International Journal of Multimedia and Ubiquitous Engineering
Vol.11, No.10 (2016), pp.57-66
http://dx.doi.org/10.14257/ijmue.2016.11.10.05

The Mobile Cloud Hospital Interoperability Information System Based on XMDR-DAI

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Abstract

This paper designed XMDR-DAI-based hospital information system in mobile cloud environment. The system supported data interoperability service between systems in the process of transmitting data collated from BSN (Body Sensor Network) environment to the hospital information system. This study suggested XMDR-DAI-based MCBS (Mobile Body Cloud System) in the mobile cloud environment. The system integrated sensor information obtained from BSN to support interoperability service for medical information between HIS (Hospital Information System).

Keywords: *XMDR-DAI, BSN, HIS, Data Interoperation, System Integrated*

1. Introduction

Among many researches on mobile health care, some researches attracted attention for such as removing unnecessary duplicated check-up or excessive medical expense by collecting information from body sensor, which is obtained through mobile device attached to bodies of patients [1]. Currently, as the body sensor devices were developed by different manufacturers with individual software and communication protocol, the body sensor data was hardly interoperable with HIS (Hospital Information System) [2]. Moreover, as the structures of database in each medical organization's system were heterogeneous, it was difficult to share the data. Thus, this study suggested XMDR-DAI-based MCBS (Mobile Body Cloud System) in the mobile cloud environment. The system integrated sensor information obtained from BSN (Body Sensor Network) to support interoperability service for medical information between HIS. The service converted and integrated IEEE 11073-based sensor information to HL7-based medical information to transmit bio-information to the hospital information system [3-4]. Furthermore, data collision, occurred during the process of sharing personal health data between the medical organizations, was solved by data integration service in application of XMDR-DAI [5], which was one of cloud technologies. This paper is organized with 5 sections in which Section 2 outlines related work and Section 3 describes the proposal system. Similarly, Section 4 describes Implementation and Section 5 concludes the paper.

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ISSN: 1975-0080 IJMUE

2. Related Work

2.1. Body Sensor Network (BSN)

Currently, body sensor network was utilized to monitor personal health conditions, play motion sensor-based games, share information, and *etc.* While necessity of multi-functional, small-sized, and medical mobile devices and request of developing personalized health check-up and management were increased, bio-information of personal bodies was transmitted to medical organizations in real time based on ubiquitous environment, and sensor technologies and wireless communication technologies with servers were converged to receive personal information for the patients' self-treatment service [1]. Moreover, technologies of detecting, analyzing, and transmitting bio-signals were converged, and real-time automatic transmission technologies were in development using data-mining. In Japan, one of the researchers measured and managed personal health conditions through self-communication and established in-home monitoring system to constantly monitor patients' health conditions, alarm deviations from normal conditions in early stages, predict the future health conditions, and utilize the saved data in detecting any symptoms. Furthermore, in Europe, one of researches measured breathing, oxygen saturation, pulse, blood pressure, pupil size/response, and *etc.* to transmit GPRS [6] (General Packet Radio Service) and UMTS[7] (Universal Mobile Telecommunications System)-based wireless broadband data.

2.2. XMDR-DAI Technology

XMDR-DAI [5] was an agent adopted to solve metadata schema, data structure, and semantic collision occurred due to data integration using XMDR, which was an expanded concept of MDR; the technology saved metadata of relational database to object-oriented database. In other words, it was storage integrating data by combining MDR and ontology to solve collision between schema structures and instances of dispersed data. This study composed the association of BSN's metadata with XMDR-DAI to support data interoperability service for using the medical information effectively.

2.3. Hospital Information System (HIS)

The structure of hospital information system was divided by 3 main levels such as levels of central government, region, and patient transport [2]. Generally, all kinds of hospital information system supported client-server architecture for networking and processing. Locations of processing the hospital information system were mostly residential. Due to development of smart phones, it supported application services for the smart phones. An official standard for exchanging patients' information between the hospital information systems was not existed, but there was HL7 project supporting ISO for data types and data exchange. HL7 improved monitoring of drug uses and researches of the effects using the patients' medical information and moreover it enhanced to prescribe more appropriate drugs. Data integration through HL7 would improve the integrity of patients' information and reduce the items of information [3-4]. Furthermore, it grafted cloud computing system to the hospital information system for loading the information from the cloud servers as a perfect function [8-9].

