SOA-based Integrated Pervasive Personal Health Management System using PHDs

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***Abstract*—Nowadays, the need for effective integrated health information management is very high, with which each individual can monitor his/her health status and the ever increasing healthcare cost can be significantly reduced therefore. Moreover, advancements in information, communication and sensor technology have made readily available many types of highly accurate yet affordable PHDs (Personal Health Devices) including glucose meter and blood pressure monitor just to name a few. In this paper, we present our experience with the design and implementation of an integrated pervasive personal health management system with the following features: (a) PHDs with wireless communication capabilities so that various kinds of health data can be pervasively captured; (b) standard interfaces so that various components can interacts with each other in interoperable manners; and (c) a SOA (Service Oriented Architecture)-based service architecture so that customized services can be easily implemented using well-defined reusable components.**

Keywords-component; personel health management, personel health device, interoperability, Service Oriented Architecture

I. INTRODUCTION

With the growth of economy, interests in personal health grow as well. Also, as the information technology (IT) is advanced, the demand is ever increasing for healthcare services based on information and knowledge. Especially, recent advancements in sensor and communication technologies have opened the door to the pervasive society where not only traditional personal computers but also various portable devices such as mobile phones and personal digital assistants (PDAs) can be used to interact with humans to offer various services. Moreover, advancements in information, communication and sensor technology have made readily available many types of highly accurate yet affordable PHDs (Personal Health Devices) including glucose meter and blood pressure monitor just to name a few. And home healthcare environments are interesting for research, as they constitute small, dynamic domains, created on demand to cater for an aspect of a patient's well-being [1].

Through these changes, it is possible to get healthcare service in all living areas as well as home. And the paradigm is changing from disease treatment to prevention and health maintenance. In this regard, there are lots of researches for diabetes care using Personal Health Devices (PHDs) [2-4]. In addition, pervasive healthcare-related and home healthcare research is underway as well as telemedicine [5-8].

PHD manufactures are very diverse and the fact that such vital signs have different structures and formats makes it a challenging task to send and receive the vital signs and is one of the primary obstacles in effective health information sharing. Consequently, it is important to transform vital signs from each PHD to standardized format to prevent increasing complexity.

Although each PHD manufacture provides the solution can manage vital sign from PHD, it is need to manage the integrating information for better service. Also, in the pervasive health environment, we need to integrate based on international standard format because a user not only link one healthcare provider but also diverse healthcare provider and healthcare facility.

Different users may need different types of services. For instance, services and devices for diabetes patients (mostly needing constant monitoring of glucose levels in the blood using a glucose-meter) are different from those of people suffering from cardiovascular diseases (SpO2, blood pressure, ECG, etc.), obese (weight and body composition) or other kinds of health problems. To provide such personalized or customized services, the system must be designed such that each service can be easily built upon a set of well-defined, reusable, core services.

In this paper, we present our experience with the design and implementation of an integrated pervasive personal health management system with the following features: (a) PHDs with wireless communication capabilities so that various kinds of health data can be pervasively captured; (b) standard interfaces so that various components can interacts with each other in interoperable manners; and (c) a SOA (Service Oriented Architecture) -based service architecture so that customized services can be easily implemented using well-defined, reusable core services.

II. SYSTEM STRUCTURE

In this section, we describe the overall structure of the system, as illustrated in Figure 1. The entire system consists of three sub layers: Personal Health Device, Transformation and Transmission Gateway (TTG), Integrated Service Server (ISS).

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ISS is further divided into Message Process Service (MPS), Information Integrating Service (IIS), and Document Generation Service (DGS) subsystems. Descriptions of these layers are given below.

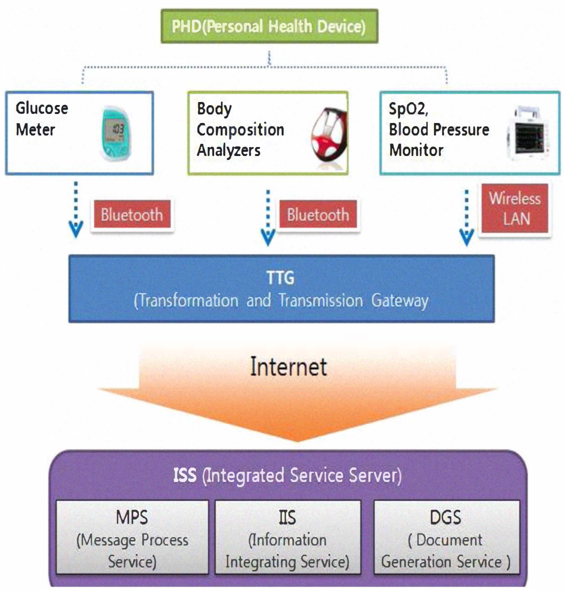

Figure 1. System structure of the entire system

A. *Personel Health Device*

PHD manufactures are very diverse and the fact that such vital signs have different structures and formats makes the challenging task to send and receive the vital signs and is one of the primary obstacles in effective health information sharing. To solve this problem, ISO/IEEE is developing 11073 standards to make message from PHDs to standardized format.

