Self-Organized Software Platform (SOSp)-based Mobile Chronic Disease Management With Agent-based HL7 Interface

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Abstract

In modern society, aging and chronic disease is becoming common 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.

Keywords: *HL7, CDA,U-Health, Self-organization, Chronic Disease, Mobile Vital Signs, Context-aware, Opportunistic Computing, interoperability, Multi-Agent Systems, JADE*

1. Introduction

In modern society there are increasing lots of people with bad eating habits who do little physical activities. These people have been experiencing lifestyle-related diseases. Also, 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 creates 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 comes from users with many devices at the same time, and the huge flow of information that would represent.

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.

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.

2. Backgrounds

2.1. Health Level 7 (HL7)

Health Level Seven (HL7) International is the global authority on standards for interoperability of health information technology with members in over 55 countries. HL7 Vision is to create the best and most widely used standards in healthcare.

HL7 provides standards for interoperability that improve care delivery, optimize workflow, reduce ambiguity and enhance knowledge transfer among all of our stake-holders, including healthcare providers, government agencies, the vendor community, fellow SDOs and patients. In all of our processes we exhibit timeliness, scientific rigor and technical expertise without compromising transparency, accountability, practicality, or our willingness to put the needs of our stakeholders first.

2.2. Self-Organization

Self-organization is a process in which structure and functionality (pattern) at the global level of a system emerge solely from numerous interactions among the lower-level components of a system without any external or centralized control. The system's components interact in a local context either by means of direct communication of environmental observations without reference to the global pattern [4].

2.3. Self-Organized Software Platform

Development of a SOSp is a national project at Kyungpook National University in South Korea. This project goal is specifically to develope 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 Figure 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, 5].

SOS Client communicates with SOS Router for requesting a service. SOS Router recognizing the location and status of SOS Client searches for SOS Service and requests the service. SOS Service offers the service that SOS Client needs (Figure 2).

SOS Router of SOS Platform needs a middleware to manage SOS Clients around itself and interact with SOS Service. Furthermore, standardized messaging in clinical data transmitted from SOS Client is required for interoperability of clinical data exchange. JADE (Java Agent Development Framework) is a frameworks that programmers can implement software agents without having 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.

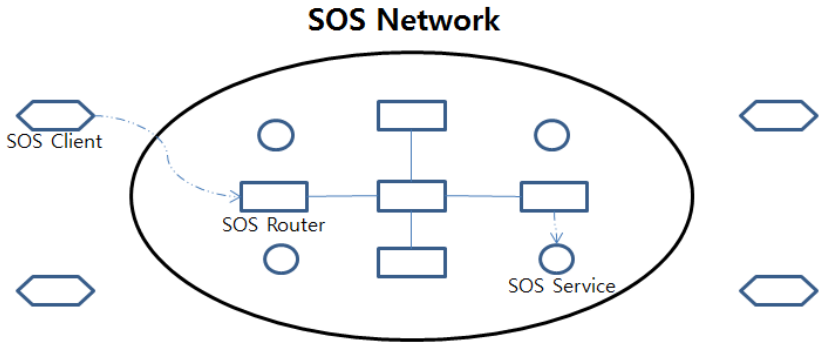

Figure 2. The Architecture of SOS Platform

In this study we use devices that can measure vital signs and also perform as part of a SOSp, in order to carry out effective chronic disease management.

2.4. JADE (Java Agent Development Framework)

JADE (Java Agent Development Framework) is framework to develop multi-agent systems in compliance with the FIPA (the Foundation for Intelligent Physical Agents) specification [6]. FIPA specifications represent a collection of standards which are intended to promote the interoperation of heterogeneous agents and the services [7].

JADE have a Container that is each running instance of the JADE runtime environment (Figure 2). It can contain several agents. And the set of active containers is called a Platform. A single special must always be active in a platform. In Platform, first container must be a main container while all other containers must be normal containers. A main container has two special agents that automatically started. AMS (Agent Management System), one of the two special agents, provide naming service that ensures that each agent in the platform has a unique name) and represent the authority in the platform. And DF (Directory Facilitator) provides a Yellow Pages service by means of which an agent can find agents providing the service [6].

