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Improving Chronic Disease Management with Mobile Health Platform

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***Abstract*—In modern society, aging and chronic disease is becoming common phenomenon due to the increasing numbers of elderly patients. To best treat this growing segment of the population, medical care should be based on constant vital sign monitoring. In this study, we propose a mobile vital sign measurement and data collection system for chronic disease management. . And we implemented a middle ware using Multi-Agent platform in SOS (Self-Organizing System) platform that transmits patient clinical data for services. We also implemented a HL7 messaging interface for interoperability of clinical data exchange. We propose health services on a self-organized software platform.**

I. Introduction

In modern society, the numbers of people who have bad eating habits and do little physical activities are increasing. These people have been experiencing lifestyle-related diseases. Also, the numbers of elderly people with chronic diseases are growing as well. Despite the development of medical technology, successful treatment rates of chronic disease are significantly low. The failure of the management of chronic disease causes complicated problems that lower the quality of life, increase the economic burden, and create social problems.

Most chronic diseases can be cured by active self-management based on a doctor's guiding advice. When we can take a more active services from healthcare providers for long-term management of chronic diseases, it would be possible to maximize therapeutic effects. In order to do that, a patient's biological signals must be measured at all times and instantly transmitted to medical staffs. [1]

To implement this type of comprehensive patient monitoring system would be a joint effort between information intermediaries and public healthcare providers. They would have to work together to provide equipment and home facilities. The raw bio-metric data from the patient must be identified and filtered before being sent to the healthcare providers. We can easily gather patient information from personal devices. The problem occurs when many people use the same equipment. It is hard to identify specific patient's data among the huge flow of data coming from the equipment.

We should estimate the quality of data collected outside the hospital. Some devices do not create data that conforms to international medical standards, and so medical staffs cannot take full advantage of it. In that case, medical staffs find it difficult to give feedback to the patient.

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And we need to consolidate the patient information across the numerous systems in health organizations. Each clinical data stored in systems have different format and are stored using local terms. In this situation, clinical data exchange across healthcare providers is meaningless [2]. To solve these problems, we comply with the standards. Health Level 7 is ANSI-accredited standards developing organization dedicated to providing a comprehensive framework and related standards for the exchange, integration, sharing, and retrieval of electronic health information. HL7 Version 2.5 Message and CDA (Clinical Document Architecture) – Release 2 are also ISO standards. [3] Accordingly, we are required to comply with HL7/ISO standards for interoperability of clinical data exchange.

In this study, we propose a mobile chronic disease management system using a self-organized software platform (SOSp) and implementing international standards to ensure the interoperability of comprehensive and convenient health information. We implemented the interface to transmit HL7 Version 2.5 Messages for interoperability of clinical data exchange.

II. Backgrounds

Development of a SOSp is a national project at Kyungpook National University in South Korea. This project goal is specifically to develop a SOSp that connects disparate health monitoring devices. Also it aims to support consumer empowerment services based on SOSp. The SOSp concept is shown below Fig.1.

Figure 1. Concept of self-organized software platform

SOSp has three essential features, which are named Opportunistic Computing, Context-awareness, and Self-Organized Swarm Intelligence.

SOSp clients attempt to connect to other devices within a reachable distance. This also makes it possible for a device to capture both a user's biometric and information on the surrounding environment. [4]

SOS Router of SOS Platform needs a middleware to manage SOS Clients around itself and interact with SOS Service. Standardized messaging in clinical data transmitted from SOS Client is required for interoperability of clinical data exchange. JADE (Java Agent Development Framework)[5, 6] is a framework that programmers can implement software agents without studying to study the related standards specifications in great detail. We implemented a middleware using JADE framework for managing SOS Clients and SOS Services. We also implemented a HL7 Messaging Interface of clinical data transmitted from SOS Client.

III. Self-Organized Software Platform-based Mobile Chronic Disease Management

A. Existing chronic disease management U-Health System

Existing chronic disease management U-Health Systems need patient authentication before collecting a patient's vital sign. (Fig. 2) This is a very cumbersome process and the cause of confusion in an environment that uses a lot of patient authentication. Also if the patients can't be identified, the measured data does not get transferred to the medical staffs, which makes diagnosis more difficult. This will lower healthcare service quality. [7].

B. Mobile Chronic Disease Management Architecture based on Self-Organized Software Platform

Unlike existing U-health systems, the SOSp client authenticates for the patient automatically, reducing hassles. The authentication is performed by comparison with patient's SOSp Client ID and registered ID on the server. All the measured data is recorded on the server. This means that medical staffs always have the necessary data for diagnosis, which means that they can provide higher quality healthcare services. [8] Many vital sign measurement devices do not observe international standards for medical data in many cases, and also often do not include patient information.

