

Event-driven Open Service Platform Based Remote Healthcare System

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Abstract—A lot of remote healthcare systems have been applied to monitoring and manipulating vital signs for people with chronic disease living at home or inpatients living in hospital. Although useful, medical device are difficult to integrate and use. This paper outlines an approach to make use of international standard and open service platform to decrease the barrier and use easily. The approach was implemented in the event-driven, auto-configuration network management system. In the system, the open service gateway has the Broadband forum CWMP TR-069 CPE functionality and ISO/IEEE 11073 manager functionality to monitor health status of people and operation state of OSGi service gateway.

Keywords – Healthcare, CWMP, ISO/IEEE 11073, OSGi

I. INTRODUCTION

Because the network is blooming at this new age after 1990, there are many systems or applications would be support and made use of Internet Communication Technology (ICT), such as, the Global Position System, car entertainment application, and so on. The E-healthcare application is also need to be developed by Internet Communication Technology, because the expenditure of chronic disease medication grow up every year and dominate over 50 percentage of total medical expose. Additionally, there are not enough hospitals and medical staffs to support the elder grow up speed requirement. Therefore, each government has to make use of ICT to solve the shortage of professional staffs and bring the remote E-healthcare system [1, 2] from hospital or medical institution to home. In smart home, there are many medicine management systems [3, 4] which were implemented and assist the elderly and persons with special requirements. Because there are many benefits of OSGi, a lot of systems [5, 6] use OSGi as a core technology to provide healthcare services. Make people can help themselves from those health systems. Those health systems can monitor the health of people live at home and trace the health statue of the elders who are handicapped and not good at walk outdoor. It also can provide weight loss program and slim body suit for every different user. In the paper, the proposed system can accomplish our targets. The rest of this paper is organized as follows. Related works on the E-health transport protocol, open service gateway, and CPE WAN management protocol are described in Section 2. A detailed view of our mechanism and architecture is given in Section 3. Section 4 includes the implementation and experiment of our proposed platform. Finally, this paper

concludes with Section 5.

II. RELATED WORK

Because there are a lot of different interfaces and communication protocols in thousand of hundred medical devices, most of medical staffs cannot know how to operate correctly, and it is a troublesome problem to integrate all devices in a healthcare system. Therefore, a lot of organizations or alliances were founded to make new specifications or make use of existing technology to achieve easy-use purpose. Like several wireless or wire solutions, they have been produced to meet real requirement. A few enterprises, such as ISO, IEEE, and CEN joins a work group and addresses the interoperability of medical devices called ISO/IEEE [7] 11073 in 2000.

Continua Health Alliance [8] is an organization build by Intel, and there are several different domain companies join it, such as medical institution and health care domain. More than 200 member companies around the world join it to establish personal health solutions. Continua Health Alliance makes use of ISO/IEEE 11073 as data communication protocol and Bluetooth as physical media and TCP/IP in a total solution.

Open Service Gateway initiative (OSGi) alliance [9] provides specifications, reference implementations, test suites and certification to develop a lot of systems. OSGi technology is a set of specifications that define a dynamic component system and developer can hide their implementations from other components while communicating through services, which are objects that are specifically shared between components.

Broadband forum [10] defines the CPE WAN management protocol (CWMP) for Auto-configuration and dynamic service provisioning, Software/firmware image management, Status and performance monitoring, Log file, and dynamic notification, Diagnostics. The CWMP can assist OSGi to manage platform, control bundle life cycle, manage bundle configuration, and handle event and logging.

III. ARCHITECTURE

At present, there are some continua health certified medical devices; however, it's not available on the market. Therefore, we select Stollmann [11] chip module as ISO/IEEE 11073 manager and agent hardware, and manufacture prototype 4 IN

1 device as medical device. Between ISO/IEEE 11073 manager and agent, they use Bluetooth as communication media and follow TCP/IP to transfer network packages. The ISO/IEEE 11073 agent will be encapsulated in Vital Sign Monitor (VSM) adaptor and communicate with medical device in RS232 serial transfer port. The main functionality of ISO/IEEE 11073 agent is to translate none ISO/IEEE 11073 format data to ISO/IEEE 11073 format data. The data flow between Health Management Server (HMS) and Telecare Service Gateway (TSG) is not compliant to any standard, but service provider can implement in a HL7 or any standard. Remote Management Server (RMS) talks to TSG with CWMP protocol on the internet. The proposed event-driven open source system means that the TSG can be event driven by RMS through CWMP protocol. Additionally, TSG and VSM adaptor communicates with ISO/IEEE P11073-10404/D10, ISO/IEEE P11073-10407/D07, ISO/IEEE P11073-10408/D04, ISO/IEEE P11073-10417/D08, and ISO/IEEE P11073-20601/D24. In Figure 1, it shows the architecture of the proposed system and every component of system including HMS, RMS, TSG, VSM adaptor, and medical device.

