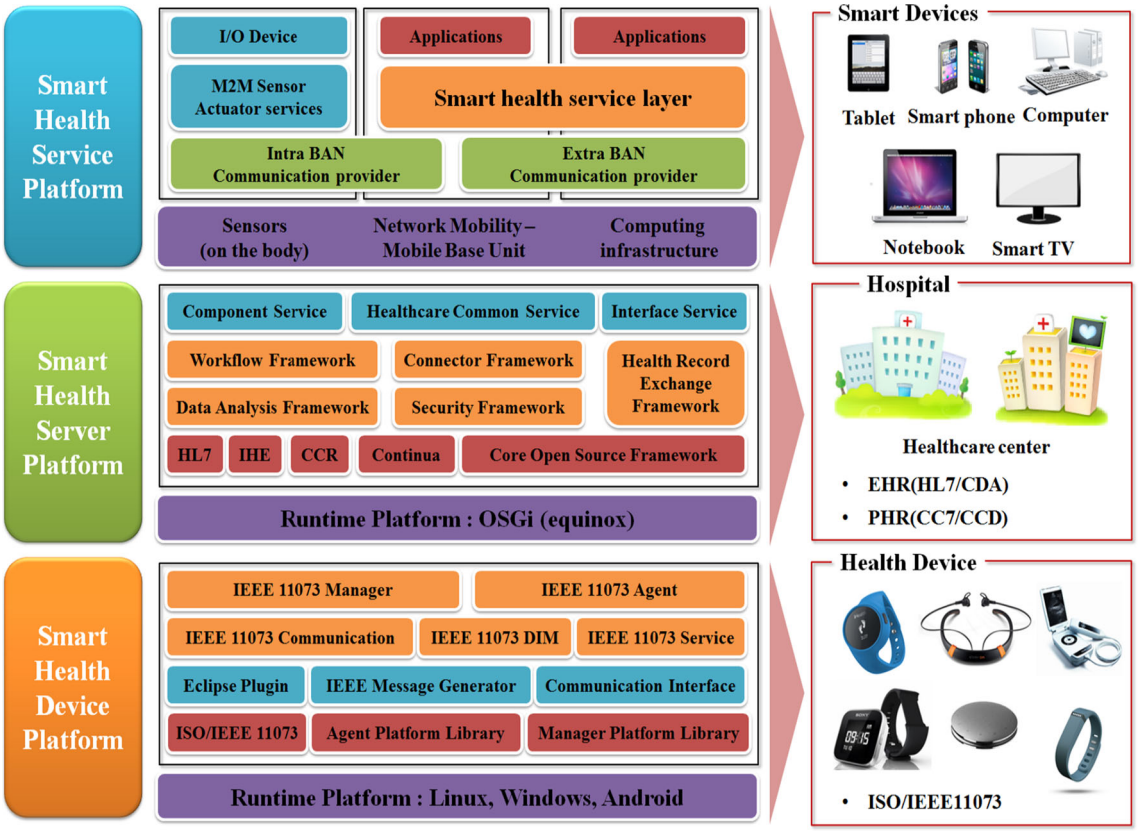


Fig. 9 Framework of M2M based smart health service

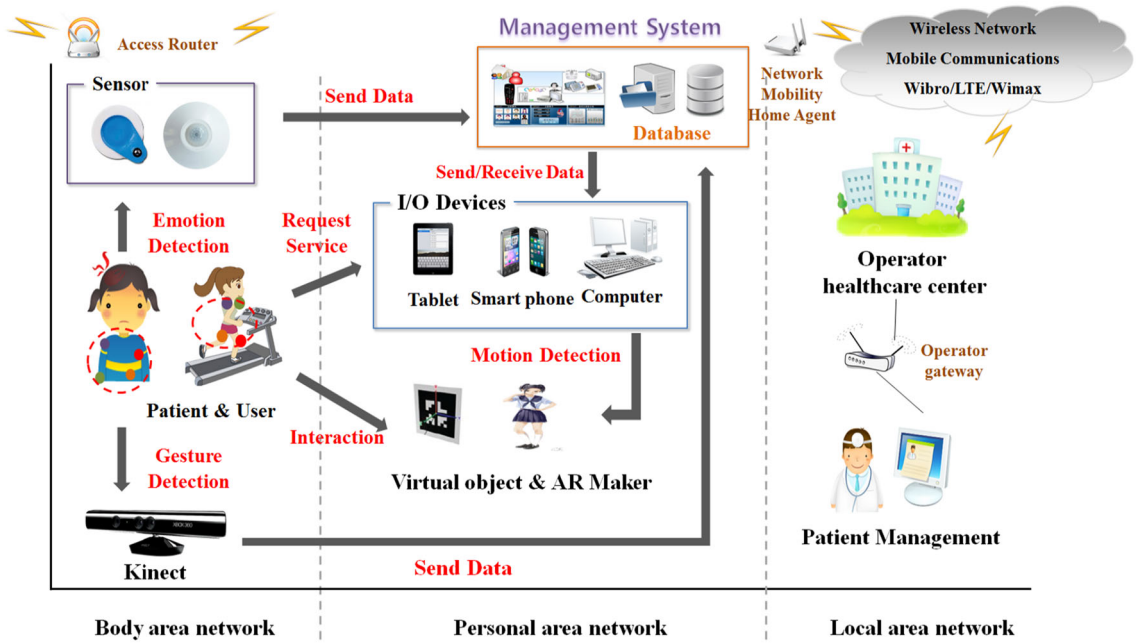


Fig. 10 Example of M2M based smart health service

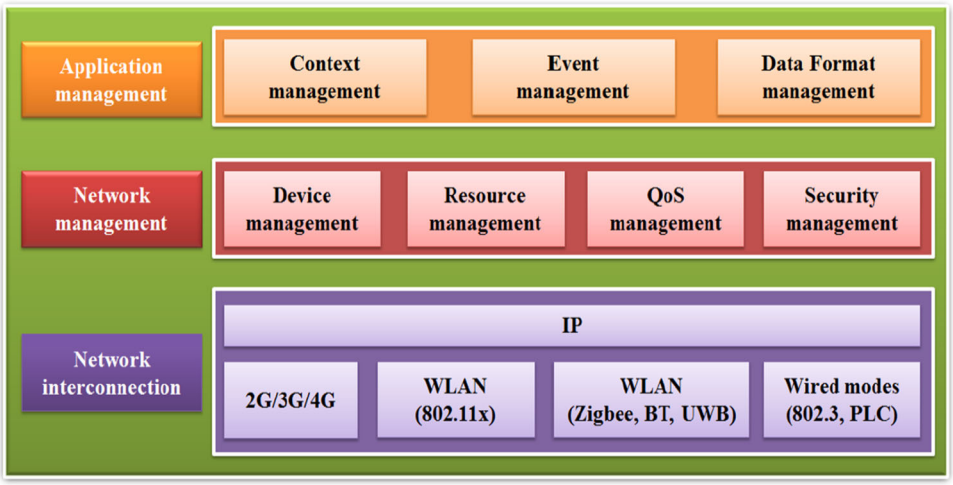


Fig. 11 Network mobility home agent architecture

sonal area networks, can play various roles as a coordinator, router, and end devices, etc. For medium access control layers, IEEE802.15.4 defines two channel access methods, which are access methods with or without a beacon. The beacon method includes a coordinator that creates and sends the beacon for synchronization. In the non-beacon method, a device adopts carrier sense multiple access with collision avoidance (CSMA/CA) system to compete channel access.

In a LAN, the network mobility home agent sends information collected from the M2M device along the external network to the healthcare center. Once the network is generally set, family, guardians, or doctors check the information of both the user and patient in real-time. The optimal method for communication between various networks can efficiently conduct off-load between network areas through end-to-end QoS without increasing complexity or reduction of overall performance. Figure 11 shows the architecture of the network mobility home agent, which has access control, security management, QoS management, and multimedia conversion functions. The sub-network is operated in a self-organized manner, can be designed for a specific application, and has a SGW for connecting the sub-network to the backbone network. The network mobility home agent and SGW are logical objects, and their functionality can be physically implemented in a single device.

4 Conclusions

