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PHR open platform based smart health service using distributed object group framework

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Abstract As an interest in health and disease has increased, medical service has changed to prevention of disease and health care from treatment oriented service. Medical service industry is creating various services and added value for promotion of health. Aging, extension of life expectancy, increase in lifestyle and income growth have brought about a change in paradigm of medical service which led smart health to become an important issue. Smart health caused medical service for promotion of health to change into remote medical treatment that uses personal health record from medical service which has been provided by mainly large hospitals. Medical service for promotion of health has developed into u-Healthcare which monitors condition of health in everyday life. This enabled problems of time and space constraints that occur in medical service for promotion of health that requires a medical doctor to examine bio-signal related information of a patient while facing a patient to be solved. It is difficult for a remote medical treatment to care for chronic patients who require a care of lifestyle because it focuses on treating specific diseases. As a remote medical treatment does not provide innovative medical service and it only delivers general bio information on a patient to a medical doctor remotely, remote medical open platform is needed. Thus, in this paper, we proposed a PHR open platform based smart health services using the distributed object group framework. A PHR open platform based smart health system is distributed object group framework based smart health service for managing chronic diseases. When Medical WBAN sensor uses multi-channel in transmitting data, emergency data is very important in patient's life, smart health environment is built using distributed network considering importance according to data. As WBAN sensor is very different from other networks in terms of application, architecture and density of development, it is important for WBAN sensor to be combined with external network. High quality of service of integrated network as well as link connectivity should be maintained. Since automatic diagnosis function should be reinforced in order for remote diagnosis service to be provided, integration of each small unit system and model design are important. Therefore, smart health network environment that makes the most of performance of distributed network based on automation technique and distributed agent for optimum design of system is built.

Keywords Distributed object group framework · Chronic disease · PHR platform · Mobile health service · Mobile application · U-Healthcare service

1 Introduction

It is necessary to lay the groundwork for future's health service. It is advisable for future's health service to cover disease management for healthy people and self-care at wellness level, service for preventing diseases and passive service for treating and alleviating patients. It is desirable to develop smart health service which is integrated in open remote medical treatment platform so that lifelong health care and promotion can be possible [1,2]. As IT convergence technology has developed in recent years, an interest in smart

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health in which WPAN based personal medical equipment is combined with home wireless network based medical service has increased. Smart health service in which medical service and wire & wireless network information technology are combined is future oriented medical service [3–5]. With appearance of mobile 3.0 age, users can enjoy smart life that uses contents such as hobbies and information retrieval based on various applications of smart phone by connecting mobile technology, wireless internet technology such as WiFi and Bluetooth and personal environment network technology [6,7]. Research on smart health service in open remote medical treatment platform that can provide personal health data of a patient who does not visit a hospital and expand medical areas based on development of pervasiveness of mobile device and biomedical sensor has been conducted actively [8]. Smart health service can provide personalized medical service in real time based on medical equipment which is connected to mobile beyond space and time constraints by using network technology based advanced ICT [9,10]. However, existing health based medical service does not treat various kinds of patients because its service is designed to the extent that it simply expands limit of time and space in medical treatment [11]. This plays a role of delivering general personal data of patients who are in a remote place to medical doctors but this is difficult to be expanded into various areas because this is not enough to provide new service [12–16]. As chronic diseases have increased rapidly, an interest in personal health has risen which demands new paradigm on health care. Care of chronic diseases is an important element of medical research and medical expenses to manage chronic diseases have increased year by year and users who are provided with medical service ask existing health care system to be changed [17–19]. Existing healthcare was designed in such a manner that special device is inserted for bio sensing and it is not suitable to manage various chronic diseases. In Medical WBAN case, interference occurs because frequency bandwidth of medical equipment is different and the interference can cause erroneous information of chronic patients [20–22].

Thus, in this paper, we propose PHR open platform based smart health service using distributed object group framework. Smart health system is distributed object group framework based smart health service for managing chronic diseases. When Medical WBAN sensor uses multi-channel in transmitting data, emergency data is very important in patient's life, u-Health environment is built using distributed network considering importance according to data. As WBAN sensor is very different from other networks in terms of application, architecture and density of development, it is important for WBAN sensor to be combined with external network. High quality of service (QoS) of integrated network as well as link connectivity should be maintained. Since automatic diagnosis function should be reinforced in order for remote diagnosis service to be provided, integration of each small unit system and model design are important. Therefore, smart health network environment that makes the most of performance of distributed network based on automation technique and distributed agent for optimum design of system is built which helps to solve users' cell interface problem of Health gateway and WBAN gateway arising offerload within each area by minimizing load of smart health network. A proposed system is composed of physical sensor layers which are connected to health web portal layers via wireless node through existing network infrastructure structure with PHR open platform that provides personal bio-data using a variety of bio-sensing device and Medical WBAN. Physical layers consist of wireless nodes and each wireless node is comprised of a series of medical sensors. Unlike existing systems, a proposed system can provide remote data collection and monitoring of patient data via web and mobile and support self-care of chronic patients by providing open platform for real time decision making and a long term change in social behavior.

The rest of this paper is organized as follows. Section 2 describes research related to the PHR service for chronic disease management and mobile based smart health service. Section 3 describes PHR open platform based smart health service using distributed object group framework. Section 4 describes the mobile based personal health management service. Conclusions are given in Sect. 5.

2 Related research

2.1 PHR service for chronic diseases management

A change in lifestyle, improvement of quality of life and extension of life expectancy led to an increase in chronic diseases which has emerged as a major issue in medical service industry. It is necessary to focus on managing diseases and promoting health rather than focus on treating diseases [23,24]. Health has become the main public interest not limited to senior citizens and usual prevention of diseases and health care are becoming more common. Smart health service that can interact in PHR open platform is necessary as communication and interaction between different individuals have become important due to development of communication including wireless communication [25,26]. Judging from management, use, and exchange of health record, this can be approached from the viewpoint of electronic medical record (EMR) and electronic health records (EHR).