In this study, we implemented a middleware of SOS Router using JADE. We registered a SOS Service agent in middleware of SOS Router. SOS Client transmits clinical data recoded by well-being devices to SOS Router, and HL7 Interface of SOS Router converts clinical data into HL7 Message and transmits to SOS Service agent. SOS Service agent parses HL7 Message and SOS Service provides service for SOS Client.

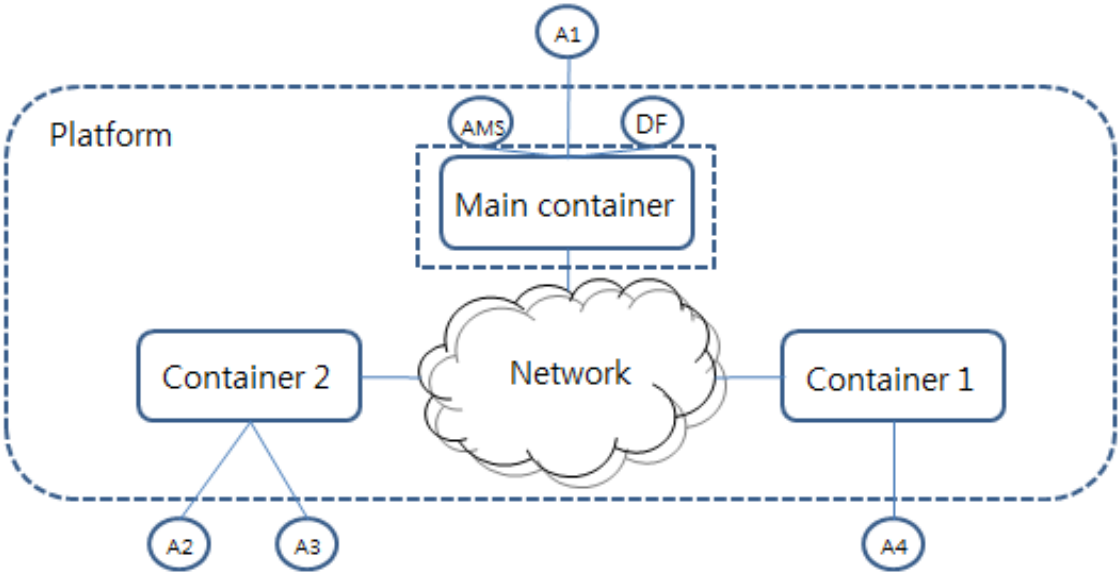

Figure 3. The Structure of JADE Framework

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

3.1. Existing Chronic Disease Management U-Health System

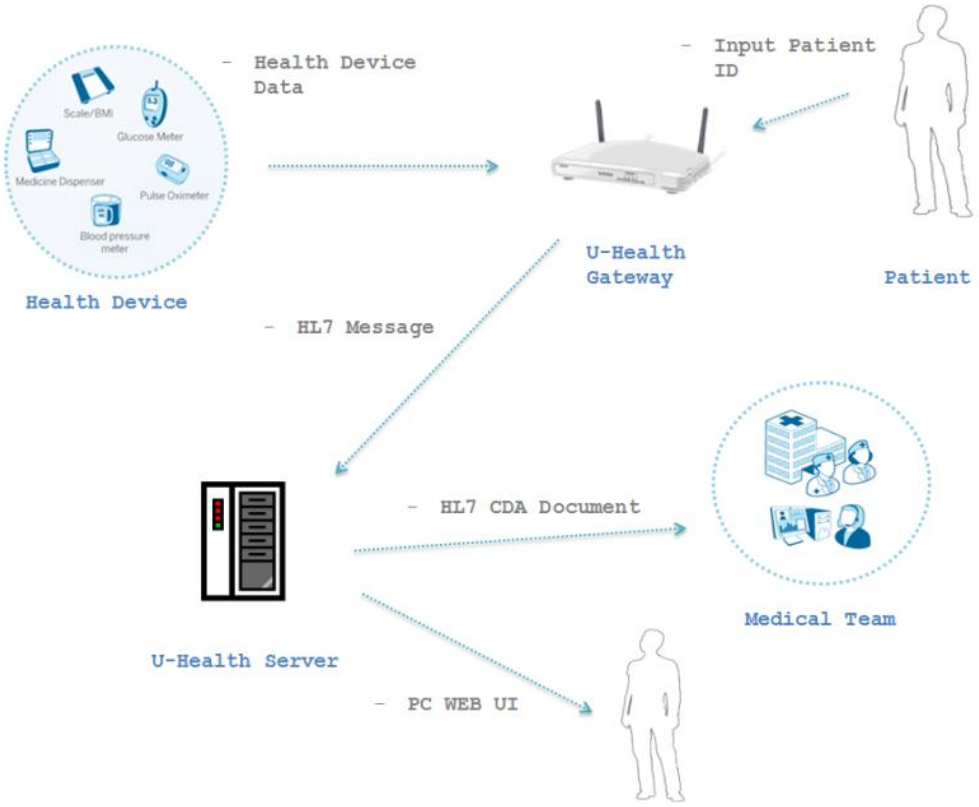

Figure 4. Existing Chronic Disease Management U-Health System

Existing chronic disease management U-Health Systems need patient authentication before collecting a patient's vital sign. (Figure 4) This