SOA and Cloud based Architecture for Non-invasive Health Monitoring

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Abstract: The increasing incidence of chronic diseases is becoming a heavy burden for both public and private healthcare sectors. Many industrial and academic efforts are trying to alleviate this burden using various clinical solutions. Establishment and execution of prevention plans and subjects' monitoring are among the promising solutions. In keeping with these efforts, we describe in this paper our proposed architecture, for health monitoring of patients with chronic diseases. The architecture relies on the service Oriented Architecture (SOA) and cloud computing for the implementation and integration of services from various stakeholders. The monitoring scheme allows to proactively detect risks of disease' aggravation and dynamically generates and customizes prevention plans according to the patient's health profile and context. A prototype of our system is under development and preliminary data have been collected and analysed.

1 INTRODUCTION

Chronic and cardiovascular diseases (CVD) are increasing at an unprecedented rate all over the world. For instance, in the United Arab Emirates (UAE) over 25% of fatalities in the UAE are caused by cardiovascular diseases (BIM, 2010). Multiple factors contribute to the prevalence of these diseases: cholesterol, diabetes, high blood pressure, physical inactivity, and smoking. Consistent with statistics from the World Health Organization, the UAE has the second highest rate of diabetes in the world. Furthermore, research studies at the UAE University estimate that up to 29% of the population over 30 years old of the UAE has diabetes.

To tackle the rising incidence of chronic diseases and their associated complications, a prevention approach can contribute to reducing the risks of their occurrence. Likewise, continuous monitoring of subjects' health condition is vital for detecting the diseases' symptoms as early as possible.

The implementation of monitoring, prevention, and tracking mechanisms is becoming possible due to the integration of different technologies, systems, and communication infrastructures. These technologies include sensing, pervasive computing, and wireless and mobile computing technologies. They are greatly impacting the healthcare industry, which is undergoing fundamental changes by: (1) Shifting from hospital-centric services to ubiquitous and ambulatory systems (with homecare, day-care clinics, remote healthcare), (2) Providing support for the treatment of chronic diseases through active involvement of patients, (3) Providing patients and healthcare professionals with easy access to important health information anytime/anywhere, and (4) Optimizing healthcare costs.

In this paper, we propose an architecture for monitoring and prevention of chronic diseases. The system relies on SOA–and cloud computing. SOA has proven to be an adequate solution for integrating heterogeneous systems, allowing application-to-application communication over the internet, reducing cost of integration, and making data available to different stakeholders. The system will allow deploying various services for continuous data gathering, automatic monitoring, and taking proactive measures to identify risk factors and prevent subjects from severe heath consequences. These services can be accessed from any computing systems, and from mobile handheld devices smart-phones and tablets. Besides, the system can be integrated with other healthcare systems.

The remainder of this paper is organized as follows: Section 2 discusses the state of the art in health monitoring. Section 3 portrays our proposed architecture for non-invasive health monitoring,

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which relies on SOA and cloud computing technologies, and describes the monitoring process. Section 4 presents the implementation and the experiments we conducted. Section 5 concludes the paper and highlights some future works.

2 RELATED WORK

Several research works and initiatives have investigated the challenges of building e-health solutions. These solutions differ on how they tackle the integration issue given the heterogeneity of systems, middleware, and architectures used to build an e-Health system. Xiang et al. (Xiang et al., 2003) proposed a distributed framework for a Web-based telemedicine system, which uses CORBA technology and a database fragmented on different sites. The system requires an intermediary middleware to handle the heterogeneity of heath systems and huge development effort to adapt the system to the integrated system requirements.

In (Omar and Bendiab, 2006), the authors proposed a multi-layer SOA-based e-Health services architecture, which has six main components that define the interactions among the layers. The system is generic. However, it describes only the architectural design without detailing the implementation and its challenges. In addition, their proposed system hasn't been implemented. Kart, F. et al. (Kart et al., 2008) described a distributed e-healthcare system that uses SOA as a mean of designing, implementing, and managing healthcare services. The users of the system are physicians, nurses, pharmacists, and other professionals, as well as patients. The system includes a clinic module, a pharmacy module, and patient's interfaces, which are implemented as Web services. Various devices can interact with these modules, including desktop and server computers, Personal Digital Assistants and smart phones, and even electronic medical devices, such as blood pressure monitors.

The authors in (Hsieh et al., 2007) described the design, the implementation, and the deployment of a multi-tier Inpatient Healthcare Information System based on SOA and on the HL7 message exchange standard at the National Taiwan University Hospital (NTUH). The services-tier includes Computerized-Physician Order Entry (CPOE), Billing, Pharmacy, and Diet. The authors in (Juneja et al., 2009) investigated how healthcare organizations, using SOA, can leverage their shared services to automate multiple business processes and reinforce overall interoperability. The authors in (Yang et al., 2008) designed and developed a SOA-based platform for home-care delivery to patients with chronic diseases. This work shares some of the goals with our project with regards to monitoring chronic diseases patients.