3. Proposed System

3.1. System Overview

The overview of system suggested in this study was shown in the <Figure 1>, composed of a patients' group, a doctors' group, HIS cloud, and the suggested system. Each group was described as follows:

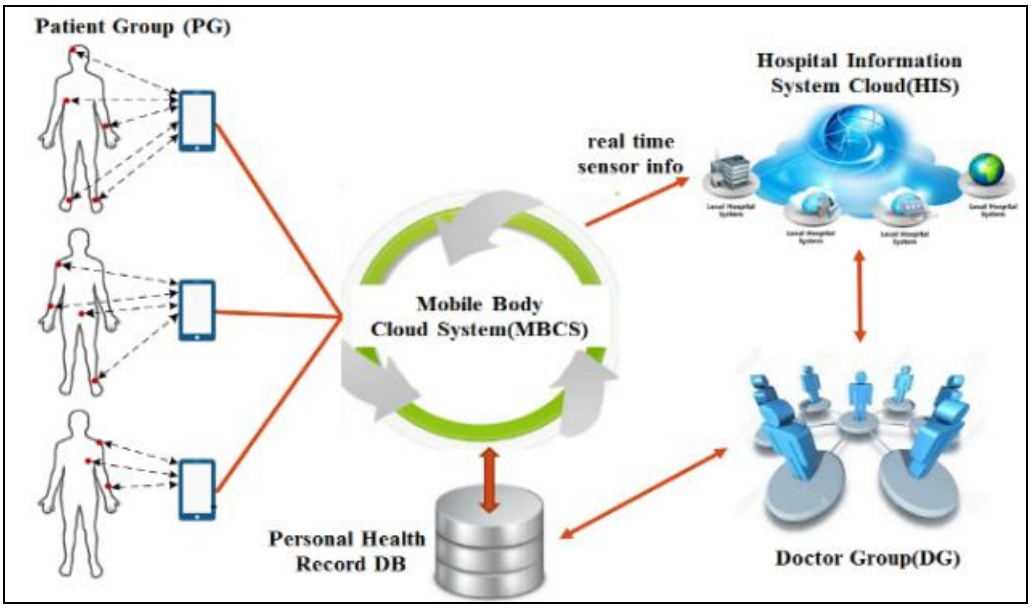

Figure 1. Mobile Cloud System and Hospital Information System

● **Patients' group**: This group obtains the bio-information from sensor data attached to their bodies in real time through Bluetooth of their smart phones.

● **Doctors' group**: This group receives the patients' information from each local HIS cloud through wireless communication. As they are transmitted the patients' information in real time, they can immediately give prescription to the patients.

● **HIS Cloud**: This group of hospital information systems is dispersed by regions, and it contains patients' information of each hospital. This system group is associated between hospitals.

● **MBCS**: The information transmitted from sensors, attached to patients, through smart phones is integrated and transmitted to HIS cloud according to its standards. The transmitted information is more easily shared between dispersed PHR of hospitals based on HL7 to obtain patients' condition information in real time.

3.2. System Operation and Structure

The Figure 2 illustrated elements and structures of MBCS as suggested in this study.

● BSN Sensor: BSN sensor collects, adjusts, and manages sensor information of patients' bodies through nodes for monitoring.

● Mobile Service Manager: Mobile service agent facilitates doctors to check the sensor information through mobile devices and manages the information. In other words, the doctors check patients' information in real time, and they search, save, and share the patients' medical information in HIS cloud through mobile phones. Accordingly, the patients' medical information is shared between the doctors.

● Acquisition Data Agent: It provides and manages transmission service to identify the transmitted information from the patients' group in real time through HIS.

● Security Manger: It encrypts the sensor information transmitted to HIS cloud through data agent for its security.

