Smart Personal Health Care Monitoring Services Design using UML

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Abstract*—Telecare systems are costly solution to treatment of patients with chronic diseases such as heart disease. The self health care monitoring system aim to be able to monitor the condition of the vital organs in patients continuously at home. The proposed system consists of a data acquisition module that uses a non-invasive wireless sensors, sensor gateway that serves to process data, store medical data to the server and sends a warning message the abnormal condition of the patients to the relevant parties, medical servers using cloud computing that feature electronic health records and web portals, and applications on mobile devices to display data the patient's condition. UML will be used to represent software development system in self-monitoring of health care.

Keywords— UML design, smart personal health care, mobile application

I. INTRODUCTION

Heart disease became one of the main causes of death. Based on the health map released by the World Health Organization (WHO) [1], heart disease and stroke has killed about 17 million people or one third leading cause of death each year worldwide . And is expected in 2020 , heart disease and stroke will become the main cause of mortality worldwide . While data from the Health Research by the Ministry of Health in 2007 [12] , shows that the main cause of death for all ages is stroke (15.4%) , hypertension (6.8%), ischemic heart disease (5.1%), and other heart diseases (4.6%). The death rate in the age group 45-54 years in urban areas by 15.9% due to stroke , heart disease and then by 8.7 % and systemic hypertension and other cardiovascular disease of 7.1 % . Meanwhile in the countryside , the highest death rate due to infectious diseases are tuberculosis (TB) followed by stroke by 11.5% and 9.2% of hypertension and ischemic heart disease 8.8%. Increased heart disease one caused by chance and the level of public accessibility to health services. According to data from the Ministry of Health Riskesdas in 2013 [13], the prevalence of coronary heart disease been diagnosed by a doctor in Indonesia of 0.5%, and based on a doctor's diagnosis or symptoms of 1.5%. While the prevalence of heart failure had been diagnosed by a doctor in Indonesia amounted to 0.13% and is based on a doctor's diagnosis or symptoms of 0.3%.

Health services to prevent heart disease are still constrained by the equipment used to inspect and monitor the patient's heart condition. This is because the ECG and its supporting equipment are only available in a hospital or clinic and can not be used to monitor the condition of cardiac patients undergoing outpatient services. As a result, patients who had heart attacks more often given treatment too late. Generally, the methods used to determine the health condition of the heart, through the check up is done by means of ECG which are in the hospital or clinic. With a short period of examination, it is very difficult to know when there will be life-threatening heart attack patients. Based on data reported from the results of the study, the period of heart attacks that harm could have occurred several times in the span of a week. Therefore, there is a need for devices or equipment and technology that will monitor the heart health condition continuously.[10]

The development of information and communication technology has increased the possibility to perform remote patient care (telecare). As mentioned in the literature, the first telecare service has been performed using the PSTN. Lee et al in their research has been using a cable television network for telecare applications in monitoring the patient's heart condition and sends its data to the data center[2]. Due to the increasing development and use of the Internet, the remote health care applications can possible be done over the internet by sending the patient physiological data.[2][19]

Moreover, information and communication technology has changed social interaction, lifestyle and work place. The use of ICT is also used to improve the care and health services. The paradigm of health care itself changed, originally based reactive response

to proactive. Characteristics of proactive maintenance are characterized by early detection of the symptoms of a disease, preventive measures (preventive) and the management of long-term health conditions.[20]

Also, the current trend places an emphasis on the monitoring of health conditions and management of wellness as significant contributors to individual healthcare. It is very important to implement a monitoring self healthcare system in Indonesia, because the limitation of health facilities and costly intensive healthcare. Mobile systems are currently being used to monitor, record and relay variety of health-related data applications, such as hypertension, blood oxygen levels, blood sugar, and disease-related condition, such as : diabetes and dialysis. Other health-related activities such as weight tracking, cardiovascular monitoring, and patient location tracking are also monitored using mobile health.[21]