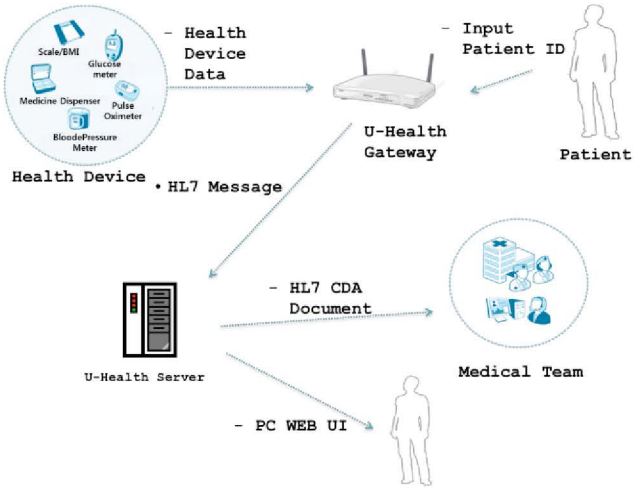

Figure 2. Existing chronic disease management U-Health system

This hampers the interoperability of devices. We designed the necessary structure to transform patient information and vital signs into the HL7 V2.5 international standard message format in order to maximize interoperability. [3, 9, 10, 11]The data that are gathered by devices are transmitted to the SOSp client and integrated with the rest of the patient's information. Then it is transmitted to the SOSp router. If there is no SOSp router or SOSp client that is connected with SOSp router, the measurement information is stored until one can be found using the self-organizing network. (Fig. 3) [12]

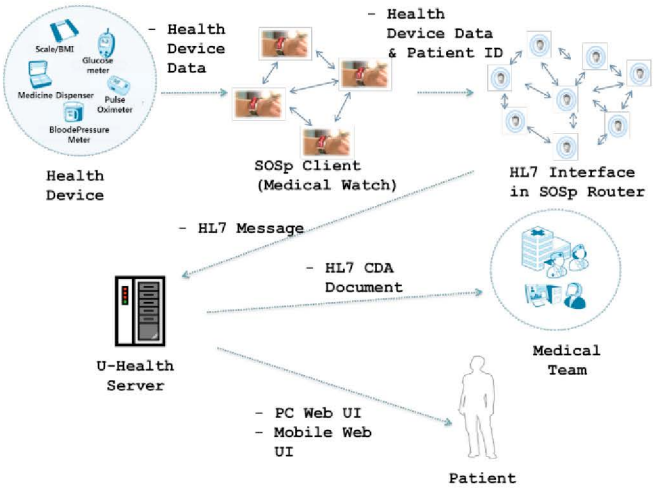

Figure 3. SOSp-based mobile chronic disease management

SOSp router receives integrated data from SOSp client. SOS Router generates a HL7 Message of the clinical data and sends it to Healthcare Service center. (Fig. 3) In this study, we implement a middleware of SOS Platform using JADE framework. SOS Client transmits recoded clinical data to HL7 Interface of SOS Router. HL7 Interface creates a HL7 Version 2.5 Message containing the clinical data and transmits the HL7 Message to the SOS Service agent that offers a service SOS Client requires. SOS Service uses the information parsed by HL7 agent and provides a service

JADE provides JADE management GUI. (Fig. 4) DF agent to provide the Yellow pages service is active when the main container is launched. JADE framework offers API for registration to DF agent. So, we register the service easily when we have implemented the middleware in JADE framework. From now on, various Service will be registered in SOS platform. Using JADE framework for implementation of mid-dewier, we can register and manage the services easily. Accordingly, SOS platform has high scalability

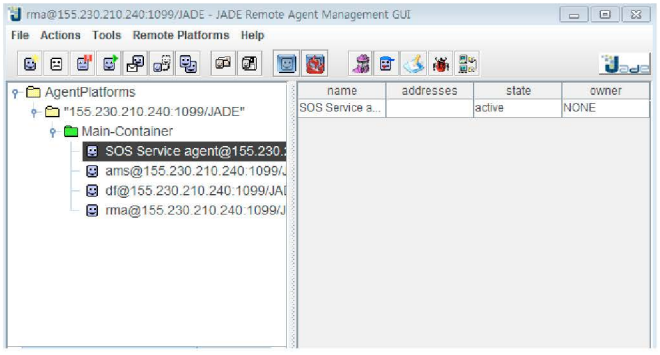

Figure 4. The JADE management GUI of JADE framework

There is a sample of HL7 Version 2.5 Message that HL7 Interface transmitted to HL7 agent of SOS Service (Fig. 5). It contains Diastolic blood pressure data of the person whose Id