● XMDR-DAI Manager: XMDR-DAI manager associates the medical information of between local hospital DB and doctors'group. At this time, schema collision occurred in the process of sharing the medical information is solved by XMDR-DAI. To associate with HIS, IEEE 11073-based information was integrated to HL7-based information.

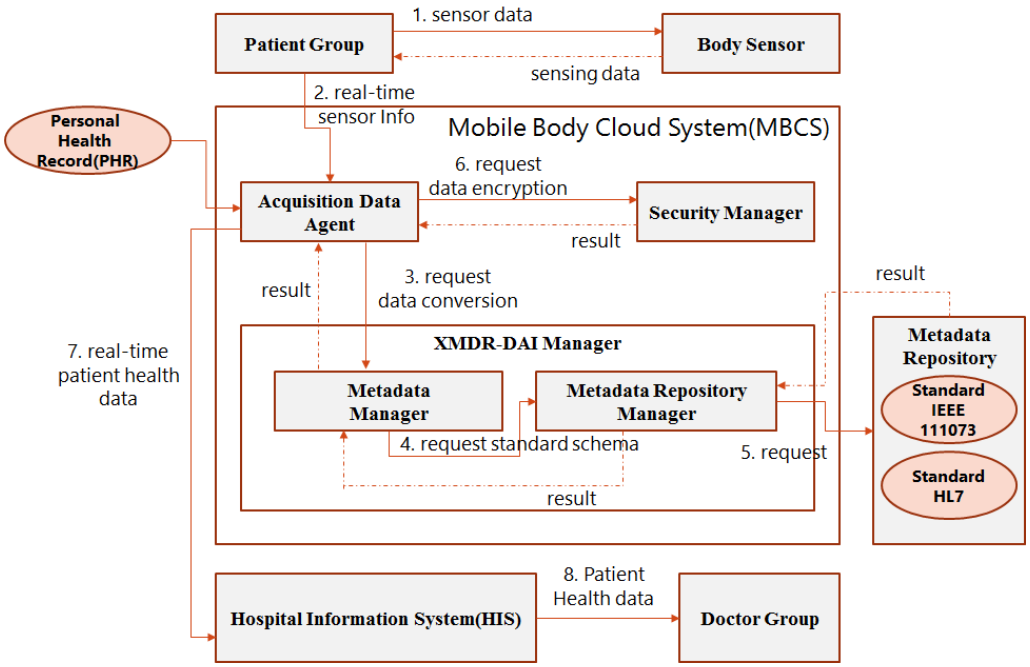

Figure 2. System Operation

Figure 2. is a process for performing a process for transferring the sensor information that has been integrated with MBCS based on XMDR-DAI System for HIS. Description of the execution of each process are as follows. Patient Group acquires sensor data generated by the body sensor via Bluetooth to patient smartphone. Acquired data is transferred in real time MBCS System. When transferring the sensor information of each patient to the Hospital Information System, for interoperability of data, and to integrate a standard HL7 and IEEE11073 of medical information. Integrated data, after performing encryption on the Security Manager for security, to be transferred to the HIS. Doctor Group saves the health information of patients who have been sent from the HIS to the smartphone. The stored data in the mobile cloud environment, it is possible to exchange data between the doctors.

3.3. Body Sensor Data Standard format

This body sensor data is composed of the IEEE 11073 PHD standard and divided into transfer layer, device standard and exchange protocol. <Table 1> shows the current IEEE 11073 PHD standard. This paper does not define the transfer method of data but assumes the use of currently implementable Bluetooth and only deals with blood pressure used for an experiment.

