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Survey on Cloud-based Health Management Solutions

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Abstract

In this day and age of connected living, it is critical for people to interface the wellbeing factors and health conditions into trends so as to picturize the state of health of an individual. In addition, it is essential to include the wearables and therapeutic gears to viably speedup up the treatment cycle. It is equally important to pull health records and scanned images from various systems which follow different standards and ensure that they interact appropriately. These interactions could either be driven from the clinics and hospitals, or performed as a part of awareness by the end users (patients and health conscious individuals). To understand these interactions, we have taken Diabetes management as our use case. Diabetes is turning into a lifestyle disease and hence is an ideal candidate since we need to monitor the health conditions of the patient continuously. The vital parameters of the body could either be monitored through medical devices and equipment, body sensors, mobile applications, or wearables.This paper analyses the solutions proposed so far for effective diabetes management using cloud technology. The paper also touches upon IoT-based solutions which could be used to treat chronic ailments from remote locations.
Keywords: Cloud Computing, Health Platform, Diabetes Management

I. INTRODUCTION

Fast growing technology and gradual change in the lifestyle has triggered an immense interest in the individuals to know more about the health conditions by tracking every symptom and observations. With a wide range of standards and entities involved in the healthcare domain, it is always difficult to integrate the solutions to provide the big picture. Simple example could be an allergy, where the physician needs to really know the routine to exactly identify the cause. More importantly, the symptoms of the disease or ill health need to be treated immediately to avoid chain reactions. All this is only possible when the end user can track every detail of his life, while this data immediately flows to the monitoring system for analysis and decision making. The details could be tracked from multiple sources such as medical equipment like glucometers, pill dispensers, wearable watches and weighing scales, monitoring cameras, hospital records, x-ray and ultrasound reports, imaging systems, and so on.

This paper is organized as follows, section 2 provides an overview on the need of cloud computing in health systems, section 3 gives an insight on the work done so far with respect to Diabetes Management solutions, section 4 discusses the feasible issues and counter measures. Last but not the least, section 5 summarizes the intent and conclusion.

II. CLOUD COMPUTING IN HEALTHCARE

Cloud Computing can be defined as a network of connected servers or data centers (remotely located) which are used by the end users to compute and store data via internet, on demand. Cloud follows a pay-as-you-use model where the end user pays for only those resources which are used. The resources in this case could be anything ranging from applications and software to hardware and computational capacity. Cloud computing is offered as three major implementations:

A. Software as a Service (SaaS):

SaaS as a cloud offering provides access to the software and applications without having to install them on the local machines. There could be multiple reasons why one would want to use SaaS, few of which are security of data, low cost of resource maintenance and technical support. It also provides access to tools and data from any location any time without hassle.

B. Platform as a Service (PaaS):

PaaS favors the developer community by offering the development environment and tools as a service. This also includes the deployment of applications with specified operating system, in a particular programming language, servers and virtualization, etc. PaaS focusses on reduced time-to-market since it provides a readymade environment which is tailored as per developer needs.

C. Infrastructure as a Service (IaaS):

IaaS on the other hand deals with infrastructure resources such as hard drives, servers, storage and network firewalls as a pool. These resources are provided to the customers as a service and are billed as per consumption. This dynamic nature of resource allocation and provisioning adds to the flexibility of the system.

Having understood the flavors of cloud computing, it is time to dig deeper into the application of cloud in health systems. The healths records be it simple or complex are now being moved globally over the internet. The stake holders in this context could be anyone ranging from doctors and physicians, care providers, insurance companies, pharmaceutical companies, health NGOs, or some IT companies in healthcare domain. With millions of users continuously recording and tracking their health information, it is necessary to store this data at a global location such that it is accessible to authorized entities quickly. As per the Certification Commission for Healthcare Information Technology (CCHIT), more than 1000 vendors offer cloud options for medical records. Many healthcare companies such as GE Healthcare, Dell, IBM and Philips have explored the cloud platform to provide effective solutions while the data and services are accessible across boundaries. In fact, cloud survey in 2014 conducted by Health Information and Management Systems Survey revealed that 83% of health organizations today either use or have foreseen the power of cloud services which include information interchange, data backup and recovery along with hosting of clinical applications.

Health and clinical data is crucial and needs to be securely handled while performing analytics and research. Moreover, electronic health records (EHR), Personal Health Records (PHR), images and scan information; need to be stored safely to protect the sensitive information from being misused. In all, the solutions are turning out into patient friendly, data-driven diagnosis-treatment iterations which require extensive access to health data.