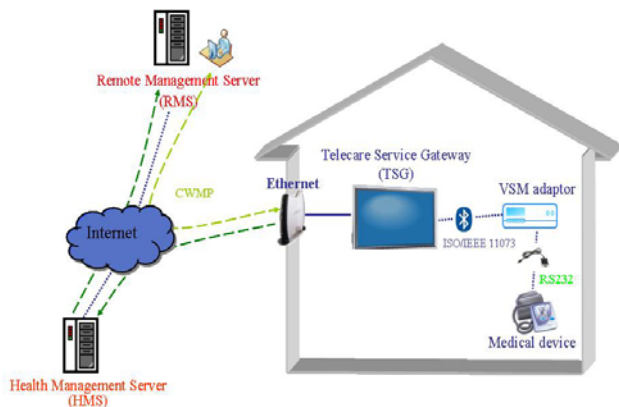


Figure 1: the architecture of the proposed system

TSG is a home-side gateway and plays a main key actor in the proposed system, it has compatibility to communicate with 4 IN 1 mixed medical device through ISO/IEEE 11073 protocol and make using of continua Bluetooth Health Device Protocol communication protocol. These two protocols contain manager and agent sides, and comprise an adaptor which is a bridge to transfer 4 IN 1 device vital sign data to compliant ISO/IEEE 11073 protocol and transfer data to ISO/IEEE 11073 manager resident TSG home gateway. Because the RS232 interface is commonly used in medical device in real world, there is a RS232 serial port interface in VSM adaptor. Additionally, VSM adaptor has to compliant to Continua standard and uses wireless Bluetooth communication network to talk to ISO/IEEE 11073 manager.

HMS is a data center that saves any data from TSG and applies event requests for asking for RMS to send events to TSG for event notification or emergent thing. TSG talks to HMS based on scenario requirement. TSG can also actively send those vital sign data to HMS immediately and get user

profile data from HMS periodically or passively. While HMS wants to ask for TSG to do something, it has to request RMS to send the event. However, there is one thing different from others which is emergent thing and must do immediately. TSG manipulates the task at the time immediately actively and waits the result back from HMS. If HMS could not receive communication request from TSG for specified task at a periodical time, it will request RMS to send the command again in order to avoid network loss. As shown in Figure 2, HMS issues a command to TSG through RMS while the command type is not belonged to emergent event. Therefore, the command will be executed by TSG until TSG CWMP period is coming.

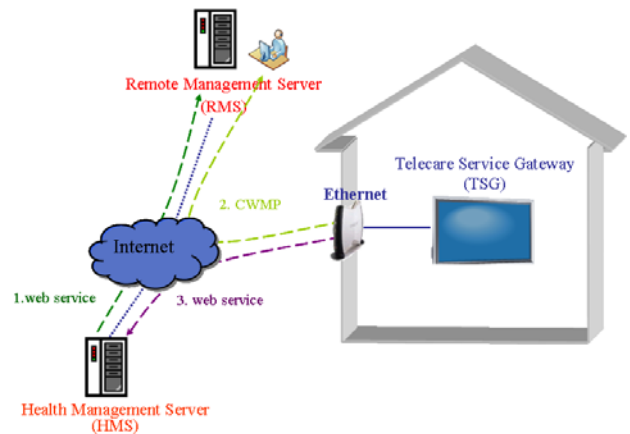


Figure 2: the event procedure between HMS and TSG

RMS is a management server and responsible for controlling and monitoring TSG status. Besides these two tasks, it also is a transfer station for HMS and provides a few web services to HMS for calling TSG to get data or upload log. RMS uses CWMP to communicate with TSG, and then they follow the specification of TR069. RMS always triggers TSG if it wants to tell something to TSG. TSG also can actively connect RMS for polling and ask what any thing to do. Apart from this, it gets all of properties of TSG for management, and sets all of writable parameters. In addition to those, RMS passively and actively receives the notification from TSG, and it is designed to handle millions of devices. It doesn't need to provide on-line side service because it knows almost every thing of TSG, automatically configuring, dynamically service provisioning TSG, and update TSG new software/firmware easily.

