Ontology and CDSS based Intelligent Health Data Management in HealthCare Server

Eun-Jung Ko, Hyung-Jik Lee, and Jeun-Woo Lee

***Abstract*—**In ubiqutious healthcare environment, user's health data are transfered to the remote healthcare server by the user's wearable system or mobile phone. These collected user's health data should be managed and analyzed in the healthcare server, so that care giver or user can monitor user's physiological state. In this paper, we designed and developed the intelligent Healthcare Server to manage the user's health data using CDSS and ontology. Our system can analyze user's health data semantically using CDSS and ontology, and report the result of user's physiological raw data to the user and care giver.

***Keywords*—**u-healthcare, CDSS, healthcare server, health data, ontology.

I. Introduction

AS computing power and network infrastructure and device technology are developed, there have been studies concerned with ubiquitous technology. Ubiquitous technology means that user can use service anytime anywhere [1] [2]. This ubiquitous technology and interests of well-being lead U-healthcare (U-healthcare). U-healthcare means patient or users can use healthcare service as like diagnosis service, emergency management service, monitoring service anytime anywhere [3] [4].

To provide U-healthcare service for user, ubiquitous healthcare infrastructure should be constructed. U-healthcare infrastructure is generally consisted of sensing device, network, and user's mobile system and healthcare server.

The sensing device senses user's physiological data like skin temperature, respiration rate, heart rate, blood pressure, etc. These sensed physiological heath data are analyzed in the context aware middleware of user's mobile system and transferred to healthcare server. Healthcare server gets a number of user's health data and stores the data to the database. Also healthcare server analyzes user's physiological raw data using CDSS (Clinical Decision Support System) and ontology. Thus healthcare server should manage user's health data efficiently.

CDSS (Clinical Decision Support System) is active knowledge systems which use two or more items of patient data to generate case-specific advice [5]. CDSS is typically designed to integrate a medical knowledge base, patient data and an inference engine to generate case specific advice [6]. As out system is based on the U-healthcare, we use CDSS system to analyze user's health data and get a user's health advice in the healthcare server.

Ontology is a formal, explicit specification of a shared conceptualization of a domain [7]. Ontology includes the machine-interpretable definition of basic concepts in the domain and relationships among taxonomies. Ontology shares a common understanding of the structure of descriptive information and enables reuse of domain knowledge [8]. Ontology is used in order to make explicit assumptions and to separate domain knowledge from operational knowledge. Additionally, ontology has the advantage of sharing of knowledge, logic inference and the reuse of knowledge. If any system uses ontology, the system can provide a general expressive concept and offer syntactic and semantic interoperability. By mapping concepts in different ontologies, structured information can be shared. Hence, ontology is a good candidate for expressing context and domain knowledge. Thus we use ontology to modeling health data. As we use ontology, our system has the common concept of the health data.

So, in this paper, we propose the CDSS and ontology based Healthcare Server for health data managing in ubiquitous computing environment.

II. U-Healthcare System

U-healthcare enable user and care giver to access user's health data anytime and anywhere. The usage of U-healthcare example is shown in Fig. 1.

If there is U-healthcare infrastructure, user can use U-healthcare in smart home, smart care, smart office and outdoor activity. No matter where user is, user can use U-healthcare service anytime, anywhere. If user is in physiological emergency status, the context-aware middleware detects user's emergency status and then notifies user's family, care giver and emergency office. As user has a sensor for detecting a user's location like GPS, user's location, health data

Manuscript received June 12, 2007. This work was supported by the IT R&D program of MIC/IITA, [2005-S-069-02], development of wearable system using physiological signal processing.

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status, emergency occurrence time are notified to the family and care giver.