EMR aims to manage health record and medical record and keep record efficiently by computerizing health record and medical record produced in medical institutions. It is common for EMR to be built within a single medical institution which focuses on managing personal health record rather than exchanging or using personal health record. EHR

aims to reduce wrong medical examination and treatment and provide medical service efficiently and improve safety of a patient and guarantee continuation of medical examination and treatment by making computerized medical record to be used through exchange of information between medical institutions [27,28].

PHR platform refers to a tool that enables medical staff to inquire and manage health and medical related information collected from medical institutions anywhere and anytime and a patient manages and to use information gathered from various sources. PHR platform and EHR are complementary. Unlike EHR, PHR platform supports a role of the subject of personal health information widely. PHR platform analyzes information on activity pattern in situations and extracts pattern of behaviors which are not uncovered in information on activity pattern of a user perceived [12,44,45]. Figure 1 shows PHR platform service. PHR platform aims to improve lifestyle of high risk chronic patients by finding pattern which is not uncovered in information on behavior of patients through Mining Hidden Patterns. PHR platform draws index provided by Korea Meteorological Administration and public data portal and presents health information such as body mass index, abdominal obesity, obesity risk, glycemic index and cholesterol index. PHR platform serves elements which people have much interest and frequency is high among elements which are related to health according to users and presents matters that require attention and measures to deal with matters [29,30].

2.2 Mobile based smart health service

As wireless communication technology and wearable smart devices have developed and convergence of ICT and medical equipment such as miniaturization and high integration of bio sensor have increased, mobile based smart health service has gained more attention. Devices that are used in mobile healthcare are classified into smart devices, wearable devices and the others. This kind of smart device senses physical activities through bio sensor which is attached in OS and equipment and has health care which a user enters his/her own information and tracks it according to functions of mobile applications. Wearable devices and other devices transmit data which are entered into devices to smart device application by connecting to a smart device through wireless communication such as Bluetooth, Near Field Communication (NFC), and WLAN or attaching it directly. A user is provided with his/her health information in a form of dashboard and can see relevant information through application [31–34].

Figure 2 shows connection of bio-sensor and wearable device in mobile health care system. Biosensor which converts bio recognition elements via signal output is to track physical result of motion such as distance, moved position and movement and measure information on human body such as heart rate and blood pressure. Service provider processes health care information based on health record so that it can be user friendly useful information and processed information is conveyed via mobile application [35,36].

As an interest in mobile health care for managing personal health has increased, major ICT enterprises such as Apple, Google and Samsung Electronics and lots of start-up companies have advanced into health market and investment in relevant businesses have increased. Apple established itself in a wearable market by developing Fuelband with Nike, sports goods business including Nike + iPod Sport Kit. Apple developed activity tracker and fitness oriented wearable devices