III. COMPARATIVE STUDY OF DIABETES MANAGEMENT SOLUTIONS PROPOSED SO FAR

Yong-Gang Gong and Xin Chen in [1] presented a health platform to manage the information flowing from different sources including hospitals, government officials, insurance agents, laboratories and health agencies. The proposed solution made use of XML based Service Oriented Architecture (SOA) to store and shares the information using Health Level 7 (HL7) standard. Health Information Integration and Shared Platform (HIISP) comprises of four modules, data repository, management level web services to retrieve and store the data sources, a messaging platform to communicate between components and the development platform itself. The HL7 V3 supports Reference Information Model (RIM) which data as business objects or resources for modelling and scheduling purposes. Although the authors foresaw the need for unified platform of patients, employees and their mapping, some important features were missed like providing analytics or data mining on the stored data repositories. However, it provided an overview of what are the basic features to be taken up when providing a health platform.

W Liu and E.K. Park in [2] in proposed a platform approach to manage the information and infrastructure in hospitals. It acts like an enabler for patient and clinical support systems while it creates a health network within the system. The idea of privacy and security of information is established with the fact the no critical information should be transmitted across the network. Instead, the data is wrapped into identifiers which map to the entities present in the system. The patient encounters could be related to registration, prescriptions, scan reports, laboratories and hospital administration. The paper defines a prototype for service based platform including pervasive applications with end to end scenario for patient encounters with hospitals. PHR repositories are continuously updated based on patient data and reflected across Electronic Medical Records (EMR) across doctor dashboard. This system also took care of predefined Quality of Service (QoS) and network bandwidth usage [11] while consuming the underlying services. Although the solution ventured in mobile based health tracking, it could not completely support non-stable standards and collaborative computing.

Yan-Yu Lam Andy et.al in [3] came up with the concept of self-management in patient health and disease conditions where the information registered was sent to build the PHRs and continued care. Diabetes management was taken into consideration as a pioneer project where glucometer devices were assigned to patients, and data was offered as web services. All the vital body parameters, food intake, diet and exercise status were tracked throughout via the internet, and combined with EMR to remind patients about regular checkups and reporting symptoms if any. The analysis was conducted on 70 patients for three months and it should significant effect. Team also developed a web based portal to give a clearer depiction of continuous care document created using the data. As a part of future work, they planned to work on more complex disease types such as heart failure, mental health, HIV, Gastro-intestinal ill-health, etc. The team also proposed a telepathy based applications to cut down the treatment time.

Xiamao Fan, Chenguang He, et.al in [4] designed a preventive healthcare solution called HCloud which focused on early detection of symptoms which can lead to chronic diseases. The proposed platform harnessed the loose coupling in cloud computing to analyze the heterogeneous characteristics of electrocardiogram (ECG) along with other physiological data for data mining and feature selection. Raw data procured from the sensors is processed before it can be stored onto cloud. This is done by storing the signals in digital format as chunks, onto distributed filesystems. Data is then stored onto NoSQL database since it does not have a fixed schema and is easily scalable. The platform comprises of a web cluster, messaging and imaging servers, distributed storage and caching servers. Web cluster is the front face of the platform which accepts the user requests and services them accordingly. Internally, the messaging middleware contacts the data mining layer to publish or subscribe the data stored onto the backend. However, the security aspects of the platform were never addressed and were scoped for future work.

Haluk Demirkan in [5] put forth the concept of health systems framework which harnesses the features of both cloud as well as mobile computing to provide cost effective IT solutions. The authors realized the advent of personalized care in health systems along with tele-medicine and e-health to integrate solutions for long-term gains. Unlike other solutions, the framework endorsed a business-to-business model with service-level agreements set such that the cloud services could be used on mobile phones and web3.0 rich applications. The framework also supported big data for business intelligence and analysis. A simple example quoted by the authors is for smart room, where the patients can easily identify their caregivers, who in turn can provide inputs to the clinicians about the medications prescribed so that they are really aware of the daily habits of the patient. The authors also suggested that the performance can be improved drastically by improving on the technology usage and automation.

The authors, S. Srinivasan in [6] suggested the use of wireless sensor networks and parallel computing to develop services in the health platform. It also used SMS and Global System of Mobile Communication (GSM) to inform their stakeholders regarding any updates or anomalies observed in the gathered physiological information. This solution was named Public Oriented Healthcare Platform (POHCP) and was intended to offer support for complex diseases like cerebral palsy, coronary heart disease, diabetes, etc. The API is designed to offer the data stored in the SQL Server database to the consuming applications apart from SMS alerts. The Global Positioning System (GPS) also provides inputs on if the patient falls down, hence sending SMS to call for assistance. The decision support system is designed to intimate the necessary people immediately, even if it's a seasonal illness or personal health data deviations. However, the details of handling complex multi modal data were discussed out right. Also, it is important to know that the discussion revolved around using body sensors as input devices unlike the earlier systems.