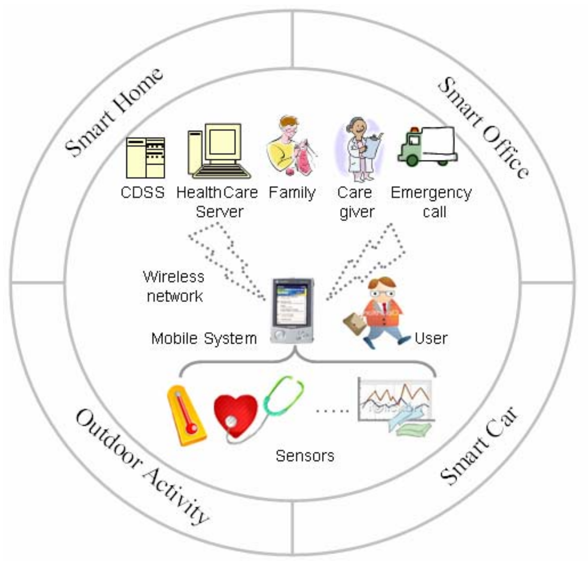

Fig. 1 Applicable U-healthcare

The wearable sensing device senses user's physiological data and transfers raw data to the mobile system. The context-aware middleware in the Mobile system get user's health raw data and analyze user's health data using inference engine. If it is possible to run a healthcare service in the mobile system, the agent invokes service in the mobile system. The diagnosis service in the mobile system shows user's health data using user interface and then transfer the health data to the remote healthcare server. Some healthcare service transfers health data and raw data to the remote healthcare server. Also some healthcare service manages user's emergency status.

If user's health data are gathered into the remote healthcare server, care giver can access user's health data in remote. The healthcare server manages and analyzes users' health data using CDSS and ontology. If healthcare server uses CDSS and ontology, healthcare server can use medical domain knowledge and provide more efficient and semantic service to user. As user's health data is very private, there should be an access authority on health data. Moreover transferred health data should be encrypted for user's privacy.

A. U-healthcare Infrastructure

In our research, U-healthcare infrastructure is consisted of the Wearable Sensing Device, BAN (Body Area Network), Mobile System, network and remote various servers. Fig. 2 shows our ubiquitous healthcare infrastructure.

In the U-healthcare infrastructure, the Service Provider deploys service module into user's mobile system when user select the services which user want to use. As computing power of user's mobile system is very restricted, only selected services are downloaded from the Service Provider and installed into the user's mobile system. Once service modules are downloaded and installed in the mobile system, the agent manages the service modules.

Once user turn on the Wearable Sensing Device, the related device descriptions and device providers are downloaded from the Device Provider into the user's mobile system. Thus, context-aware middleware in mobile system can analyze the sensed data.

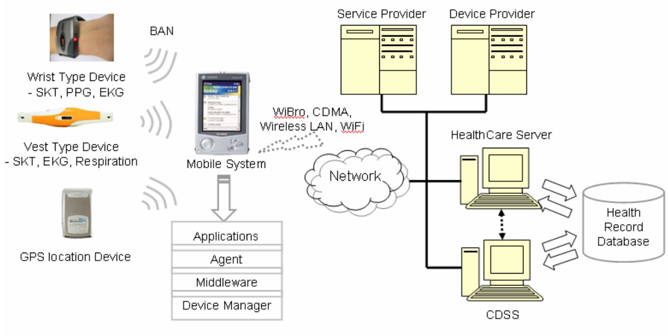

Fig. 2 U-Healthcare infrastructure

In our research, we uses three type sensing device. Two of them are for sensing physiological data, and the rest is for sensing user's location. The GPS sensor measures latitude and longitude of user location. The wearable Wrist Type Device measures user's skin temperature, heart rate, PTT (Pulse Transit Time). The wearable Chest Type Device measures user's skin temperature, heart rate and respiration rate. These data are transferred to the mobile system using BAN.

The Context-Aware Middleware in mobile system manages and analyzes the sensed data and then generates sensed data to the context. The Context-aware middleware also generate high-level context which is used in the agent and service using inference engine.

If there is a diagnosis service, the service display user's health data in the user interface and then encrypt the data and then transfer to the healthcare server. Also there is a remote monitoring service, remote monitoring service gathers user's physiological raw data, and then encrypts the raw data, and then transfers the data to the healthcare server. Because of privacy, these data are encrypted before transferring.

Like this, sensed health data are transferred to the healthcare server to be managed. If health data are gathered into healthcare server, care giver can manage user's health information in remote. So health data management in healthcare server is needed.

B. CDSS and Ontology based Healthcare Server

In U-healthcare infrastructure, all health data are transferred to the healthcare server. So, healthcare server should have huge storage and manage health data efficiently. Also healthcare server should analyze health data automatically, and notify the analyzed result to user and care giver.

The major functions of healthcare server are as follow.

1. Generates, manages and deploys the user profile which contains user information and health threshold.
2. Displays user's health value and raw data based on the access authority.
3. Decrypts and stores the encrypted health data which is transferred from user's mobile system.
4. Analyzes stored health data using the knowledge base like CDSS or ontology.
5. Notifies analyzed data result to user and care giver automatically.