Table 1. IEEE 11073 Standard Format

Standard	Measurement	Elucidatory Notes
IEEE Std 11073-10404	Pulse Oximeter	Device specialization
IEEE Std 11073-10407	Blood Pressure Monitor	Device specialization
IEEE Std 11073-10408	Thermometer	Device specialization
IEEE Std 11073-10415	Weighing Scale	Device specialization
IEEE Std 11073-10417	Glucose Meter	Device specialization
IEEE Std 11073-10420	Body composition analyzer	Device specialization
IEEE Std 11073-10421	Peak flow	Device specialization
IEEE Std 11073-10441	Cardiovascular fitness	Device specialization
IEEE Std 11073-10442	Strength fitness equipment	Device specialization
IEEE Std 11073-10471	Independent living activity hub	Device specialization
IEEE Std 11073-10472	Medication monitor	Device specialization
IEEE P11073-10406	Basic ECG	Device specialization
IEEE P11073-10413	Respiration rate monitor	Device specialization
IEEE P11073-10418	INR	Device specialization
IEEE P11073-10419	Insulin pump	Device specialization
IEEE Std 11073-10404	Pulse Oximeter	Device specialization
IEEE Std 11073-10417	Glucose Meter	Device specialization

3.4 Body Sensor Data Filtering

This body sensor data filtering service module provides the service through filtering that enables the acquisition of data to be observed instead of simple data for medical service personnel.

Algorism 1. The Filtering Algorithm of Body Sensor Data

```
public class DataFiltering {
  private static final Logger logger =
      LoggerFactory.getLogger(DataFiltering.class);
      private static final String bsndatabase = "C:\\bsndatabase\\";
      FilteringService filter;

  public void doFilter(ServletRequest request, BSNdata data) throws Exception   {
    String bsndata = data.getBSNdata();

    /* Normal Range Data */
    if(bsndata.equals("normal")) {
      return filter.filtering;
    /* Observation Range Data */
    } else if(bsndata.equals("observation")) {
      return filter.save;
    /* Danger Range Data */
    } else {
      return filter.save;
....
```

The data filtering function of mPHM System only acquires data that exceed or lack the established measurement scope out of the body sensor data created by the body sensor device from the subjects of observation, and performs the operation to remove data belonging to the measurement scope. The body sensor device to measure the heart rate creates 40 ~ 200 data, and in case of ECG (electrocardiogram), average 1,000 data per second are created. Since most of the data occurrence rate of the body sensor device is high, it becomes the cause of system overload or brings about a problem with data lose or

difficult monitoring. Therefore this paper is able to perform much smoother monitoring by solving various problems including overload followed by large scale data transfer through filtering function and providing medical service personnel with simple information. Algorithm 1. shows the data filtering algorithm suggested by this study.

3.5. Schema mapping rule based on XMDR-DAI

Figure 4. is the design regulation for mapping of the local schema of the standard HL7 schema of mCloudHIS and the medical information system as a process to share medical information between medical information systems. The mapping regulation design is based on diagnosis information among the items about PID and OBX segment as the basic information of patients. (F) in the figure means Field Mapping as the mapping of standard field and local field. (T) as the mapping of other types stands for Type Mapping, and (+) integrates each item.