To promote interoperability among healthcare organizations that are seeking to develop SOA-based architectures, a joint collaboration effort among standards groups, specifically HL7 and the Object Management Group (OMG), was formed under the name: Healthcare Services Specification Project (HSSP). This effort intends to develop health industry SOA standards. The intent of HSSP is to produce standard services that define services' responsibilities, behaviour, and interfaces so that ubiquity can be achieved across implementations and vendor products (HL7 and OMG, 2008).

Our solution is aligned with above initiatives and addresses mainly the chronic diseases monitoring and prevention. It also addresses some difficult issues in the design of an e-health system and protection of medical data. Our solution relies on SOA to integrate different systems, data, and make it available for CDs monitoring, and prevention. The net implication of using SOA in our solution is that it facilitates interoperation among various systems that typically do not speak the same language. Using a common SOA reduces the complexity of the integration of heterogeneous systems. New services can be developed to satisfy the needs of integration, and existing system capabilities can also be organized into services.

3 HEALTH MONITORING ARCHITECTURE

3.1 Architecture Overview

Figure 1 depicts our proposed architecture for health monitoring that allows the collection of health data of patients and its dissemination to healthcare professionals anytime and from everywhere. The architecture takes advantage of the recent advances in sensing technology, wireless and broadband communication, computing capabilities of handheld devices, services' delivery, and cloud computing to enable smart monitoring of patient's vital health parameters. Each layer of the architecture includes a set of components that interact to provide an integrated solution for monitoring patients' health.

Non-Invasive Sensing Layer: this layer includes various devices (e.g. sensors, smart-phones), which sense one or more health parameters such as

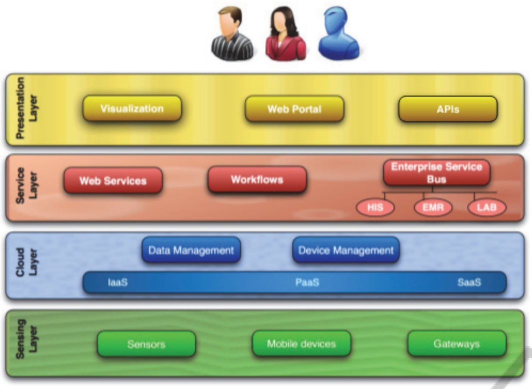

Figure 1: SOA & Cloud based Architecture for Non-Invasive Health Monitoring.

blood pressure, blood sugar, body temperature, and oxygen saturation. It also includes gateways that collect data from sensors, perform some processing (e.g. filtering), and store data on the Cloud. Gateways generally provide an interface to access and retrieve sensed data.

Cloud Layer: this layer serves as the underlying infrastructure and platform that hosts data and applications. It includes the following components: Connectivity Management, Device Management, Data Processing, and other cloud-based services that support monitoring activities.

Service Layer: this layer allows integrating the components involved in the monitoring process with services of the healthcare information system. The main components of this layer are: the Enterprise Service Bus (ESB), which allows interoperation and exchange of data among different sub-systems, Web services, and Workflows Management.

Presentation Layer: this layer includes high-level applications and services that access and process health data obtained from the lowest layers of the architecture. Examples of services are: report generation, pattern mining and recognition tools, and data visualization.

3.2 Monitoring Process

The monitoring process involves the patient, healthcare professionals, sensing devices (mobile, Sensors), and the engine system. The sensing devices sense the patient's health parameters and send real-time data to a back-end server, which includes a smart engine that processes and mines collected data to detect any discrepancies in the patient's health data and report them to healthcare professionals to take appropriate actions. The engine offers a set of services to physicians and to the patient's assistance team. These services render various kinds of data such as laboratory tests, demographic, anthropometric, and biological data, which support physicians in taking appropriate actions.

Figure 2 depicts interactions among main monitoring actors. Collected data is sent to a mobile device, which stores it in a cloud repository. Once the data is available on the Cloud, the surveillance centre of a hospital can access these data and notify appropriate health professionals if immediate action is required in response to any observed irregularities of monitored health parameters. Also, physicians can access the cloud to retrieve historical data of the patient for further investigation purpose. They can recommend prevention and action plans for the treatment of the patient conditions. A prevention plan may recommend, for instance, practicing regular sport exercises, following a diet plan, changing the food habits and the lifestyle, etc. An action plan, however, consists of a series of actions that might include medications, re-education, etc.

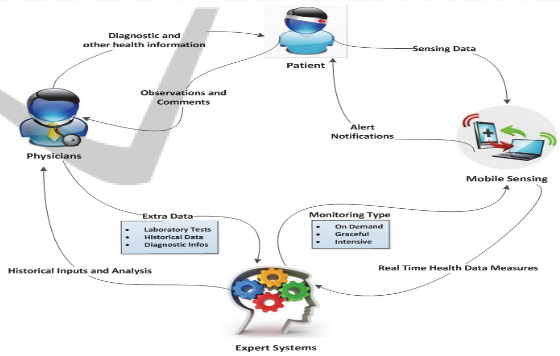

Figure 2: Mobile health monitoring process.