TSG exploits the benefit of open source platform which is easily controlled and monitored, and dynamically installs new applications and stops started applications. For example, there is only a blood pressure device for measurement; however, the doctor suggests that a patient has to measure blood glucose for getting more vital sign data to diagnose precisely. In this case, open source platform can easily remotely be installed the blood glucose bundle, and then started remotely for work normally.

Besides UI, there are a lot of functionalities in TSG and make user easily use and let system much rich. For example,

user can view the historic vital sign data, maintain user profile data, and inquiry the weather forecast. Log management is a key feature in our proposed system. The proposed system also considers the time calibration issue on medical device, while vital sign data with wrong timestamp are invalid and not for evaluation. While the 4 IN 1 medical device connecting to TSG through adaptor, it will be calibrated time with TSG system time. As for UI, it includes an operation light icon to express the TSG connection status to let user know the situation.

The none-standard ISO/IEEE 11073 4 IN 1 device has storage media for storing limited measurement data. Until the ISO/IEEE 11073 manager and agent communicate to each other, the stored data would be uploaded to TSG and HMS immediately at the same session.

IV. IMPLEMENT

TSG is implemented in OSGi gateway, it is based on Knoperfish OSGi [12] 2.2 version and there are several 3rd party library bundles and a few bundles which implemented based on system requirement installed on OSGi framework. The two main key bundles on TSG, one is TSG communication bundle, and the other is TSG UI bundle. TSG communication bundle implements all basic RPC call defined in CWMP specification for communicating with RMS and is responsible for uploading and downloading user data from HMS. Additionally, it has to set up and start ISO/IEEE 11073 manager implemented in C call with JNI technology. TSG UI bundle is responsible for GUI and data base object management. Even though soap envelopes, TSG UI bundle still help to encapsulate the soap body. While the ISO/IEEE 11073 manager receives data from the ISO/IEEE 11073 agent, the ISO/IEEE 11073 manager transfers data to TSG communication bundle, and then TSG communication bundle invoke TSG UI bundle to handle data base storage job. As shown in Figure 3, the TSG software stack includes Java Runtime Environment, OSGi framework, two main bundles, CWMP module, and ISO/IEEE 11073 module.

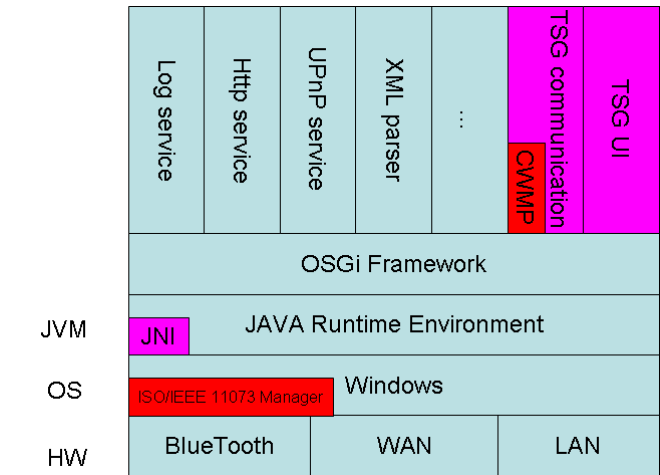


Figure 3: the TSG software stack

There are many events for TSG defined in the purposed system including error or success. Through these events, HMS knows the real status happened on TSG. In TABLE 1, there are all type events for TSG and TSG will send all events to HMS if HMS issues event request and event id is equal to 000000.

TABLE 1: EVENT FOR TSG

Number	Event id	Description
1	000000	All of events
2	013000~013499	Event Successfully
3	013511	Command is illegal
4	013512	Don't find the matched command
5	013513	Input parameter is not correct
6	013514	Other problems
7	013520	Error from HMS

HMS is a datacenter and set up on Windows server machine. There is an IIS web application server and a DB server on HMS –SQL server compliant to Windows product. It is a healthcare platform, and maintains all data uploaded from TSG. HMS cannot communicate with TSG while the network environment of TSG is not in public IP address domain or NAT setting. While TSG is in these critical environments, it must issue event to RMS through web service to communicate with TSG passively. Through this kind of mechanism, HMS gets any thing in TSG side. In TABLE 2, it shows all of web services provided by HMS and RMS can invoke them for different requirement.