is a very cumbersome and the cause of confusion in an environment that uses a lot of patient authentication. Also if the patient don't be authenticated, the measured data does not get transferred to the medical staffs, which makes diagnosis more difficult. This will lower healthcare service quality. [10]

3.2. 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. 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

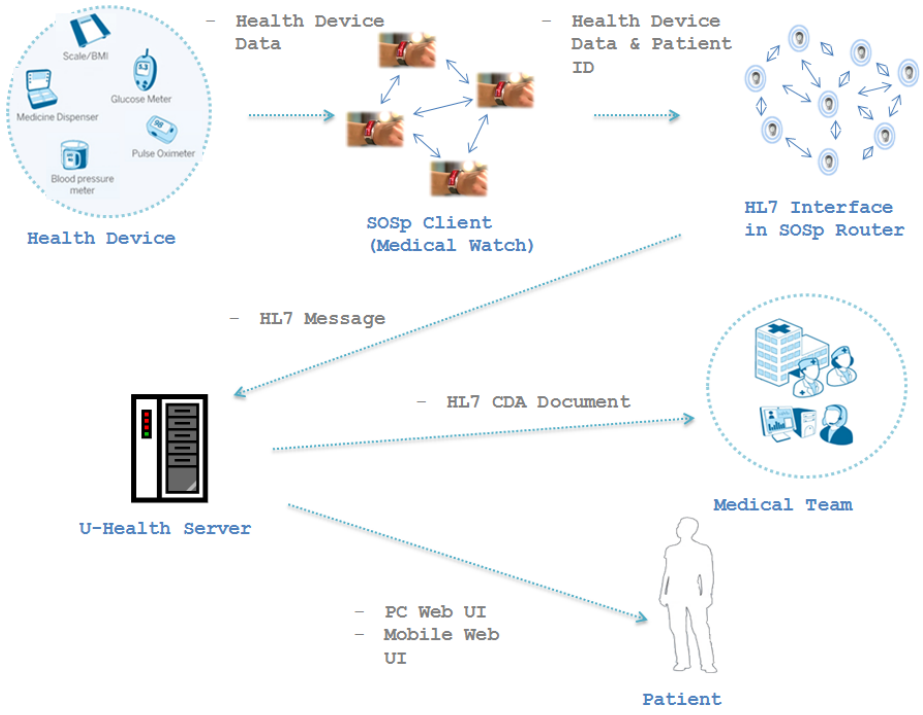

Figure 5. SOSp-based Mobile Chronic Disease Management

3.3 SOSp-based Mobile Chronic Disease Management Structure

3.3.1. Measuring Vital Signs with SOSp Client: Many vital sign measurement devices do not observe international standards for medical data in many cases, and also often do not include patient information. 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, 8, 9, 10].