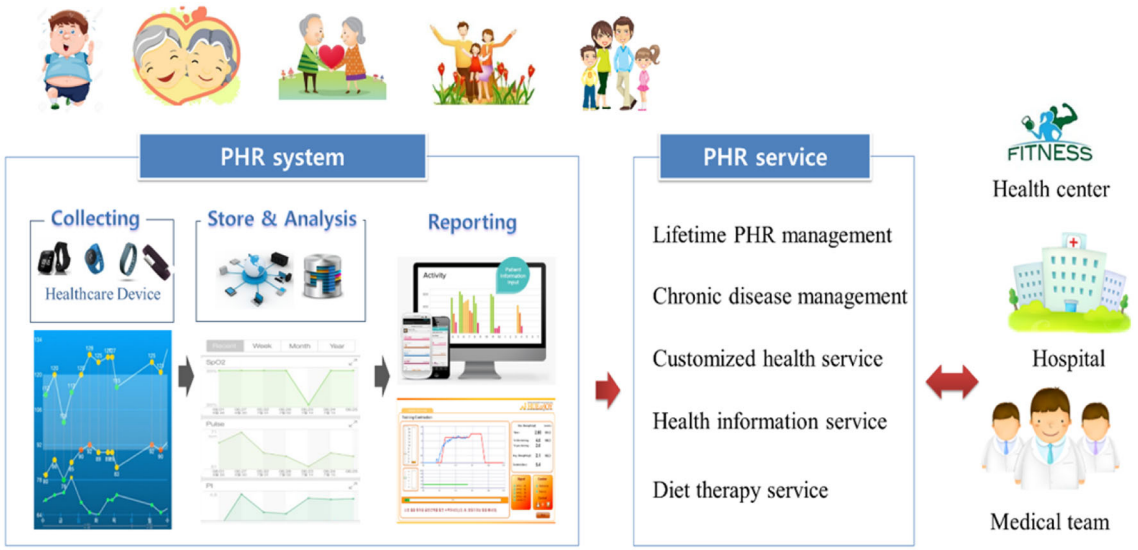


Fig. 1 PHR platform service

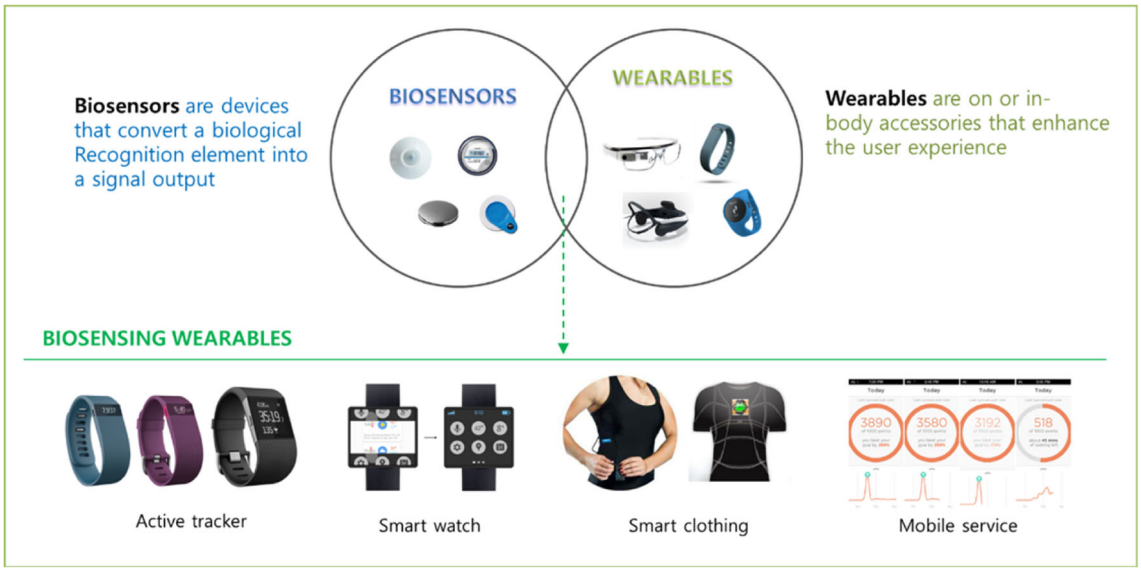


Fig. 2 Connection of bio-sensor and wearable device

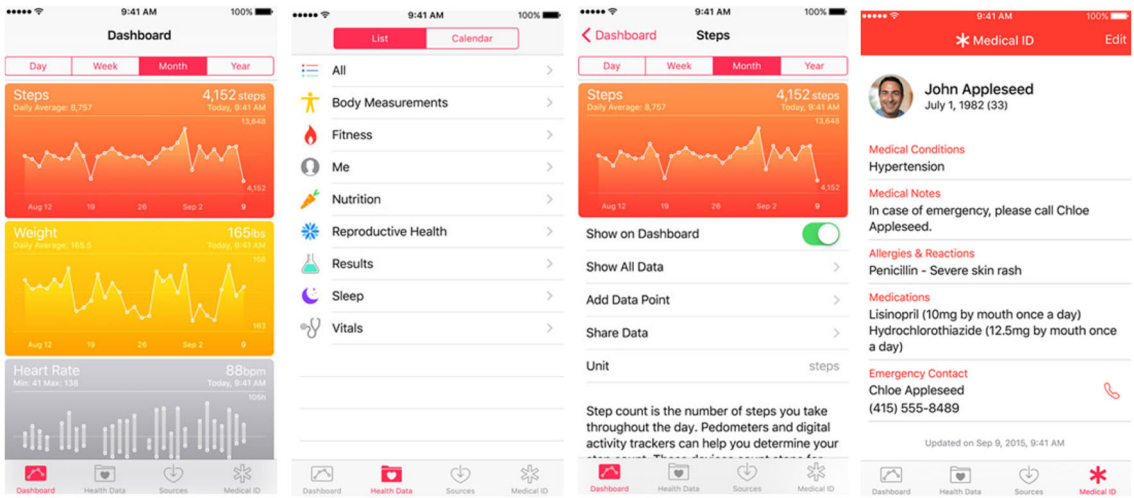


Fig. 3 Healthcare service of Apple

and application and commercialized them. Apple released application called Health and platform called Health-Kit. As shown in Fig. 3, health related data integration application shows weight and body mass index of a user and manages data on diet and exercise. The HealthKit will provide tools to developers so that you do not need to create a custom tool to transfer and synchronize your health information and match it to the data store. And developers were collected data from a large amount of applications made to provide integration in the 'Health' App.[1]

Google provides search-based portal, has performed the role of software platforms with Android OS. Wearable market in recent years, Google 'Google Glass' device developed to broaden showed the manufacturing area through the movement. Exercise helps manage running processes and performance objectives set for value through the application of LynxFit. In addition, a dedicated application Med Lev (MedRef) allows you to recognize the patient is equipped with a face recognition function and view the medical records automatically.

Like Apple, Google tracks behavior of a user and senses physical activities of a user in smart devices such as smart phone and smart pad by inserting sensors into its operation systems. Figure 4 shows Google's health care platform. Google added step detection and step counters sensors to KitKat, Android latest version. Google provides information to users by circulating data collected in health related applications which are distributed in a fitness store [37,38].

[1] Apple Health, www.apple.com/ios/Health.