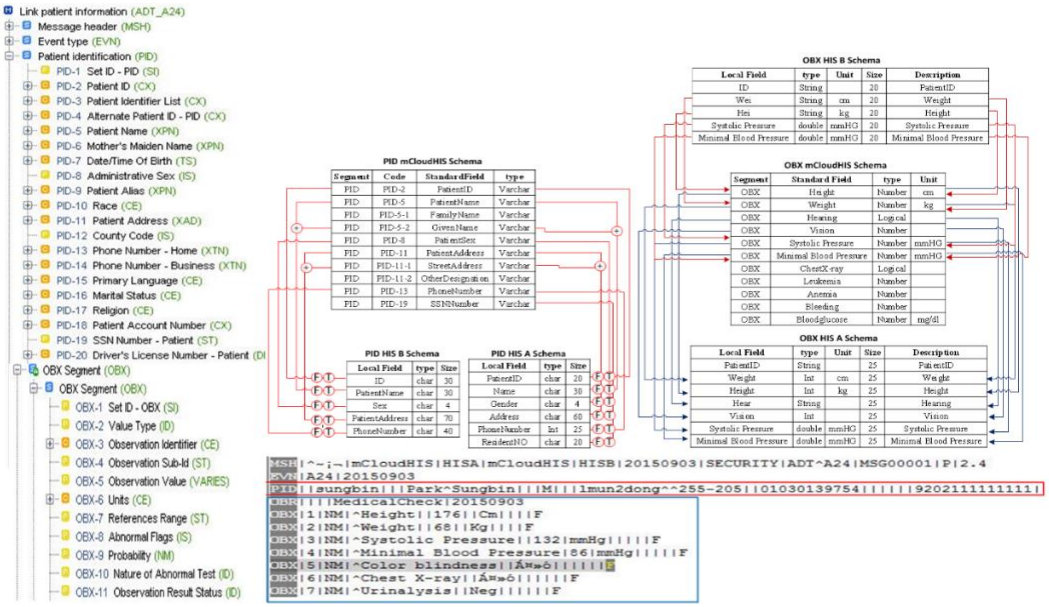

Figure 4. The Design of Schema Mapping Rule for Medical Info Share

The purpose of mCloudHIS suggested by this paper is to solve heterogeneity of data in order to share medical information between medical institutions. Accordingly, the field name required in standard HL7 was extracted to design standard metadata. In the figure, MSH defines medical information provider, data type and date as well as transfer institution. EVN has information on event treatment occurring in the process to share medical information. The mapping method of OBX segment is the same with PID. However, OBX includes 'Unit' different from PID. Therefore data sharing between medical institutions becomes enabled through the process of (F), (T) and unit mapping.

4. Implementation

The service function of this mPHM System is to input the body sensor data of the smartphone of the subjects of observation and transfer to the medical information system. mPHM System filters data collected by the smartphone prior to transfer of the body sensor data to the medical information system, and transforms to medical information to solve the problem of heterogeneity. In addition, the service that can check the health condition of the subject of observation should be provided. This study experimented blood pressure, and the data type is composed of patient's ID and data identified time,

basic health information, measured data value and monitoring scope. Figure 5. and Figure 6. is the interface screen to perform monitoring through data filtering of mPHM System suggested by this study. Figure 5. is the diagram of the body sensor data before filtering input by mPHM System through the mobile device of the subject of observation. The graph to express data was designed by using the Google chart of API provided by Google.