M2M has been applied to various fields, and u-healthcare is attracting attention in the M2M medical field. In this paper, we proposed M2M-based smart health service using motion recognition for human UI/UX. The M2M-based smart health service was divided into body area, personal area, and local area, and it offers various services through smooth communication. Residents at home can manage their health and cope with emergency situations by using information collected from a variety of sensors based on M2M technology. M2M-based smart health services considering mobility can measure various bio-signals whenever users are outside or at home. The service can measure the patient's condition more accurately and continuously offer healthcare services without interfering with daily life. Patients with chronic illnesses can manage their health efficiently in terms of both time and cost. Smart health services based on motion recognition send measurement data to the external network through mobility devices using mobility WBAN communication in sensor nodes, which sense ECG, pulse, brain waves, body temperature, user moves, etc. Diseases can be diagnosed and prevented by providing medical staff, family members, as well as users with information anytime and anywhere. Further, the individual's lifestyle is measured over a long time period through motion recognition. Health can be managed systematically by sensing the user's emotional state depending on life patterns.

In this paper, we proposed a method that interlocks the networking technologies of WBAN and network mobility. When sensors move, the 6LoWPAN network and internal BAN of WBAN deliver accurate data regardless of the user's situation. The mobility device supports mobility of the sensor node and improves the patient's well-being by managing the health of residents at home and easily coping with emergencies.

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