Fig. 4 Healthcare service of Google

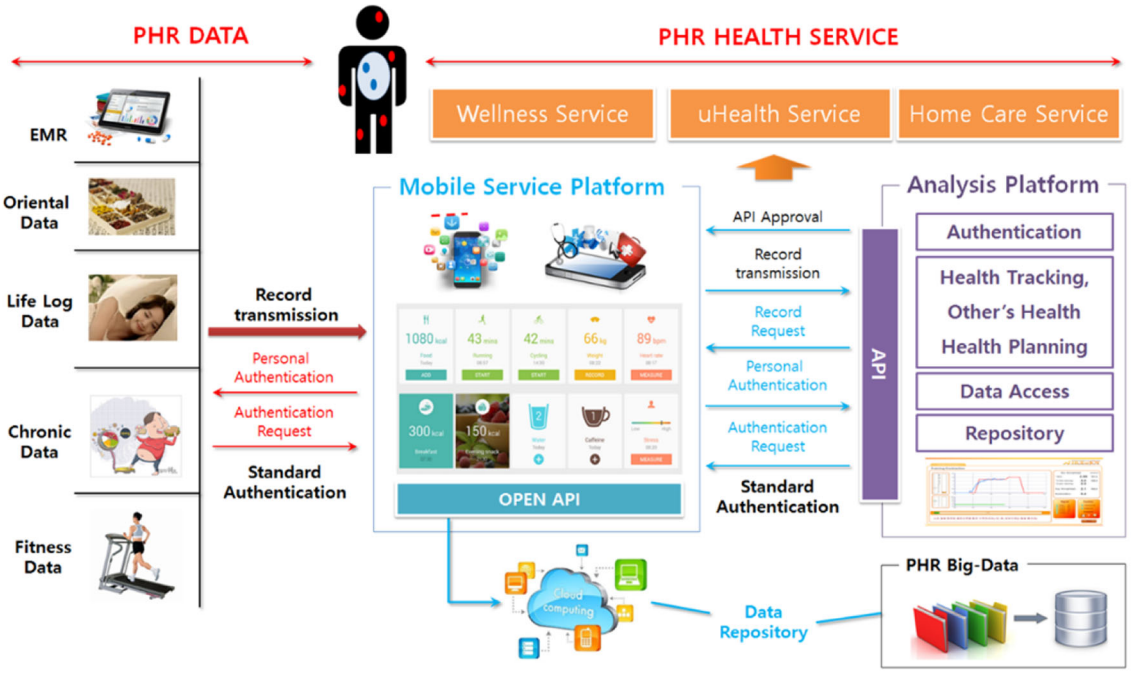


Fig. 5 Smart health service in PHR open platform

3 PHR open platform based smart health service using distributed object group framework

3.1 Distributed object group model based dynamic framework

Smart health service in PHR open platform proposed by this paper processes and manages personal health record collected by medical institutions and records which are kept by a patient and diagnoses conditions of chronic diseases efficiently and provides prescriptions which are suitable for situation [3,45,46]. Smart health service in PHR open platform provides customized service which is suitable for a patient by using decision making based personal health model [39] in mobile environment according to characteristics of chronic diseases. Smart health service in PHR open platform collects health medical information measured with personal devices in everyday life by using Bluetooth [8,9,44]. Smart health service in PHR open platform transmits data to Hospital Information System (HIS) and application of personal mobile via mobile network such as Wi-Fi and LTE while in motion for heal care. Figure 5 shows smart health service in PHR open platform.

In PHR open platform, Open API that health service, information and data are available at any time and at any place and standard medical information are connected, which makes it possible to communicate with medical staff. A proposed system is composed of physical object layers and health web portal layers. Physical object layers are connected to WBAN sensors for blood sugar monitor and blood pressure monitor so that bio signals or health conditions of chronic patients and senior citizens can be measured continuously. If high risk chronic diseases are found, data are sent by wireless. Health web portal layers that host main application of PHR open platform include presentation layer for user/device interface, system logics of disease management

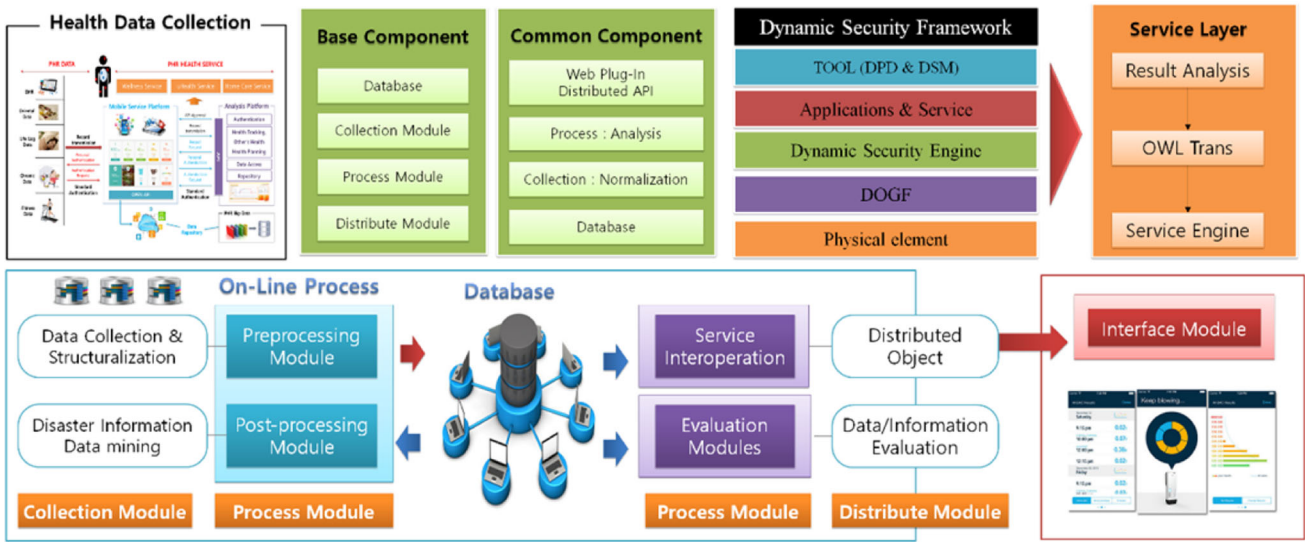


Fig. 6 Distributed agent based dynamic security framework

support and back-end storage. Application hosted by aforementioned layer is accessed by user categories. User category has an authority to access role and system service determined in advance. Components of software are integrated in health portal layers and WBAN sensor layers to improve operability, extendibility and maintainability of layers in a platform.

Hierarchical task network (HTN) is used so that performance of distributed network can be utilized as much as possible based on automation technique and distributed agent for optimum design of a proposed system [40]. In order for layer based work network to be implemented, distributed object group model based dynamic framework (DOGF; distributed object group framework) is designed in such a manner that elements such as user and distributed resources can be reconfigured dynamically in PHR open platform using DOGF's object group support components [41].

Application service of temporal elements that real time system has and functional elements by messages that appear when bio information of chronic patients is collected and sent by using TMO scheme and distributed real time middleware is provided. As safety technology that can protect router and AP physically, IEEE 802.1X based user authentication, use of WPA2, modification of values of Default SSID, application of MAC address filtering, static IP allocation and activation of firewall between computer and router are required to construct network which can provide safe security service, context cognition based dynamic security service is provided and distributed object is managed with security domain. Figure 6 shows distributed agent based dynamic security framework to provide smart health service in PHR open platform. A proposed dynamic security framework is composed of a total of five layers.

The first layer which is physical element layer is composed of sensors for collecting health information of chronic patients in PHR open platform, WBAN device, hardware and data to be transmitted. The second layer which is framework layer in which DOGF is located provides smooth communication between physical component layers and upper layers in middleware and distributed agent model group management and real time service. The third layer is composed of dynamic security engine layer which manages security domain and dynamic security service. The fourth layer which is application and service layer is composed of application services that have distributed objects and groups which support smart health service.