ISO/IEEE 11073 Medical / Health Device Communication Standards is a family of ISO, IEEE, and CEN joint standards addressing the interoperability of medical devices and they defines parts of a system, with which it is possible, to exchange and evaluate vital signs data between different medical devices, as well as remote control these devices. The primary goals of the standards are to "provide real-time plug-and-play interoperability for patient connected medical devices and facilitate the efficient exchange of vital signs and medical device data, acquired at the point-of-care, in all health care environments [13]." Table 1 lists the status of IEEE 11073 PHD Standards.

TABLE I. THE STATUS OF IEEE 11073 PHD STANDARDS

Device/Other	***Standard***	***Status***
Pulse Oximeter	11073-10404	Completed
Blood Pressure Monitor	11073-10407	Completed
Thermometer	11073-10408	Completed
Weighing Scale	11073-10415	Completed
Glucose Meter	11073-10417	Completed
Cardiovascular	11073-10441	Completed
Strength	11073-10442	Completed
Activity Hub	11073-10471	Completed
Optimized Data Exchange	11073-20601	Completed
Basic ECG	P11073-10406	Draft
INR – Blood Coagulation	P11073-10418	Draft
Insulin Pump	P11073-10419	Draft
Body Composition Analyzer	P11073-10420	Draft
Peak Flow	P11073-10421	Draft
Physical Activity Monitor	P11073-10443	Draft
Medication Monitor	P11073-10472	Draft
Technical Report Overview	P11073-0103	Draft

As we can observe from the status column of the table, standards for some PHDs have been completed, yet those of others have not. Also, no standard-conforming PHD produced by domestic manufacturers is available in the market yet. Therefore, we design the system to transform the vital signs to international standard message format HL7 V2.5 message. For our research, we used following devices.

- Body Composition Analyzer: IHU-070B (InBody R20) which transmits body fat percentage and BMI value to Transformation and Transmission Gateway (TTG) via Bluetooth communication. This device provide interface to input user's height, age, and gender.
- Glucose Meter: Allmedicus AGM-3000B (GlucoDr. plus) also provide Bluetooth communication. It can transmit date of measurement with glucose value.
- SpO2, Blood Pressure Monitor: Bionet BM3, BM5 can transmit SpO2 and blood pressure using Wireless LAN.

B. *Transformation and Transmission Gateway (TTG)*

This system is in charge of receiving vital signs from PHDs and transforming to HL7 V2.5 message, after that, sending to Integrated Service Server (ISS). It is possible to use one PHD by various people, so we developed interface that can insert user ID on TTG. ISS try to match user ID that was registered before with user ID from Gate Way Service (GWS). And then, ISS can store the vital signs with user ID. As such, TTG based on standards are critical for seamless data communications PHDs and service server. Based on standards, the design offers independence of the types and vendors of PHDs.

C. *Integrated Service Server(ISS)*

Message Process Service (MPS) parse the message from TTG. If an addition PHD can join, we can call the MPS and

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configure the service to get necessary information. Information Integrating Service (IIS) integrate the various vital signs associated with user ID and we can use the disperse information in the system as an integrated information. And, we can view diverse vital signs from PHDs and retrieve them, using IIS. Furthermore IIS have alert service about abnormal vital sign. Document Generation Service (DGS) generate CDA (Clinical Document Architecture) document [15] can provides interoperability to pervasive healthcare participants. Also we can see generated CDA documents and issue them. CDA is a document markup standard that specifies the structure and semantics of "clinical documents" for the purpose of clinical information sharing and exchange. In addition, ISS has User Management Service (UMS) for the management of users, including authentication and authorization, and Audit Trail Service (ATS) that manages various aspects of audit trails.

One of the key factors that provide the personalized health information is to configure the core functions to service unit. And if the new PDH or new kind of users may join the system, it is possible to provide optimal service. Figure 2 shows the service server architecture.