RMS is management server and set up on Windows server

TABLE 2: WEB SERVICE FOR HMS

Number	Web service name	Description
1	addRegisteredTSG	Add a registered TSG
2	deleteRegisteredTSG	Delete a registered TSG
3	getTSGList	Get all TSG name list
4	getTSGConfig	Get configuration of the specified TSG
5	getTSGStatus	Get connection information of the specified TSG connect to RMS
6	getTSGLog	Ask for the specified TSG to upload the specified log to HMS
7	getUpdatedProgramHistory	Get the update software historic record of the specified TSG
8	getCommandStatus	Get all RPC command status of the specified TSG
9	pollHMS	Ask for the specified TSG to connect HMS
10	getTSGStatistic	Get the online time statistic of the specified TSG
11	getTSGCPEID	Get the CPE ID of the specified TSG

machine. However, it uses Apache Tomcat as web contain instead of IIS on HMS and MySQL as DB. It complies with CWMP Auto Configuration Server (ACS) standard to implement and add several user-specified RPC for scenario requirement. Because of following CWMP management protocol, TSG CPE must have a heartbeat mechanism to periodically poll RMS ACS. Because of that, HMS can make use RMS to transport command to TSG. There are many web service on RMS specified in TABLE II and provides HMS to invoke.

The proposed healthcare system considers secure issue at the same time, there are secure mechanisms used in it. Transport Layer Secure (TLS) is chosen in this system because of its popular encryption method and used wide in the web application.

In Figure 4, it shows the interoperability between TSG and commercial CWMP ACS is workable. The commercial product ACS is Prosyst [13] mPower Remote Management (mPRM). During system test, the commercial CWMP ACS can get parameter value, parameter attribute, and parameter list from TSG normally.

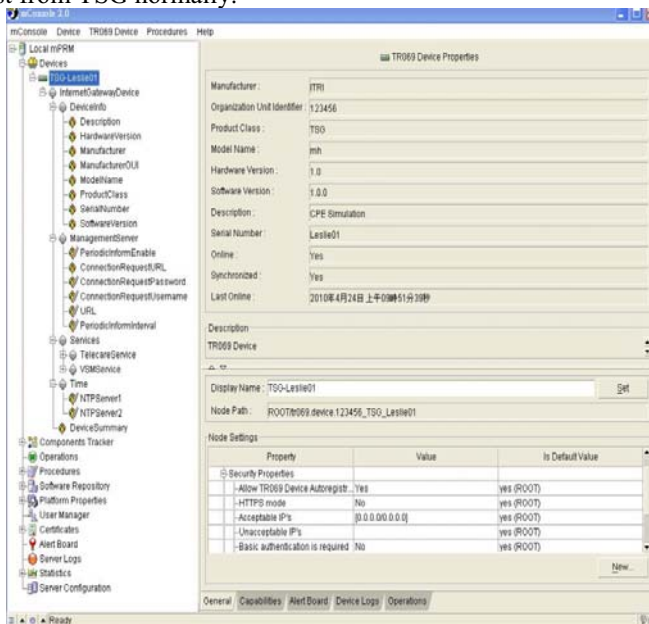


Figure 4: Interoperability of TSG

V. CONCLUSIONS

The proposed system can help user with chronic disease easily to measure vital sign data and conveniently figure out their historic record by themselves. In addition to health application, user can use all other useful functionalities in our system such as weather forecast report. Our system also can automatically make data transfer from one part to the other, and it completely follows international standards. It's interoperable with other systems implemented in the same specification; therefore it could be cost down and easily integer new functionalities.

Through event-driven CWMP mechanism, TSG don't always connect with HMS any more. Because of this remote

management mechanism, our system decreases much overhand of HMS and TSG. Making use of benefit of remote management, users don't need to apply for repair guys that come home for installing new service and repairing TSG. In remote side, the RMS server administrator controls every thing about TSG through CWMP.

Although there are many advantages and functionalities in our system, it is still not insufficient and robust. For example, non secure communication channel between TSG and RMS, non flexible database design in TSG and Bluetooth connection loss between VSM adaptor with TSG, we will keep going to make it stronger and much robust. With ISO/IEEE 11073 international specifications, it makes integration become easily and legacy medical devices become usefully in our proposed system.

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