Tool layer which is top layer is composed of DPD Tool and DSM Tool that manages distributed application development, security components and security policies. Context based dynamic security service can be provided by managing security domain which is constructed in smart health service based on security framework. Applying dynamic access control rule and security policy to security domains between layers is possible by creating dynamic access control rule and security policy and presenting dynamic access control model. Security service of PHR open platform can be provided by authorizing users, system resources, object groups and individual distributed objects.

3.2 Smart health service of context aware based security framework

Customized service is provided to users based on data from bio signal of users by connecting data from sixth national nutrition survey to PHR open platform [44,45]. National nutrition survey [43] is to find out health level, health related

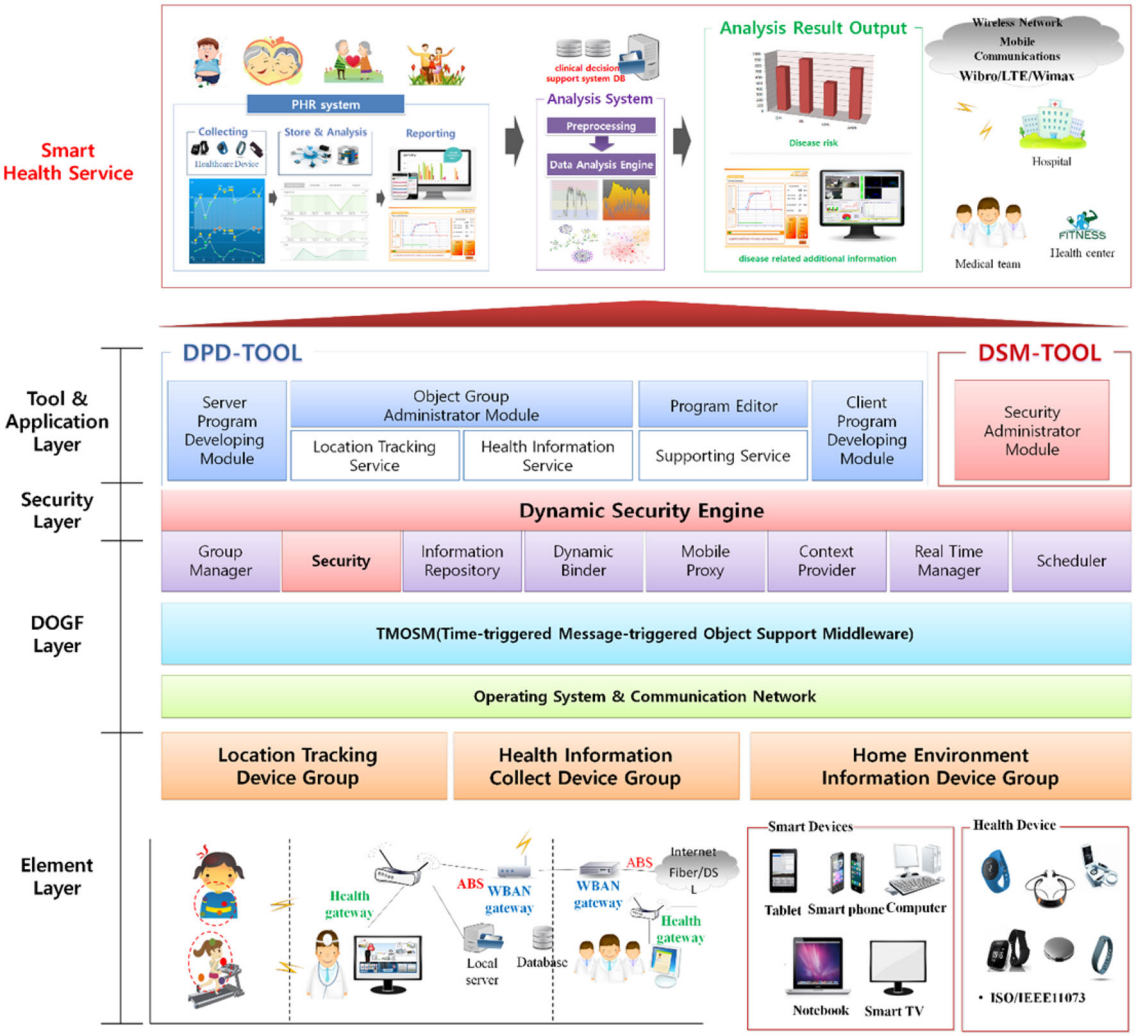


Fig. 7 Proposed smart health using context award based security framework

awareness and behavior, actual condition of intake of food and nutrients of people. Data collected by national nutrition survey serve as basic data which are required to establish and evaluate health policies such as assessment of a comprehensive plan for health promotion and development of health program. Context cognition based security framework is applied when connecting PHR to protect medical information by observing standard based encryption and security guides. Context cognition based security framework is applied when connecting PHR to protect medical information by observing standard based encryption and security guides. Figure 7 proposed smart health using context award based security framework.

Dynamic security framework uses DOGF's object group support components in order to provide service. Each object and element that provides is managed via security domain and context cognition based security service is provided by means of dynamic engine which security policies are applied. Smart health supports abstraction for functional and temporal processes in collecting and analyzing context of chronical patients. Distributed object group system which is composed of DPD-Tool and distributed object group framework supports application service by managing execution objects and provides service according to request of application system in home healthcare area [10,12,45]. Security management system which is composed of dynamic security engine and DSM-Tool provides security service supporting DOGF for smart health service.

Security manager is provided with information via dynamic security engine before making security policies and renews security domain information by using DSM-Tool. DSM-Tool retrieves security information database to renew security policy list. DSM-Tool provides information which is renewed in security information database when asking security domain manager for the latest security domain information. DOGF's group manager objects information on

service object to security object when a client asks health information to be transmitted. Security object requests access control by delivering context provided and information on elements to dynamic security engine layers and executes dynamic access control over object elements, context elements etc. to return a result via access control.