Jiang Hanping and Zhang Fulin [7] examined the importance of a data platform for healthcare, with APIs that provide administrative functionalities and clinical archives which are to be devoured by the cutting edge applications. The proposed system bolstered proof based remedies for speedy and precise arrangements which are astute and fast. The healthcare information network connects to the web server via API calls, which in turn contacts the data warehouse and business intelligence units which stores the normalized data for security and auditing purposes. All the data is mapped from Minimal Data Set (MDS) to HL7 messages before storing in the repository. Due to numerous standards available in the Healthcare industry, the challenge was to ensure that data arising from different sources is slinked in appropriately.

Fuchao Zhou et.al in [8] took diabetes management into consideration for their analysis and designed a solution for logging activity, body parameters and diet inputs during the span of research. They identified Google Health to maintain the PHRs generated from different health providers. Also, the idea of smart home along with Google Health provided a base for pulling data from end users. The solution also provided precise analysis on how weather information could be used to provide options of exercising indoor or outdoor, using RFID to track if the user is in the house or has gone out, tagging bar code for every snack eaten etc. The research provided a functional overview of the comprehensive smart platform for free health management to all its patients. It however did not take care of development details on the technology front, along with accuracy of data being tracked. The authors are also looking at a complete solution for diabetes by closely monitoring the plasma glucose levels and their dynamic relationship with weight, food habits, exercises, etc.

Lama Nachman and Amit Baxi in [9] worked on a Diabetes Management use case where they established a co relation between energy spent and its impact on diabetic health. It involved a survey on 15 patients for two months where in the correlations were established. The system imposed two levels of data inputs, one from body sensors and others from user interfaces such as mobile applications and web pages from both patients and doctors. The sensing unit mainly comprised of accelerometers, barometers, light and humidity sensors, temperature and microphones. Classifiers were designed to ensure that the system distinguishes between the postures and presence of the patients clearly. Micro-controller enabled HR-SHIMMER was used to track the energy spent, heart rates and body movements to accurately calculate the calories burnt. Data logging through mobile phones was enabled to provide real time feedback on the right kind of food to be consumed. Improvements were suggested based on live experiments conducted on people to improve the quality of devices and to reduce the number of tracking devices.

Adelina Ochian and George Suciu [10] provided a brief analysis on developing middleware for interconnecting various heterogeneous clouds and health solutions. Health Information Exchange (HIX) was considered as a core platform to co-ordinate the services offered to the hospitals. A broker was established between the hospital server and Picture Archiving and Communication System (PACS) to manage the x-ray imaging. Cloud providers like Google, Amazon, Microsoft, etc. were evaluated thoroughly for the data center. It also leveraged the Software Defined Network (SDN) for setting up the hospital system which constantly interacted with the services. In other words, the proposed solution pulled the SaaS, PaaS and IaaS to integrate different systems already available.

IV. ISSUES AND COUNTERMEASURES TAKEN

It is difficult to completely digitize the healthcare encounters due to its depth and complexity. The services offered by the platform should always support interoperability and interaction between different systems and standards related to imaging, hospital systems, analysis and databases. It is required to understand that patient data needs to be effectively handled for quick analysis failing which the purpose of faster feedback and recovery goes in vain.

Major issues faced during the work done so far was due to data normalization. Since data flows in from multiple systems and tracking devices, the data needs to be standardized and transformed into meaningful information. Also, data mining on huge datasets is fairly critical and time consuming. Distributed computing is the only solution attributed to this issue.

Yet another problem arises when the information needs to be exchanged in real time. The trade-off between network bandwidth consumption and data reporting is the only solution in such scenarios. Since the tracking devices are generally sensor networks, it is important to understand the need for availability of high speed networks dedicated for this purpose.

Cloud infrastructure support has its own demerits when it comes to deperimeterization and vendor lock-in which cannot be completely solved.

V. CONCLUSION

With the advent of cloud infrastructure, the healthcare industry has already started to move towards extensive service-oriented solutions. To add to it, the sensor networks, pervasive computing and mobile applications have all aided to the growth of newer platforms for personalized offerings. Market is drifting towards self-management of health conditions and healthy living apart from the usual process of diagnosis and treatment.

Right combinations of infrastructure are important in the platform based approach for health management as the systems are intolerant to any delay or inaccuracy. In the meantime, the solution stack provided by the platform services should be secure and only authorized personnel should have access to it.

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