4 IMPLEMENTATION

We conducted a series of experiments to monitor and collect data about temperature, blood pressure, ECG, heart rate, and blood sugar of some subjects. Sensors sensed real-time data and transmitted it to a mobile device (Samsung Galaxy Note running Android 4), which stored them in a Cloud data repository. We developed a mobile application to parse the data stored in the cloud to generate, visualize, and interpret the monitoring results. Figure 3 depicts the main interface of the application.

Figure 3: Snapshot of the mobile health application.

Figure 4 shows results of monitoring the ECG; the user can scroll left or right to see rest of graph.

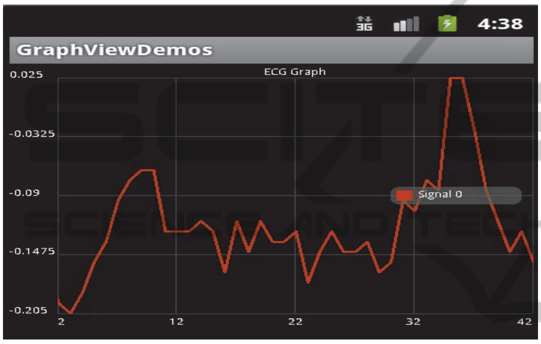

Figure 4: Results of ECG monitoring.

Figure 5 shows a graph that resulted from monitoring a patient blood sugar while fasting and after meals for a period of 40 days.

5 CONCLUSIONS

With the advances in sensing technology, monitoring the health of patients using diverse non-intrusive sensors is becoming a promising solution for dealing with the increasing incidence of CD worldwide. Monitoring allows to continuously observe vital parameters such as temperature, blood pressure, and ECG of a patient.

In this paper we described our proposed architecture, for health monitoring of patients with chronic diseases. It uses the SOA and cloud computing technologies to implement and integrate services from various stakeholders. Its monitoring scheme allows to proactively detect risks of disease' aggravation and to dynamically generate and customize prevention plans consistent with the patient's health profile and condition. A prototype of our system is under development. We collected and analysed preliminary data of few patients.

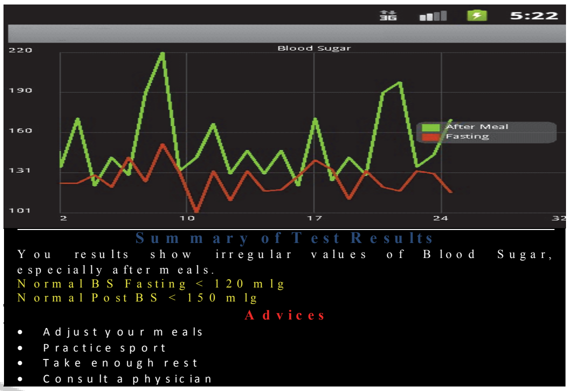

Figure 5: Results of blood sugar monitoring.

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REFERENCES

BIM, 2010. Over 25% of deaths in the UAE are caused by cardiovascular disease. *http://www.bi-me.com/main.php?id=46797&t=1&c=35&cg=4&mset=.*

HAAD, 2011. Public Health Priorities and Goals. *http://www.haad.ae/haad/tabid/228/Default.aspx.*

HL7 & OMG, 2008. The practical Guide for SOA in Health Care: A real World Approach to Planning, designing, and deploying SOA, version 1.0. *http://hssp.wikispaces.com/PracticalGuide.*

Hsieh, S., Weng, Y., Yang, T., Lai, F., Cheng, P., Ping, X., Jan, M., Lin, J. & Peng, C., 2007. Middleware based inpatient healthcare information system. *In Proc. of BIBE 2007, the 7th IEEE International Conference on Bioinformatics and Bioengineering.*

Juneja, G., Dournaee, B., Natoli, J. & Birkel, S. 2009. SOA in healthcare (Part II). *SOA Magazine.*

Kart, F., Moser, L. E. & Melliar-Smith, P. M., 2008. Building a distributed e-healthcare system using SOA. *IT professional,* 10, 24-30.

Omar, W. M., & Bendiab, A. T., 2006. E-health support services based on service-oriented architecture. *IT professional,* 8, 35-41.

Xiang, Y., Gu, Q. & Li, Z., 2003.A distributed framework of Web-based telemedicine system. *In Proc. of CBMS 2003, the 16th IEEE Symposium on Computer-Based Medical Systems,* 108-113.

Yang, C. L., Chang, Y. K. & Chu, C. P, 2008. Modeling Services to Construct Service-Oriented Healthcare Architecture for Digital Home-Care Business.*In Proc. of SEKE'2008, the International Conference on Software Engineering & Knowledge Engineering.*