Dynamic access modules execute a request from security domain manager that checks whether or not access control request information is managed. Dynamic access modules allocate elements to roles and retrieve access right allocation rule to execute evaluation of right of elements and delivers it to DOGF's security object. IEEE 11073 Point-of-Care standard and IEEE 11073 Personal Health Device standard are analyzed to use standardized health data which is delivered according to each element. Data collected by aforementioned process are transmitted to end system of destination location via broadband router. In this case, functions such as diameter which is related to proxy, relay and signaling interface between networks are used.

In hand-off between networks, delay of each link as well as network layers and re-transmission function of user data should be included. Such structure provides high QoS during hand-off and continuous service so that service can be provided without the need to newly set security session activated when a user moves. This provides smooth service by making offload between network areas executed efficiently via mechanism such as end-to-end QoS without deterioration of overall performance and an increase in complexity as a method for optimized communication between various networks. Web server and integrated management system that can store and manage data collected are built so that more accurate data can be provided by continuing to collect important personal information and condition such as electrocardiogram, pulse and blood pressure in smart health in real time. Data measured here are stored in web based system and are transmitted to a provider rapidly and monitored by medical staff and users.

4 Mobile based personal health management service

4.1 Service environment

Mobile data transmission in PHR open platform constructs database with health condition information, PHR, national nutrition survey and medical information [3,8,44]. EMR of health data from hospital, silver town, health center and medical institution is connected. Service is designed in such a manner that it can be suitable for model-view-control (MVC) pattern that provides practical solution in disconnecting user interface from data by classifying modules that process user related functions. View interacts with a model via controller that conveys input and converts it into instruction for a model or a view. MVC structure in a proposed platform includes new components in order to improve code reuse and maintenance which are important requirements in medium and large distributed system because service access interface can use the same service interface to access all characteristics and function of applications in browser and device clients. Figure 8 shows mobile service provision environment. Figure 8 show service environment to provide mobile service on proposed system. This service that receives real time personal health data which is bio sensing data via Bluetooth network of mobile smartphone and transmits personal health information in a stable way with hospital information system (HIS) via LTE or WiFi networks in smartphone.

User transmits health condition to platform via mobile interface and information is analyzed by decision making model. Information on health care according to users such as health information, improvement of lifestyle, health guideline, dietary nutrition and exercise is provided via smart health service. Only data that a user should observe out of real time personal health data that receive from smart health via WBAN device are collected by means of filtering. Overload that occurs when signals are received from various devices by means of filtering can be solved. Data collected through filtering should be processed by means of queuing service in the process of data acquisition in the order of input. Queuing service is provided to solve a problem which occurs due to delay of data service in processing data caused by asynchronism.

Server module that observes security guide of data received and protects medical information is used because HL7 which is a standard for medical record and transmission should be observed and personal health data which are collected in real time is transmitted in accordance with IEEE 11073 PHD data format. Encrypted interworking technology is used in order for collected data to be transmitted to mobile in a stable way and data are encrypted and stored into mobile database and analyzed. Analyzed information is used to give chronic disease monitoring service to users via mobile application UI and feeds back. Thus, a user is provided with customized service by retrieving his/her health information.

4.2 Implementation of service

Mobile service proposed by this paper develops an application by using Android Studio 5.1.1 (kitkat) in Intel (R) Core (TM) i7-4770 CPU 3.40 GHz, 16.00 GB RAM based Windows 8.1 Enterprise K 64 bit environment. Also, develops a website using wordpress tool. Figure 9 shows the web based smart health portal dashboard provides single page access about all data, statistics and services relating to user's health profile. The health portal dashboard displays blood