Meanwhile, one important component of the application is monitoring sensors take charge of the data objects (patients) were observed. Sensor development helps to deliver data to be used in the next process. In this case, the previous methods using the cable as a transmission medium between the sensor nodes with sensor gateway for forwarding to other parts of the system. Implementation method of wireless communication (wireless communication) is applied to the sensor gateway, so that the application of the system becomes more flexible. As the trends of the average life expectancy, the decline of health-oriented are increasingly clear, people demand better health care system. As a result, realizations of a non-contact health monitoring system (NCHMS) become more vital and urgent. And the Internet of Things technology will be the best means of its implementation. The Internet of Things not only provides the health care system for aspects of technical support, but also will solve the core problems--collecting and processing the remote medical information. The system refers to an information system that can remotely monitor the user's physical condition and physiological parameters.[23]

Moreover, the ICT infrastructure needed to support massive data access management in a smart and scalable [24]. The medical applications of cloud-based computing will facilitate the further development dynamically. The use of cloud computing will reduce the cost of the initial investment to build the IT infrastructure in the health sector, because the financing scheme that can be carried out in accordance with the use of only (pay-as-you-go). It also will improve IT resource utilization and quality of health care services. [15]

Furthermore, the development of these systems, the Unified Modeling Language (UML) is used as a language for system modeling. Where UML is a standard specification language that is used to document and specifying software development. [22]

In this paper the proposed design for health care monitoring system which consists of a global system architecture and application design using UML. In the designed system, the monitoring will be conducted on heart rhythm, blood pressure and body temperature of the patient

II. RELATED WORK

This section briefly reviews previous research and development of various health monitoring systems has been carried out independently by several previous studies. The high cost of treatment in the hospital, demanding the use of IT technology to remotely monitor, analyze and provide treatment to patients with a physician or practitioner is guided by remote health [4]. Errors in providing treatment to patients is often due to an error factor and the difficulty of communication between patient and doctor. The use of mobile devices allow doctors and paramedics see patient data and can predict the actions that should be given [16].

Moreover, the mobile health or m-health is health care applications using wireless technologies such as cellular phones, which can be used on an individual who need health care[8]. The Mobile Health (mHealth) application can be summarized as follows: improve the efficiency, equity, service time (time service delivery), safety, comfort, and quality of decision-making techniques [3].

At first the sensors will captures the entire information of the object being monitored e.q heart rate, blood pressure and body temperature. Communication standard specifically for these sensors is discussed by a working team that produced the IEEE 802.15.6 standard that defines communication optimization on devices with low-power sensors and affixed or attached to the human body, and then interact with the data collector through a sensor gateway [11].

The use of sensors in this application must meet the requirements using low power derived from the battery. It is intended to ensure the safety and comfort of the patient, who was attached to the sensor body. These sensor using IP6LowPAN communication standard. The protocol can connecting the system to internet and storing data to the medical server [7][20]. Retrieval of data in real-time by the sensor will generate huge data and will not be stored on the sensor buffer storage. The data collected by the sensors will managed in several ways. The first, all of the data stored on the server for further processing. And the second, the data will be processed first by the sensor nodes and abnormal data after reaching threshold value will be transmitted the gateway. In this way the sensor nodes are usually equipped with a specific algorithm for measuring the patient's heart rhythm. Current research has not covered the whole algorithm which includes the full range of possibilities of the patient's heart rhythm [6][15].

Data collected on the server as a medical record can be used by stakeholders such as doctors, paramedics, family and patients. Service Oriented Architecture and cloud computing can be used service provider data for different platform applications[9]. Other studies using mobile device to display data visually in the form of heart rhythm graphically [21] [6]. In the same study, the mobile device is also used to provide 'allert' or a warning sound 'beep' with a loud sound so that people around know the emergency

experienced by the patient. The system 'allert' will active if there is a condition of the heart rhythm of patients who require treatment and the provision of treatment [6].

III. PROPOSED MODEL

A. *System Analyse and Self Healthcare Scenario*

The proposed system aims to improve the life expectancy in patients with chronic diseases and can live a normal and stable life. Cases used in this system were based on people with heart disease, in which they use the system to monitor the condition of his heart and made reference to preventive action. Global architecture will be proposed as shown in Figure 1. The system is divided into several sections, namely core sensor node, the sensor gateway, medical servers, and mobile applications.