To do this, our healthcare server's architecture is shown in Fig. 3.

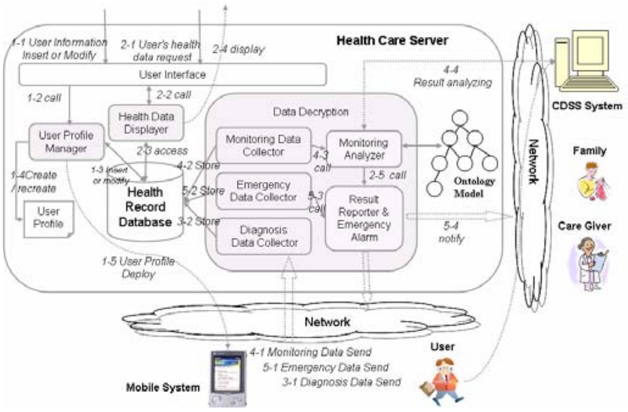

Fig. 3 Healthcare server architecture

If user joins the healthcare server or modifies user information using the User Interface, the User Profile Manager creates or modifies user profile through accessing the Health Record Database and then, deploys User Profile to user's mobile system. So the mobile system can maintain last version of the user profile.

In out research, our user profile is formed by xml and the contents of the User Profile are shown in Table I. If this User Profile is downloaded into mobile system, the Context-Aware Middleware in the mobile system parses and processes the User Profile file.

TABLE I
THE CONTENTS OF USER PROFILE

category	contents	category	contents
Personal Information	ID	Health Information -value -threshold	PTT
	Name		Heart Rate
	Height		SKT
	Weight		Respiration Rate
	Age		Body Fat Rate
	Gender		BMI
	Phone Number		Stress Level
	Emergency Contact Phone Number		Gluco Measure Value
Attending Physician	Physician ID		Blood Pressure
	Physician Major		Stress Level
	Hospital Information		Consumed Calories

Using web-based healthcare server, user or care giver can monitor user's health data and history. User can access owns health data like skin temperature, PTT, heart rate, respiration rate. Care giver can access not only user's health data but also user's raw data. The Health Data Displayer displays user's health data to text or graph for easy understanding. When care giver requests user's health data or raw data, the care giver could only monitor a designated user's data for access authority.

In our system, we have 3 U-healthcare service scenarios, the Diagnosis Service, the Remote Monitoring Service and the Emergency Management Service. Based on these scenarios, I will describe healthcare server how to manage health data.

Firstly, I will discuss the Diagnosis Service scenario. In the mobile system, the Diagnosis Service send user's health feature value to the Healthcare Server after measuring user's physiological data as like skin temperature, heart rate, respiration rate and PTT. When the Diagnosis service transfers these health feature value, the Diagnosis Service encrypts these data for data security. In the Healthcare Server, the Diagnosis Data Collector gets encrypted health feature value, and decrypts this data. This decrypted health feature data are stored into the Health Record Database and displayed when user or care giver request.

Secondly, the Remote Monitoring service gathers user's physiological raw data according to the designated time and duration which are set by care giver. The process of Remote Monitoring service is shown in Fig. 4.

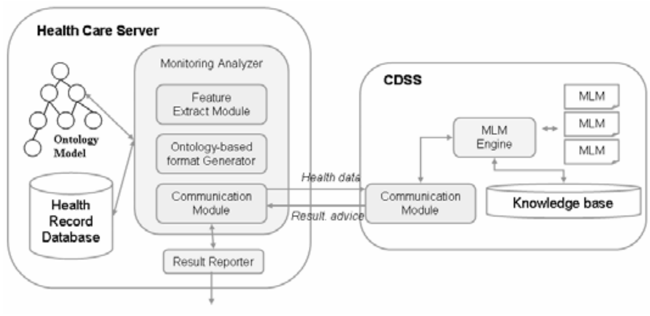

Fig. 4 The process of remote monitoring service

In the mobile system, agent invokes the Remote Monitoring Service on the designated time. The Remote Monitoring service gathers user's physiological raw data, SKT (skin temperature), EKG (electrocardiogram), PPG (photophlethysmography), and Respiration. These data are encrypted and then transferred to the Monitoring Data Collector of the Healthcare Server.