The data that is captured through devices is 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 (Figure 5).

3.3.2. HL7 Interface in SOSp Router: 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 (Figure 5).

In this study, we implement a middleware of SOS Platform using JADE framework (Figure 6). 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.

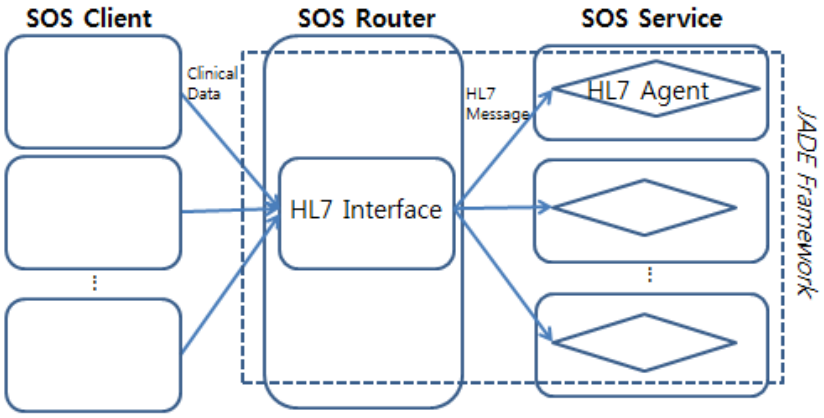

Figure 6. The Structure of SOS Platform using JADE Framework

JADE provides JADE management GUI (Figure 7). 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

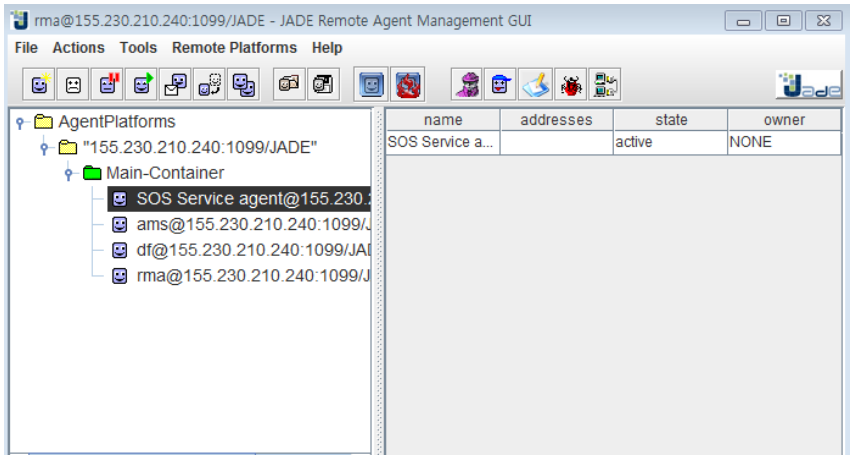

Figure 7. The JADE Management GUI of JADE Framework

There is a sample of HL7 Version 2.5 Message that HL7 Interface transmitted to HL7 agent of SOS Service (Figure 8). It contains Diastolic blood pressure data of the person whose Id is SEC003. SOS Interface of the SOS Router created and transmitted 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 8. 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 based on it was generated by HL7 Interface of SOS Router.

3.3.3. U-Health Message Server: 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 [3].

3.3.4. Use of U-Health Data: Data stored on the server must be available through the Internet. Confirmation that patient records have been measured at any time and general access is possible using a PC or Smartphone. Medical workers will check the document that matches up with the HL7 Clinical Document Architecture to monitor a patient [3].