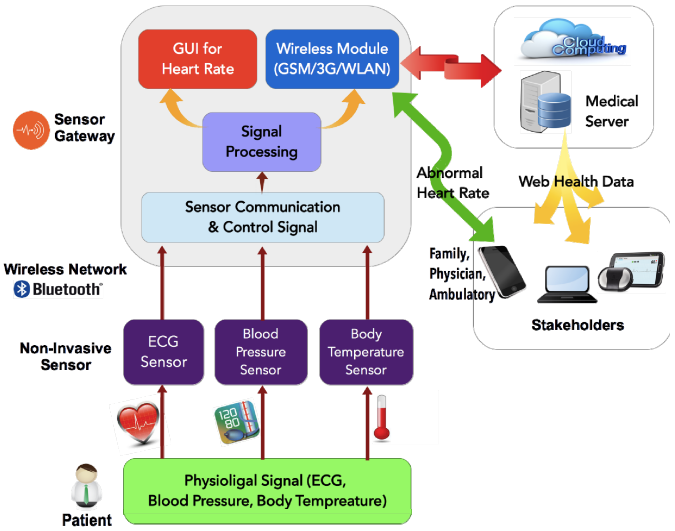

Fig. 1: Global architecture of Self Health Care Monitoring System

System usage scenarios that will be used, the patient's physiological data acquisition will be carried out by several non-invasive sensors. In this proposed research , will record the ECG , blood pressure and body temperature. Through wireless communication protocol, the data will be sent to the patient's condition sensor gateway. The sensor gateway will have three functions, first communicate with sensors and control nodes, and analyze the data signal coming from the sensor node, the second graphical user interface that displays the health condition of the patient who is being monitored; third communication with stakeholders and medical server. If the results of the data analysis in the first module showed the presence of an abnormal condition, then the third part will immediately send a warning message to the stakeholders. Giving a warning signal will be given based on the determination of the threshold value of the patient's medical condition. In Table 1 are shown in the plan that determines the difference in the level of urgency of providing a warning system and the purpose of the message recipient [17].

TABLE I. URGENCY LEVEL

Urgency Level	Strategy
- Normal	Saving data to medical server
- Urgent	Saving data to medical server, send message through SMS to family and pysician
- Critical	Saving data to medical server, send message through SMS to family, Pysician and Care Provider

B. *Design of System Software Using UML*

System software for this application analyze and design using UML. Global design with UML system consists of four modulesare node sensor module, sensor module gateways, modules and medical server monitoring application modules. First, sensor node module handles the data acquisition of 3 types of non-invasive sensors are ECG sensors, blood pressure and body temperature sensors sensor. Second, the sensor gateway module has four main functions to communicate with the sensor nodes and control signals, process and analyze the data, storing medical data to the server and sends the message to stakeholders, and provides a graphical display of the patient's heart rhythm condition. Third, medical server module using web service approach in storing the

data and provide health information. Medical server implemented using cloud-based services. Fourth, the monitoring application modules used by the stakeholders to know the patient's medical condition. Applications will be deployed on mobile devices such as smartphones and tablets.

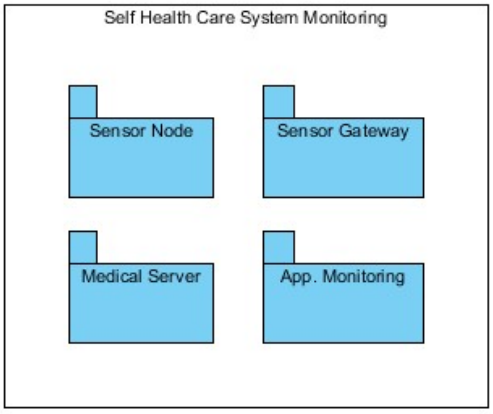

Fig. 2: Global UML

1) Data Aquisition

As seen in Figure 3, in this system the process of recording the patient's physiological signals using non-invasive sensors so it will not cause discomfort to the patient's body. Signal retrieval is done continuously and the data measurement will be stored temporarily in storage at the sensor. Sensor nodes which are used in this system, the sensors will be connected to the gateway and then sending the data that has been retrieved in real-time. The wireless connection is used to connect the sensor will provide flexibility to the patients monitored in their activities. Communication protocol used is Bluetooth with consideration of convenience and saving power in sensor that uses a battery. In the early stages of the connection, the sensor nodes will receive the request 'pairing' of the sensor nodes to avoid the connection of the unexpected.