The Data Collector gathers raw data and stores these raw data to the Health Record Database. After storing, the Monitoring Analyzer analyzes the feature and then makes the feature data to the model according to the ontology model for interoperability between healthcare server and CDSS. The CDSS gets health feature data and make the result and advice using MLM (Medical Logic Module) Engine. The knowledge base is described in Arden Syntax. After analyzing user's raw data, this result is notified to the user and care giver.

Thirdly, I will discuss the Emergency Management Service scenario. The process of Remote Monitoring service is shown in Fig. 5.

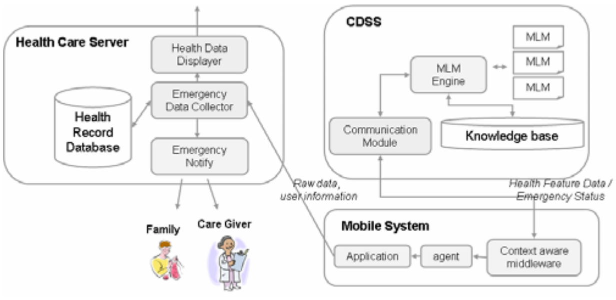

Fig. 5 The process emergency management service

If user is in the physiological emergency status, the Context Aware Middleware detects user's emergency status using the CDSS. The Context Aware Middleware generates health feature value using analyzing user's physiological raw data. Then transfer these data to the CDSS for checking emergency status.

If user is in the emergency status, agent invokes the emergency management application. The Emergency Management Application transfer not only user's raw data real timely but also emergency previous file. These raw data are encrypted and transferred to the Healthcare Server. When the Healthcare Server get an emergency file, the Emergency Notify Module notify user's status and user information, name, emergency occurrence time, user's location and feature value to the care giver and family.

C. Implementation

We built U-healthcare infrastructure which is consisted of the Wearable Sensor Device, wearable system, Healthcare Server and CDSS. We use PDA Bluebird 5000 model [9] as a mobile system. The OS of PDA is WinCE 5.0 and PDA has the 520MHz CPU and 64MB RAM and 128 MB ROM. PDA has the crème java virtual machine [10] and the XecureConnect [11] Security module which is for crème virtual machine.

The operating system of the HealthCare Server is window XP Professional was installed. The memory size is 1G and the CPU is a Pentium 4. The HealthCare Server uses mysql as a database. The HealthCare Server has the XecureConnect[11] and XecureWeb for data security.

The CDSS's operating system is linux Fedora 5 and use Oracle 10g release1 database.

The wearable system and Mobile system are connected by ZigBee. The Mobile system and healthcare server and CDSS are connected by wireless LAN. Our system's implementation is shown in Fig. 6.

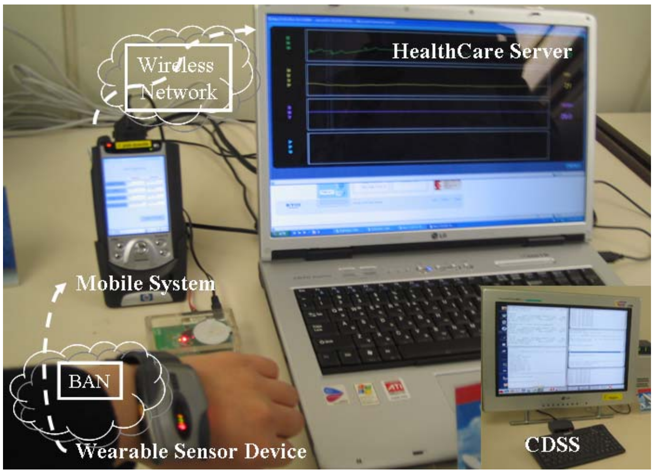

Fig. 6 Implementation environment

III. Conclusion

In this paper, we designed and developed CDSS and ontology based healthcare server for health data management. As system is based on the U-healthcare infrastructure, user can use U-healthcare service anytime and anywhere.

In U-healthcare infrastructure, mobile system gets and analyzes user's physiological data. Also mobile system transfers user's health data and raw data to the HealthCare Server to be managed. To do this, Healthcare Server has to manage user's health data efficiently.

Thus we propose the Healthcare Server which uses ontology and CDSS for health data management. As we adopt ontology and CDSS, the HealthCare System can use medical domain knowledge, and provide more efficient and semantic service to user. Moreover, our Healthcare Server can manage user profile, and display user's health data based on the access authority.

As user's health data is very private, we adopt security function for health data's security, and our healthcare server can automatically notify the analyzed result of health data to user and care giver.

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