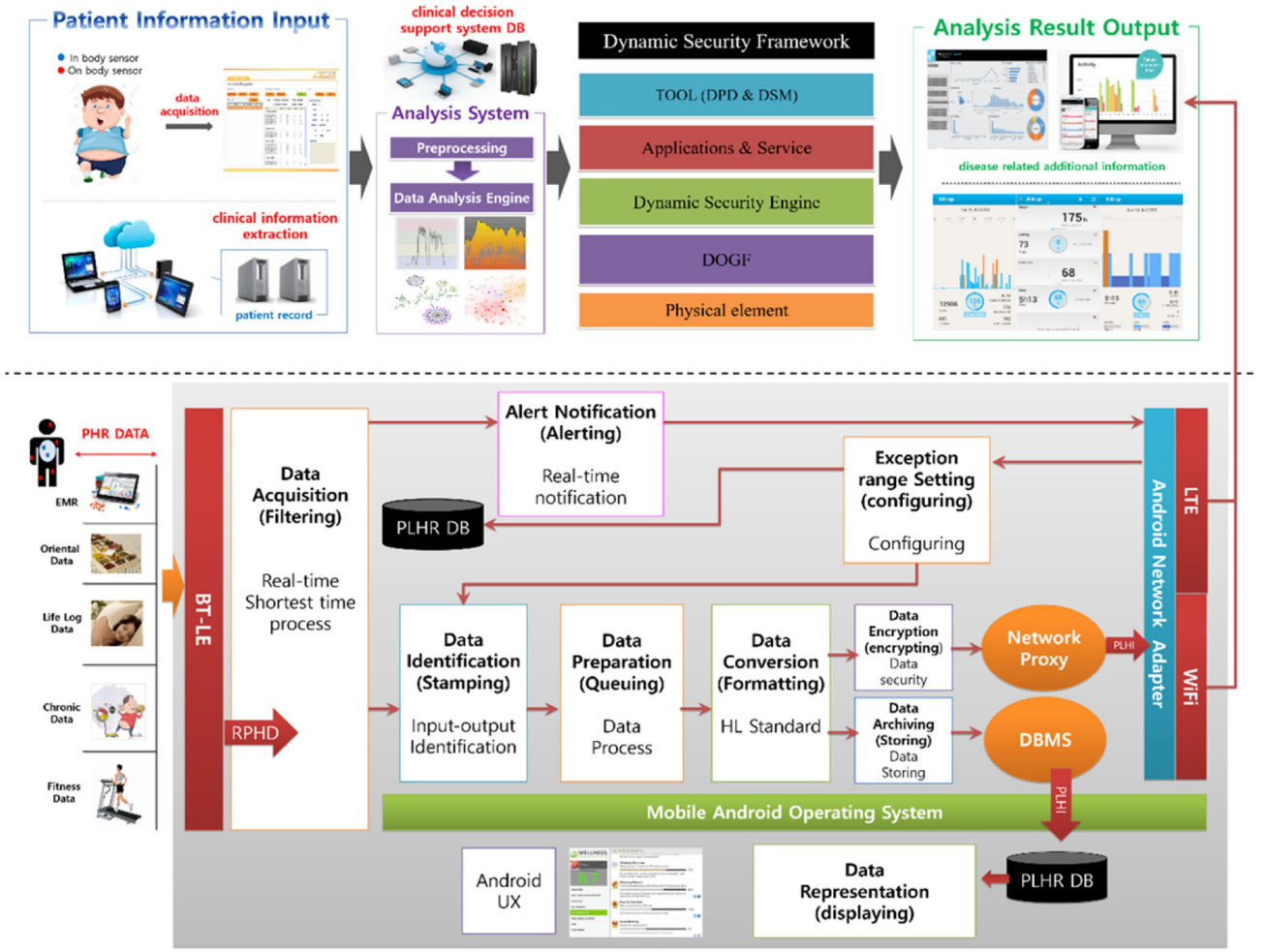
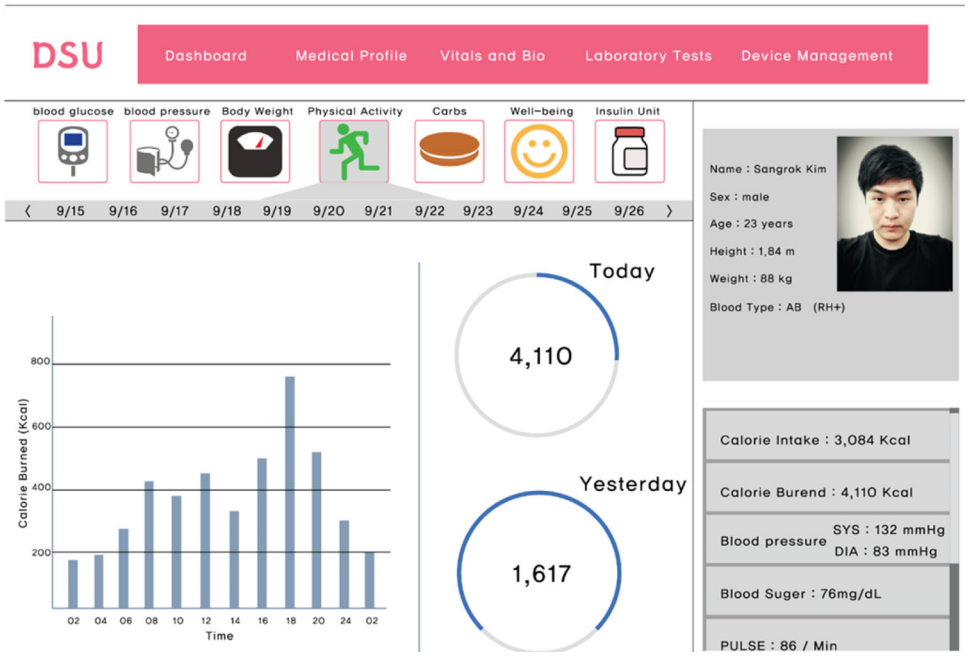


Fig. 8 Service environment to provide mobile service

sugar, blood pressure, weight, intake of carbohydrate, well-being, physical activities etc. of a user and such data items can be monitored easily through graphs and tables. When a browser-based client, the controller, in response to the request, performs a specific page, and re-acquired. If the requested page comes invoked, the user is interacting with a server through an access interface to the service using AJAX. AJAX request is to allow the loading of the partial page, thus saving network bandwidth. Also, the response of the access interface to the service, are formatted in the object representation of the JavaScript, which is a basic data structure for all browsers. Therefore, the creation of a graphical user interface for generating a browser, part of the load is transmitted from the host server to the client. It is during the loading of other portions are run on the client side, in order to perform the tasks that can be executed only on the server, to free the server resources (memory card CPU). This is supported by the availability of powerful multi-core CPU on the client's computer. Similarly, if the device client, HTTP requests are ready to sign and parameters of the service is transferred to the service interface, which executes the requested service, and feeds back the results obtained in the execution of the service that way, it will check the requests and responses.

Figure 10 shows the smart health mobile service application for treatment and dialogue designation page. This is used for a medical doctor to make and modify a treatment plan for a patient according to the need of a patient. This should be constructed perfectly so that parameters of treatment plan can be explained. This is used to designate various kinds of education and motivating dialogue. Such dialogue is prepared early and is built by professional caregiver for the sick through dialogue which constructs graphic user interface and is easy to use.

It was designed as the structure that can be integrated to improve the usability, extendibility and maintainability between the layers of web application and mobile application in the service environment above. In the suggested platform, the typical MVC structure included new components to improve the reuse of code that is the important requirement in the mid to large distributed system and maintenance. Service access interface can keep the inter-compatibility by using