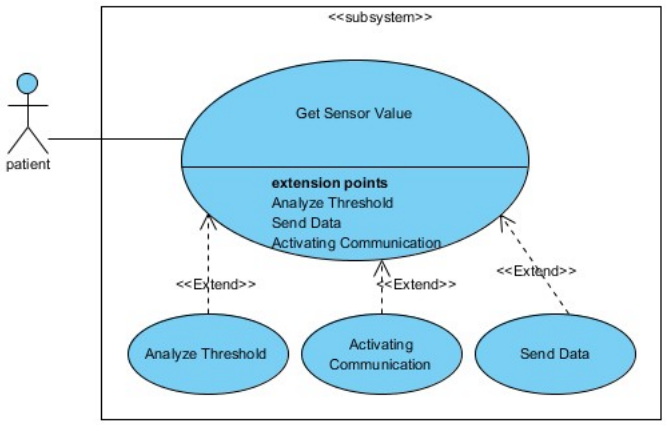

Fig . 3: Use Case Sensor Node

2) Sensor Gateway

As seen in Figure 4, the gateway sensors in this system is using smartphone devices. The selection of smartphones for completeness communication technology and operating system features that will facilitate the development of the system and its use by the user. The gateway sensor has the responsibility to:

a) Handles communication with the sensor node collecting patient physiological data. Bluetooth technology is used to connect the sensor to the sensor gateway node.
b) Analyze the data to determine the physiological condition of the patient's threshold value.

c) Generating a warning signal for the user
d) Sends warning messages to the various parties with reference to the urgency level of the table.
e) Provides a user interface that will display information the patient's physiological condition.
f) Transmit and store the physiological data of patients to medical server.

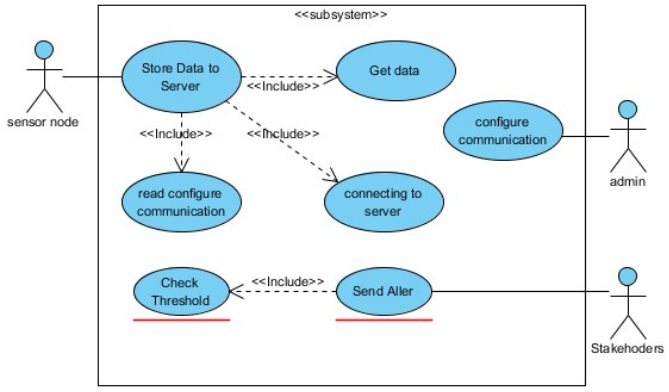

Fig. 4: Sensor Gateway

3) *Medical Server*

Patient data collected is stored on a server that is managed using cloud computing architectures. Cloud computing is chosen because it provides advantages such as cost savings on IT investments, savings on electricity payments, maintaining the availability of better data and data management for the development of the system [23]. In the medical server which will be made module Electronic Health Record (EHR), and a web portal for communication between patients with physician. In addition, all modules can be used as a web service for a variety of other health electronic client application. In figure 2, the medical server module using cloud computing architectures for handling data storage and presenting health information .

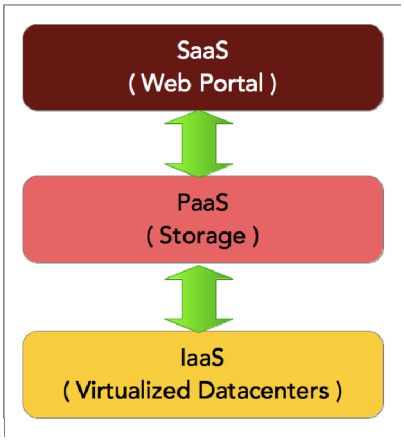

Fig 5: Cloud computing infrastructure

As seen in Figure 5, cloud computing architecture that will be used consists of three parts, namely Virtualized Datacenter, Storage and Web Portal. Web portal as SaaS has a function to represent the sensor data from the patient to view a web-based, such as ECG, blood pressure and body temperature. In this system the modules consists of first, the interceptor that will receive data in different types of data formats; second, the adapter that converts the data that has been extracted to the desired data format; third, the integrator that will integrates the EHR and Web Portal. Storage in the PaaS layer facilitates users to deploy applications on top of cloud infrastructure layer. Virtualized datacenter as IaaS models provide storage, computing resources and network resources as a service.