is SEC003. SOS Interface of the SOS Router creates and transmits HL7 Message that includes clinical data transmitted by SOS Client. We implemented ORU_R01 message of HL7 Version 2.5 Message and transmitted a message to an agent that processes HL7 Message. So, SOS platform ensures interoperability of clinical data exchange. Now, lots of healthcare providers can't process the HL7 standards. They have to modify legacy systems. But they don't want to do it. If they use the HL7 Interface, we will be able to exchange clinical data by modifying less part of legacy systems.

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MSH|^~₩₩&|HL7 Interface||HL7 Agent||201205111017||ORU^R01^ORU_R01|111|P|2.5|||NE|AL
PID|||SEC003^^^SOS Platform^PI||^^^^^^U
OBR|1||111^HL7 Agent|34566-0^Vital signs panel ^LN|||201205111100
OBX|1|NM|8462-4^Diastolic blood pressure^LN||90|mm(hg)|||||R
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Figure 5. This sample message contains Diastolic blood pressure data of the person whose Id is SEC003. Cooperating with health device, SOS Client (Medical Watch) sends a clinical data. This sample is based on the clinical data and generated by HL7 Interface of SOS Router

The SOSp server extracts the medical data from the HL7 V2.5 message. The server compares the extracted data with the stored data. They must match with patient ID and other data before being committed, to make sure that the data is something that the medical staffs can use.

Data stored on the server must be available through the Internet. Patient's data which are measured by medical equipments can be utilized by making access using smartphones and personal computers. Medical workers will check the document that matches up with the HL7 Clinical Document Architecture to monitor a patient.

In order for SOSp to combine chronic disease management, hospital and personal health management, several changes must occur.

C. *Improved Prescription and Payment Service based on SOSp*

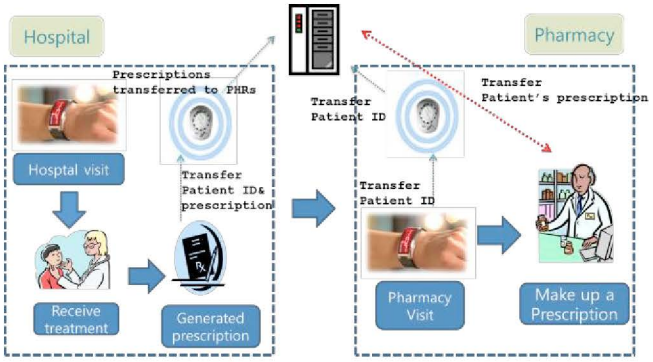

Figure 6. SOSp-based improved prescription and payment services

When patients visit a hospital, they normally take care in the order in which they arrived. Even if patients have an appointment, they often wait for some long time before getting treated. After they receive a medical examination, patients must pay the bill and often receive a prescription. Patients must often go to the pharmacy in order to pick up the medication that they need, which requires further payment.

This procedure can be greatly simplified with SOSp. If the patient has a SOSp client, they would not have to wait to register for treatment. Medical treatment can automatically be scheduled. Their on-file billing information can be used to automatically take care of payment for the treatment and the medication both. The only thing a patient would have to do is to move to the hospital reception desk and then the pharmacy. When the patient enters into the pharmacy, their identifying information can be transferred to a server. The pharmacist can receive all the information he/she requires and help the patient immediately. (Fig. 6).

D. *Chronic Disease Management Mobile Services based on SOSp*

Vital signs and user activities can be measured and recorded in a SOSp environment. If a patient exercises, SOSp client can collect data about the exercising user like current temperature, amount of time, heart rate, and blood pressure. Based on the collected data, patients will be able to receive high-quality feedback from the SOSp client and excellent advice from health professionals [4].

Even if you don't have a router, you can build a SOSp environment with a wireless Internet device and a SOSp router dongle. Just by installing the routing software from the dongle (Fig. 7), you can establish a low-cost SOSp environment, and the leverage of the total network will be increased. [1, 4]

Personal users can build a SOSp environment using a SOSp dongle. Patients who visit health care services can record vital signs information with the SOSp Smartphone environment. This service can be applied to both inpatient and circumstances.