4. Other Medical Services with Self-Organized Software Platform

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

4.1. SOSp-based Improved Prescription and Payment Services

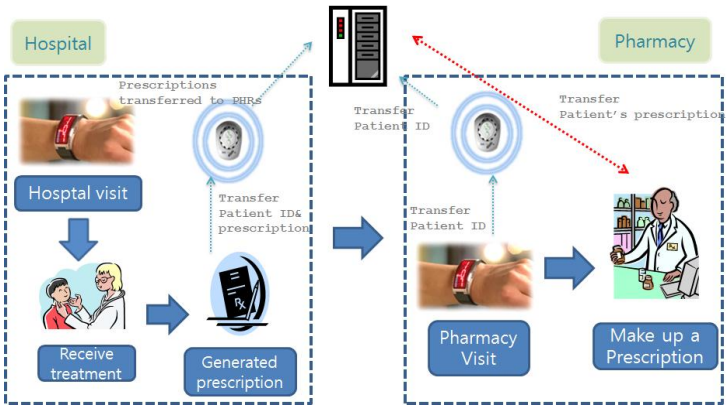

Figure 9. SOSp-based Improved Prescription and Payment Services

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 (Figure 9).

4.2. SOSp-based Chronic Disease Management Services

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, exercise time, heart rate, and blood pressure (Figure 10). Based on the data collected, patients will be able to receive high-quality feedback from the SOSp client and excellent advice from health professionals [5].

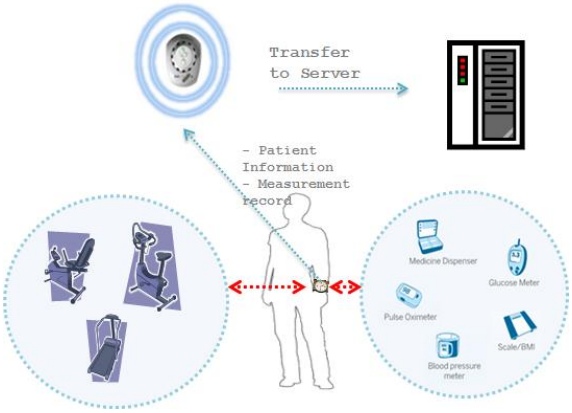

Figure 10. Chronic Disease Management Related Directly with the SOSp Service

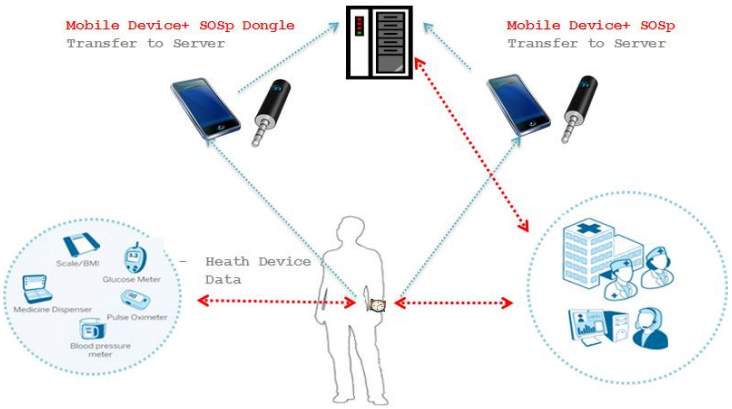

Figure 11. A Diagram of the Envisioned Chronic Disease Management Service with a SOSp Client

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 (Figure 11), you can establish a low-cost SOSp environment, and the leverage of the total network will be increased [1, 5].

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

5. 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 be authenticated, 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.

SOSp combines existing systems. It connects local devices and the natural environment. It is context-aware, fully decentralized, and autonomous. It consists of three elements, Opportunistic Computing, Context-awareness, and Self-Organized Swarm Intelligence. This technology provides an autonomous community software platform combining existing systems, which makes a big difference.

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.

JADE is a framework to develop the multi-agent system. JADE is able to communicate between agents and to offer and receive the service that an agent wants. So, JADE is adequate to apply to middle ware of SOS platform. HL7 Interface implemented in an agent is able to process HL7 Messages of clinical data. As a result of, SOS Platform ensures the interoperability of clinical data exchange. Even if healthcare providers do not process HL7 Messages, they can process HL7 Messages without large modification.

SOSp is a fully-decentralized and autonomous community that can preserve and transmit data without any losses. Based on the data thus obtained, accurate treatment of chronic diseases can be done, and patients can live longer.

It is still not fully implemented yet, because 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.

Acknowledgements

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