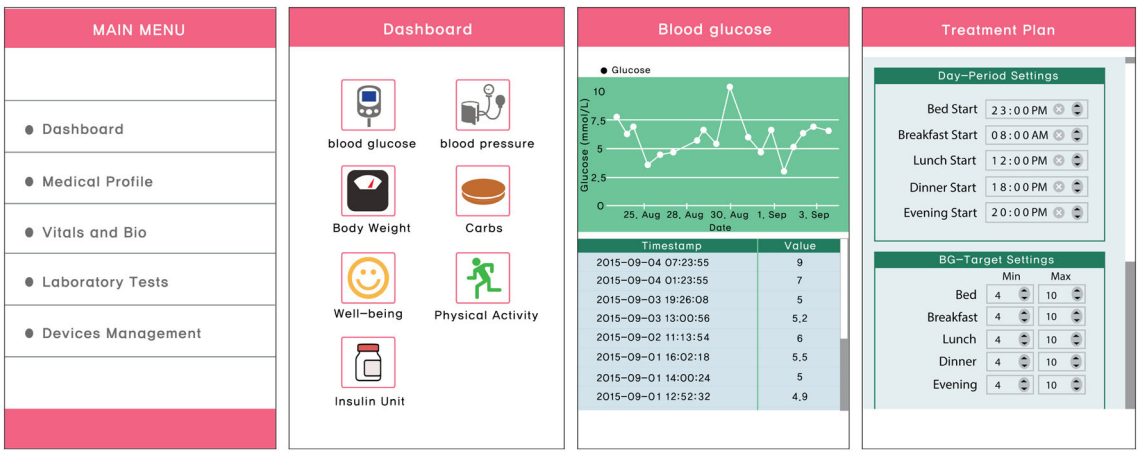


Fig. 9 Web based smart health portal dashboard

Fig. 10 Smart health mobile service application

the same service interface between browser-based client and device-based client and is capable of carrying out the features and functions of various applications. In case of browser-based client, the controller performs the interaction with the server through service access interface using AJAX according to the request and the request of AJAX can receive the service that is not restricted by device environment as the characteristic that can save network bandwidth because partial page loading is allowed. And, service access interface is composed to be formatted as JSON that is the basic of all browser. Now that the resources that is capable of other works are free in the server while they are carried out in the client, computer of client can support the usability of multi-core CPU. In case of device client, the request of HTTP is arranged with the signature of service and parameter and transmitted to service interface, and it checks the request and response by implementing the requested service and giving the feedback against the gained results. Figure 11 shows the request process scenario for intercompatability. Step 1–5 explains the sequential order that processes the request of browser-based client. Like the figure, browser transmits the request to the certain page from the suggested platform server. This request is processed by the profile controller and it obtains the required data from database using the model. After that, the controller transmits the obtained data to the requested view and transmits the requested data to the browser, however, it is transmitted to service access interface through AJAX request. As step a–d shows the sequential order that processes device-client request, in case of inputting health data of the users with mobile application, service access interface is used to store data in health portal database.

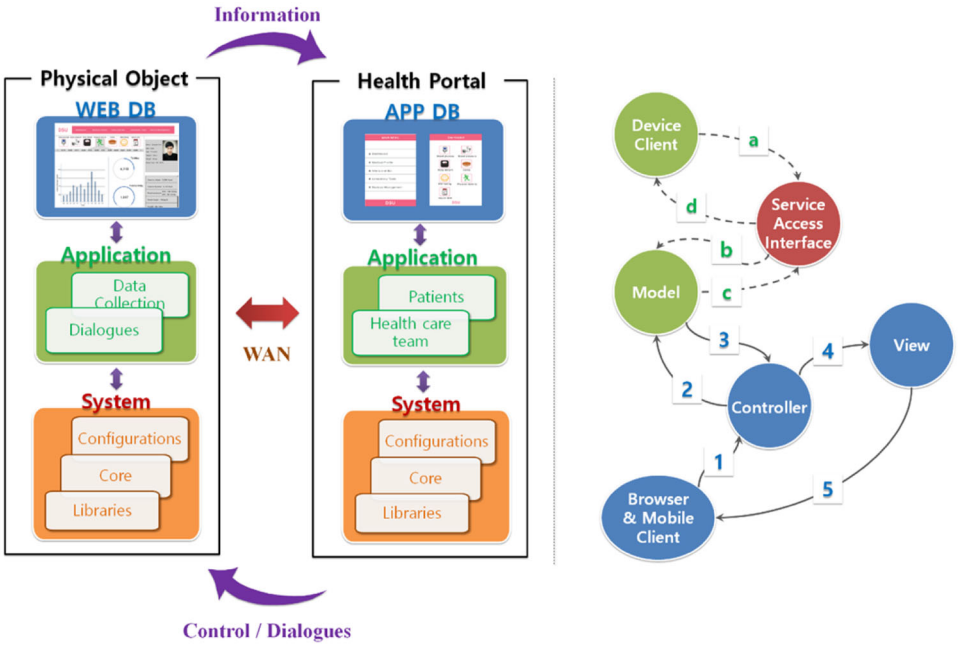


Fig. 11 Proposed request process scenario for intercompatability

5 Conclusions

In this paper, we proposed PHR open platform based smart health service that uses distributed object group framework for chronic disease management. PHR open platform based smart health service is customized smart health service by providing real time personal health data of chronic patients so that medical doctors can diagnose condition of chronic diseases efficiently and prescribe properly. Hierarchical task network is used so that performance of distributed network can be utilized based on automation technique and distributed agent for optimization of proposed smart health service. PHR open platform based smart health service provides application that functional and temporal elements are combined by making elements such as users and distributed resources reconstructed dynamically in smart health service using DOGF's object group support components to implement stage-by-stage division. PHR open platform based smart health service makes it possible for context cognition based dynamic security service to be provided and distributed objects to be managed with security domain in order to construct network that aims to provide safe service. Security service of mobile health system is provided by authorizing system resources, object groups and individual distributed objects. PHR open platform based smart health service provides service which is different from existing u-Health system in terms of virtual and physical layers about various services and data resources, extendability, maintainability and interoperability between user/device accessibility. Information which is collected and analyzed in a proposed system is used to monitor chronic diseases of users via web and mobile application and feeds back. Thus, a user can be provided with customized service by retrieving health information. PHR open platform based smart health service will help medical consumers diagnose and prescribe on their own.

PHR open platform based smart health service is expected to improve quality of life of chronic patients by making them to manage their health conditions on their own. Linkage of various kinds of smartphone health applications and data makes extension to medical service applications by efficiency of aforementioned system. As value chain of diagnosis-treatment-follow up management expands, it is expected that medical approach to management of overall lifecycle of medical consumers will be made.

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