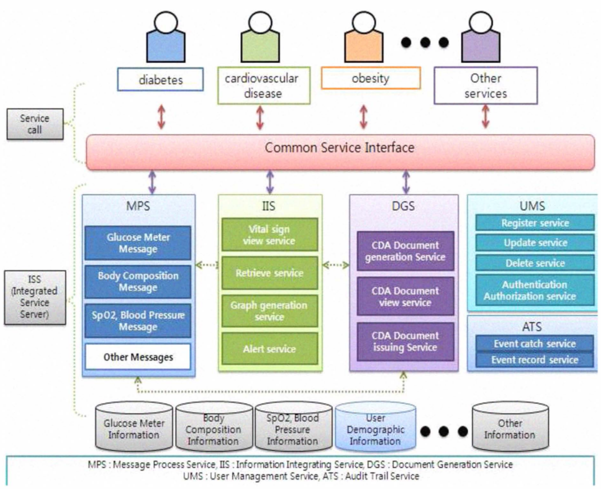

Figure 2. Service server architecture

III. RESULTS

To transform received vital signs into HL7 V2.5 message, we used ORU_R01 message. ORU_R01 message is used for transmitting laboratory results to other systems and designed to accommodate the laboratory processes of laboratory automation systems. Figure 3 shows an example of HL7 ORU_R01 Message from body composition analyzer.

```
MSH|^~₩&|^Inbody||||20091214143222||ORU^R01^ORU_R01|1|P|2.5
PID|||U0100
PV1||||||||||||||||A
OBR||||SPOTCHECK|||20091214143222
OBX||TX|^BMI^MDIL|1|21.7|^kg/m*m^MDIL|18.5~25||||F
OBX||TX|^BodyFat^MDIL|2|24.8|0004-0220^%^MDIL|10~20||||F
```

Figure 3. Example of HL7 ORU_R01 Message from body composition analyzer

It is possible to use one PHD by various people, at that time, it is important to know who used the PHD. If the PHD can insert several user IDs, there is no problem. Otherwise, we cannot know who it belongs to the vital sign. Thus we developed interface that can insert user ID on TTG.

First of all, to integrate various vital signs, user register into ISS and the HL7 V2.5 ORU_R01 message is generated in GWS. After that, it is transmit to ISS. ISS parse the message and identify user ID in the message. After that, ISS can match user ID that was registered before with user ID from GWS. And then, ISS can store and integrate the vital signs with user ID. Finally, DGS generate CDA document using integrated vital signs and user demographic information.

An example CDA document is given in Figure 4. The document includes user demographic information, glucose meter results, percentage body fat, BMI, SpO2 results and blood pressure information with the normal range for each vital sign.

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Personal Healthcare Monitoring Report

Name (Gender)	Kim So hee(F)	Diabetes	no
BirthTime	19791104	CreationTime	20091025

Glucose Meter Results

	Results	Before Meal(Normal Range)	Before Meal(Diabetes)
Glucose Meter Value	105	70~110	over than 126
		Post meal(Normal Rage)	Post meal (Diabetes)
		less than 140	over than 126

Body Composition Analyzer

	Results	Normal Rage
BMI	20.9	18.5~25
Percentage Body Fat	24.8	18~28

* BMI(Body Mass Index): A measure of body fat based on height and weight(Height(kg) / height (m) *height(m)) that applies to both adult men and women.

Pulse Oximetry (SpO2)

	Results	Normal Range	Description
SpO2	98	90 - 100	The amount of oxygen attached to the haemoglobin cell in the circulatory system
Pulse Rate	85	50 - 150	Arterial palpation of a heartbeat

Noninvasive Blood Pressure (NBP)

	Results	Normal Range	Description
Systole	115	80 - 200	Pressure while the heart is beating
Diastole	70	20 - 120	Pressure while the heart is relaxed
Mean	85	40 - 140	-

Figure 4. Sample integrated personal healthcare monitoring report

IV. CONCLUSION

In this paper, we present our experience with the design and implementation of an integrated pervasive personal health management system. The system can reduce complexity of service server because of standardized message transformation. And for interoperability, we adopted CDA document. Also,

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SOA-based service architecture so that customized services can be easily implemented using well-defined reusable components.

We expect this system will offer high interoperability and personalized health information. In near future, we plan to expand this system to accommodate more PHDs. We also plan to conduct thorough test and verifications for the effectiveness of the system in real life setting.

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