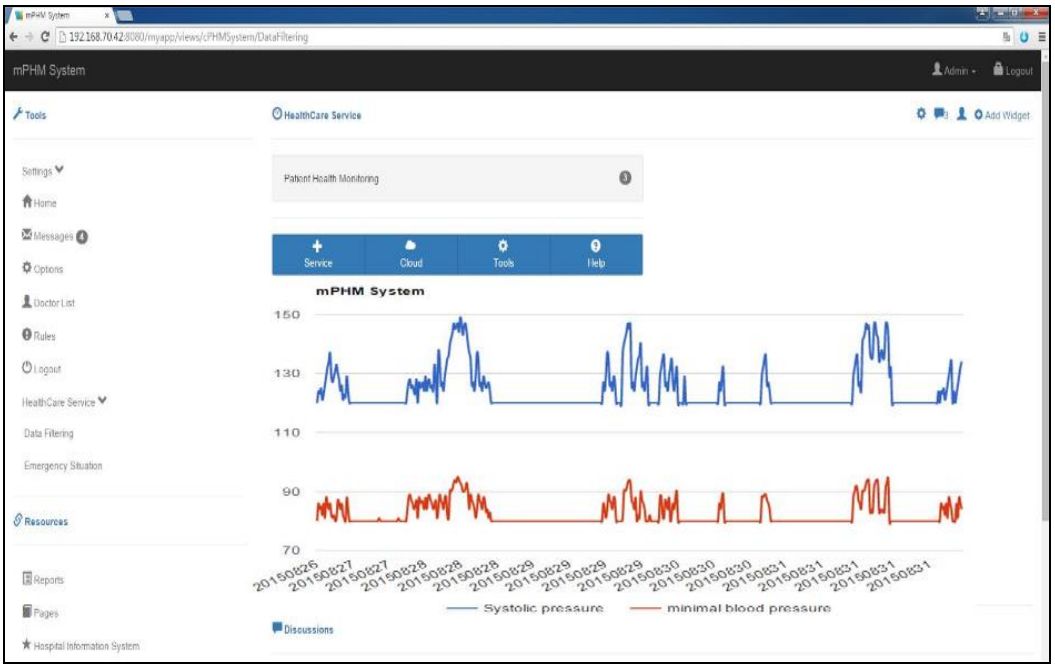

Figure 5. Filtered Body Sensor Data Input

The body sensor data acquired by the mobile device of the subject of observation are transferred to mPHM System according to the IEEE 11073 standard type. HL7, the medical information standard, should be observed to transfer the body sensor data collected by mPHM System to the medical information system. Accordingly, the process to transform the filtering completed body sensor data through the Data Conversion module is performed.

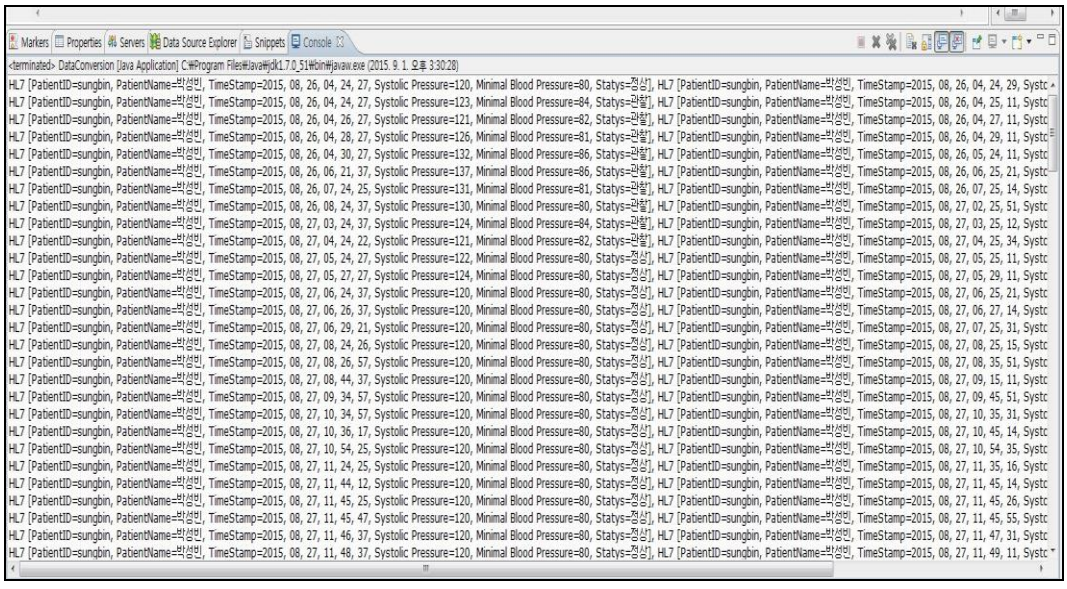

Figure 6. Body Sensor Data that has been Converted into HL7 Format

In general, evaluation according to the search results reinforced search conditions than image search and caused decrease of search results, but when including the corresponding words occurring in simple keywords, the problem of the subject of search was rather solved. Then, since multi-media ontology provision for search offers information on corresponding keywords to the user, it has a merit to transfer not simple search but knowledge.

5. Conclusion

This paper suggested XMDR-DAI-based MCBS to collect, filter, convert, and integrate body sensor data in mobile cloud environment to provide patients more fundamental prevention of disease, improvement of health conditions, and convenience. Moreover, the data collision occurred in the process of sharing personal medical information between medical organizations was solved by data integration service in application of XMDR-DAI, which was one of cloud technologies. In future studies, the data measured through several types of body sensor devices should be converged with patients' medical information to analyze the patients' conditions and predict emergency, and the predicted emergency should be immediately noticed to the hospital information systems and doctors.

Acknowledgments

This article is a revised and expanded version of a paper entitled "Mobile Cloud Hospital Information System based on XMDR-DAI" presented at The 5th International Conference on Information Technology and Computer Science (ITCS 2016) held on July 5-8, 2016 at The Mercure Bali Harvestland Kuta Hotel, Bali, Indonesia.

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