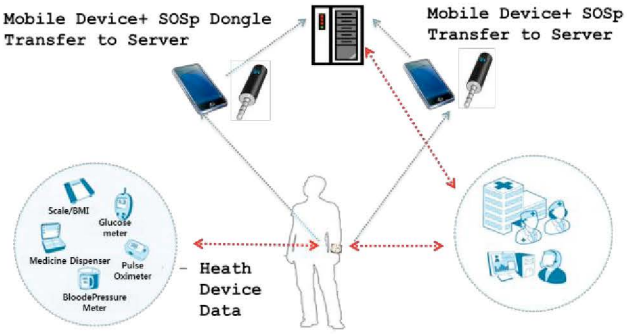

Figure 7. Chronic disease management Services With Mobile SOSp

IV. EVALUATION OF MOBILE CHRONIC DISEASE MANAGEMENT ARCHITECTURE BASED ON SELF-ORGANIZED SOFTWARE PLATFORM

In USA, Meaningful use is widely used to evaluate Electronic Health Record (EHR) systems service quality. Meaningful use is for Eligible Professional (EP) and Eligible Hospital (EH). Both EP and EH are broken down to two distinct groups for determining the Meaningful use Stage 2 compliance: a core set of objectives and a menu set.

From the core set of objectives, 6 requirements were selected. In Table 1, we compare four MH architectures by assigning a score ranging from 1 (poor) to 3 (good), for each evaluation criterion.

TABLE I. EVALUATION RESULT BY MEANINGFUL USE STAGE 2 REQUIREMENTS

Meaningful Use Stage 2 Requirements \ Mobile Health Architectures	IHE MHD	Mobile EMR	Medical App	SOMHP

Summary of care record	3	3	2	3
Demographics	2	3	2	3
Provide patients the ability to view online, download, and transmit information about a hospital admission	1	2	3	3
Provide patient-specific education resources	1	2	2	3
Capability to submit electronic reportable lab results to public health agencies	3	1	1	1
Protect electronic health information created or maintained by the CEHRT(Certified Electronic Health Record Technology)	3	3	3	3
Imaging results consisting of the image itself and any explanation or other accompanying information are accessible through CEHRT	2	2	2	2
Generate and transmit permissible discharge prescriptions electronically	1	3	2	3
Total score	16	19	17	21

The integrating the Healthcare Enterprise (IHE) Mobile access and Health Documents (MHD) is the architecture for the mobile device to access to Cross Enterprise Document Sharing (XDS). The IHE MHD is useful for sharing the health information that is exchanged in the type of documents. The Mobile EMR is the architecture that EMR system in a hospital can be accessed by mobile devices. Between a mobile device and EMR system, there should be a gateway to serve as a interconnector. The Mobile EMR is useful for the clinicians to view the clinical information retrieved from EMR system and make a decision anytime and anywhere in their hospital. The Mobile Medical App is the architecture that mobile devices can be used as an accessory to a regulated medical device or a transformation of a mobile device into a regulated medical device. The Mobile Medical App is useful for displaying, storing, analyzing, or transmitting patient-specific medical device data.[13]

The platform, SOMHP, which we are suggesting in this paper, is an advanced type that integrated Ubiquitous Health Care system for chronic disease management [1] with SOSp.

SOMHP is not only supporting a convenient authentication process of SOSp, but also providing a way to collect and manage patient's health data of uHealth system. Therefore, SOMHP provides mostly of six requirements in the Table 1.

V. Conclusion

In this study, we designed a mobile SOSp-based chronic disease management architecture based on the existing chronic disease U-health system. In particular, the approach was to improve on limitations of the current U-health system.

In the existing U-health system, users must authenticate before measuring vital signs, and that bothers patients seriously. But if they don't go through authentication process, the measurement data cannot be used. This problem is solved by the SOSp. Also, the data can be accessed by mobile web UI services, which greatly improves the ability to utilize information.

In the past, a patient's biometric information was limited due to security problems, and there was a lot of difficulty in providing medical guidance. However, in this new SOSp, communication among devices, medical professionals, and patients can be greatly speed up to give more accurate and comfortable treatment of chronic diseases.

The SOSp client is always aware of its environment and the person it is monitoring. The doctor is always able to recognize the current status and location of the patient, and the healthcare provider can always respond appropriately in emergency situations. There are still many requirements to create a functional SOSp situation. In the future, though, the necessary infrastructure will be constructed, such as chronic disease management services, mobile SOSp services that can be used in this situation, and other medical services can be adjusted to account for SOSp abilities. The health community should be fully prepared for this type platform.

We evaluated Mobile Health Reference Architectures based on Meaningful use stage2 criteria. In further research, evaluation should be done by renowned scholars all around the globe to produce trustworthy outcome.

Acknowledgment

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