4) Monitoring application

As seen in Figure 6, the applications can be deploy on mobile devices such as smartphone and tablet. Each user access to the system must login using valid the userid and password. Users can search the data, look at the data and update the data appropriate with the authorization. Other parts of the application are warning system (alerts) that informs the patient's condition being monitored their health condition.

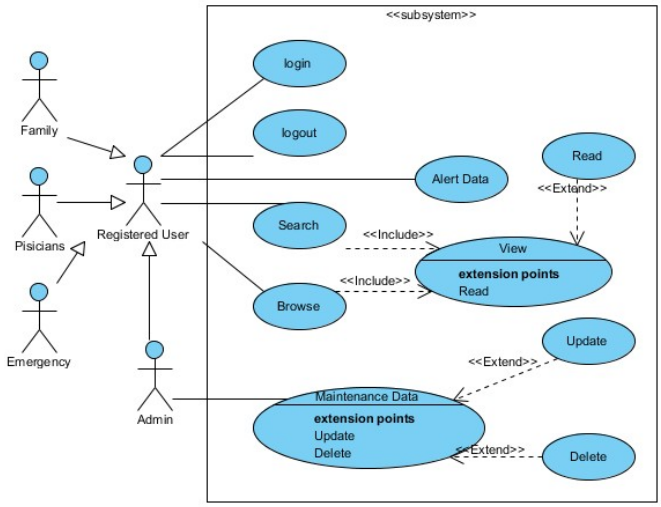

Fig. 6: Monitoring Application

CONCLUSSION AND FUTURE RESEARCH

Chronic disease especially heart disease often arising in health care are the lack of continuous health monitoring equipment that can be used independently by patients at home. This causes a delay in the provision of treatment required by the patient, and result in high cost of care and treatment. Moreover, the next process on development of self-health care monitoring system is expected to be a solution to these problems.

The system will be developed consists of several phases that are first data acquisition by using non-invasive wireless sensors. Second, sensor gateway that functions to store data to the server and is equipped with a warning system in case of abnormal conditions in a patient. Third, cloud computing which will be used to handle the data storage patients are monitored and web services for healthcare applications. Forth, applications on smart phones or tablet devices that will be used to display the patient's health condition data.

This system will be tested with two test scenarios directly under the supervision of a medical team and testing conducted independently by the patient to determine whether the system inhibits the activity of the patient. Testing aims first, to determine the accuracy and appropriateness of the data generated by the threshold value determination system developed. Second, to determine the reliability of the tools used in monitoring the health heart condition.

REFERENCES

[1] ___, http://www.who.int/mediacentre/news/releases/2004/pr68/en/, "WHO publishes definitive atlas on global heart disease and stroke epidemic", acessed on March 1st, 2014

[2] A. I. Hernandez, F. Mora, G. Villegas, G. Passariello, and G. Carrault, "Real-time ECG transmission via Internet for nonclinical applications," *IEEE Trans. Inf. Technol. Biomed.*, vol. 5, no. 3, pp. 253–257, Sep. 2001.

[3] C. Pagliari, "*Design and evaluation in ehealth: Challenges and implications for an interdisciplinary field*" *J. Med. Internet Res.*, vol. 9, no. 2, p. E15, 2007.

[4] Chan, P. Ray and N. Parameswaran, "*Mobile E-Health Monitoring : An Agent Based Approach*", IET Commun., 2008, 2, (2), pp. 223-230.

[5] Dr. B.Eswara Reddy, Dr. T.V.Suresh Kumar, Gandikota Ramu, "An Efficient Cloud Framework for Health Care Monitoring System", IEEE - 2012 International Symposium on Cloud and Services Computing 978-0-7695-4931-6/12

[6] Hyuma Watanabe, Masatoshi Kawarasaki, Akira Sato, Kentaro Yoshida University of Tsukuba Japan, "*Development Of Wearable Heart Disease Monitoring And Alerting System Asechsociated With Smartphone*", IEEE No 978-1-4577-2038-312 © 2012

[7] Internet Engineering Task Force (IETF), 2009 [Online] Available : http://ietf.org.

[8] James G. Kahn, Joshua S. Yang, and James S. Kahn, "*Mobile Health needs and opportunities in developng countries"*, Health Affair 2010, p.254-260.

[9] Jason Lester Hill, "*System Architecture for Wireless Sensor Networks",* Univerisy Of California, Berkeley, 2003.

[10] Jocelyne Fayn and Paul Rubel*,* "*Toward A Personal Health Society In Cardiology*", IEEE Transactions On Information Technology In Biomedicine, Vol. 14, No. 2, March 2010.

[11] K. S. Kwak, S. Ullah, and N. Ullah. (Feb. 20, 2011). An Overview of IEEE 802.15.6 Standard, arXiv:1102.4106v1 [cs.NI]. [Online]. Available: http://arxiv.org/PS_cache/arxiv/pdf/1102/1102.4106v1.pdf.

[12] Kementrian Kesehatan Republik Indonesia. Hasil Laporan Riset Kesehatan Dasar – RISKESDAS, 2007.

[13] Kementrian Kesehatan Republik Indonesia. Hasil Laporan Riset Kesehatan Dasar – RISKESDAS, 2013.

[14] Khalid Elgazzar, Muhammad Aboelfotoh, Patrick Martin, Hossam S. Hassanein, *"Ubiquitous health monitoring using mobile web services",* Procedia Computer Science 10 (2012) 332–339.

[15] Maria, A.F., Fenu, G., Surcis, S.: An Approach to Cloud Computing Network. In: Proceedings of the 3rd International Conference on Theory and Practice of Electronic Governance, Bogota, Colombia, November 10–13, pp. 409–410 (2009).

[16] Ole Andreas Alsos, Anita Das, Dag Svances, "*Mobile Health It: The Effect Of User Interface And Form Factor On Doctor–Patient Communication*", International Journal of Medical Informatics 81 (2012) 12–28

[17] R.-G. Lee, H.-S. Chen, C.-C. Lin, K.-C. Chang, and J.-H. Chen, "Home telecare system using cable television plants—an experimental field trial," *IEEE Trans. Inf. Technol. Biomed.*, vol. 4, no. 1, pp. 37–44, Mar. 2000.

[18] Ren-Guey Lee*,* Kuei-Chien Chen, Chun-Chieh Hsiao, and Chwan-Lu Tseng, "*A Mobile Care System With Alert Mechanism*", IEEE Transactions On Information Technology In Biomedicine, Vol. 11, No. 5, September 2007

[19] S. Guillen, M. T. Arredondo, V. Traver, J. M. Garcıa, and C. Fernandez, "Multimedia telehomecare system using standard TV set," *IEEE Trans. Biomed. Eng.*, vol. 49, no. 12, pp. 1431–1437, Dec. 2002.

[20] Sang-Joong Jung, Risto Myllyla, and Wan-Young Chung, "*Wireless Machine-to-Machine Healthcare Solution Using Android Mobile Devices in Global Network*", IEEE Sensors Journal, Vol. 13, No. 5, May 2013.

[21] Sasan Adibi, "*Link Technologies and Blackberry Mobile Health (mHealth) Solutions : A Review"*, IEEE Transaction on Information Technology in Biomedicine, Vol. 16, No 4, July 2012.

[22] Unified Modeling Language (UML) Specification 2.4.1, Object Management Group. (2011, Aug.), [Online]. Available: http://www.omg.org/spec/UML/2.4.1

[23] Xingli Zhao, Hong Zhang, Yajuan Zhang and Ning Yang, "*A Non-Contact Health Monitoring System Based on the Internet of Things and Evidential Reasoning"*, Modern Advances in Intelligent Systems and Tools, SCI 431, pp. 3–8 , © Springer-Verlag Berlin Heidelberg 2012.

[24] Wan, D., Greenway, A., Harris, J.G., Alter, A.E.: Six questions every health industry executive should ask about cloud computing,
http://newsroom.accenture.com/images/20020/HealthcareCloud.pdf