Abstract.

Conventional healthcare delivery system is facing constraints in terms of maintenance of health records, of health care data, interoperability of information communication systems and ubiquitous availability of patient’s health record. The limitation of the conventional health system can be overcome by either replacing it or supplementing it by eHealth solution. If the healthcare organizations maintain patient records electronically they can deliver better and effective healthcare to the patients. Use of information technology in healthcare especially Electronic Health Records (EHRs). This will also help to track patient history with the diagnosis of past and test results. This work proposes e-healthcare architecture using Service-Oriented architecture as well as cloud computing to improve quality of patient care with increased efficiency and effectiveness of healthcare deliver.

Out of the proposed e-Health architecture, as proof-of-concept implementation of physician portal have been carried out. Using this physician portal can check medical prescription history, clinical findings entered by pathologist and radiologist, using this system medical data can also be referred for further consultation while ensuring suitable means of data privacy and confidentiality and physicians can prescribe medical treatment and suggest clinical test to the patients by viewing their medical history and current patients’ condition. In his implementation pathologist can enter the pathology reports of the patients using standard report generated by the e-Health system and radiologist can upload the images like X-Ray etc. to the server. This physician portal is designed based on the concept of a Service-Oriented Architecture (SOA). Information exchange interface uses the Simple Object Access Protocol (SOAP) standard.

Introduction

In the field of healthcare which needs proper and correct communication and record keeping, the use of information and computer technology lags behind other areas. If the medical data of a person or patient is stored for future use, it may help in diagnosis of future ailment for the individual patient and will also support for appropriate treatment. To deliver affordable and quality healthcare to human community it is essential to make effective and efficient use of information technology in healthcare systems.
1.1 Background
The goal of healthcare systems is to be responsive to the expectations of the population and it should be at an affordable cost. A healthcare system consists of people, institutions and resources to deliver healthcare services to meet the health needs of the target population. The healthcare system can be evaluated on the basis of quality, efficiency, acceptability and equality. These can also be summarized with “the five C’s”: Cost, Coverage, Consistency, Complexity, and Chronic illness (1).

The success of the World Wide Web (WWW) has added its own dimensions. Web access to clinical data repositories is used in a growing number of systems, and web interface to commercially available information systems either already exist or are under development.

1.2 Current Scenario
The traditional healthcare record management system’s is paper-based. This method of health record keeping doesn’t allow easy access of these records. This is a time consuming process and one cannot keep the health records all the time and everywhere.

The healthcare industry is following the traditional way to store and provide the reports of health records as shown in fig. 1. Health care provides (such as the doctors and hospitals) store the medical records of their patients on their patients on paper or these records are stored with the minimal use of computers and associated database system.

In traditional way patients are required to go to the check up centre for a checkup and they have to keep their own Personal Health Record (PHR) with themselves for further analysis and reference.

In general scenario, physician gives paper-based medical prescription to patient. The patient takes the prescription to pharmacy store, waits in line to hand the prescription to the pharmacist, and waits for the pharmacist to fill the prescription. Sometimes pharmacist might be unable to read the physician’s handwriting or misunderstood on same drugs; the physician might be unaware of medications prescribed by other physicians or the patient could modify or forge the prescription.

1.3 Drawbacks in the Current Scenario
One of the major problems in healthcare today is that limited communication between the patient and the physician typically exists only within the physician’s practice: once the patient leaves the office, communication is very limited. However, monitoring the recovery progress is essential for good healthcare. At present, the speed, flow, accuracy and access to vital health information is slow because the majority of healthcare communication is paper-based. With the advent of the digital age, the technology is available which has a potential to deliver health information about the right person to the right place at the right time in a safe and secure environment but the deployed healthcare information and storage systems have following limitations(5):
• They do not interoperate with each other because they have been developed independently.
• They do not have common standards for storing maintaining, and creating Electronic Health Records (EHR) of the patients.
• Different healthcare organizations generate and store different EHRs for the same patient by the two healthcare organizations which use two different information systems.

1.5 Overview of the Proposed Solution
• Through patient centered integrated care with providing better access to health information enabling better health outcomes on the needs of patients.
• Provide easy access to health records for timely healthcare delivery.
• Provide every individual patient an HER which is controlled by the individual or the person authorized by the patient.
• Ensure individuals, privacy.
• Reducing duplication and improve efficiency in the healthcare system through streamlining access to patient information thereby improving use of resources.

The proposed prototype for distributed e-healthcare system uses service-oriented architecture (SOA) as well as cloud computing to enforce basic software architecture principles and provide interoperability between different computing platforms and applications that communicate with each other shown in fig.2.

Figure 2 – Overview of Proposed Integrated eHealth Architecture

1.6 Benefits of the Proposed Solution
It is a proven fact that cloud computing is beneficial and provides a secure and reliable computing model, it promises enormous benefit for healthcare world also. These benefits include better health for the overall population, new delivery models, and improved patient care that will make healthcare more efficient and effective and cloud computing can help do all this in a cost-effective way. Cloud computing can be extremely cost-effective for smaller healthcare organizations and physicians. The cloud technology removes the burden of hiring internal IT staff to maintain and service in-housing infrastructure. It is possible to share infrastructure between a number of hospitals for reducing cost and increasing efficiency so that cloud computing provide means to real-time availability of patient information for physician, patients and other healthcare professionals not only within the country but possibly across geographically dispersed locations as healthcare professionals can access patient information without
installing any additional software applications from any internet enabled device (7). In the cloud service model, healthcare providers only pay for what they use. In the cloud computing service delivery model, the healthcare cloud service providers maintains the remote data centre and host the application for the healthcare providers.

LITERATURE SURVEY

2.1 eHealth

eHealth [8] is the use of information and communication technologies (ICT) for health/ to for example, treat patients, pursue research, educate students

2.1.1 Forms of eHealth

The term eHealth encompass a range of services of systems that are at the edge of medicine/healthcare and information technology, including [9]:

- Electronic health records: provides way to store patients’ health related data and enabling the communication between different healthcare professionals;
- Telemedicine: providing treatments at a distance with the use of ICT enabled services;
- eHealth or m-Health: includes the use of mobile devices to collect patient level health data real-time monitoring of patient vitals, providing information to healthcare professionals, researchers and patients;
- Medical research using Grids: powerful computing and data management capabilities to handle large amounts of heterogeneous data.

Healthcare Information Systems: also often refer to software solutions for appointment scheduling, patient data management, work schedule management and other administrative tasks surrounding health.

2.2 Electronic Health Record (EHR)

As the Electronic Health Records (EHR) have the potential to improve healthcare with the proper use of information technology in healthcare. The Electronic Health Records (EHR)[10,11] is a longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting, which includes information regarding patient demographics, vitals, medications, immunizations, laboratory and radiology reports, progress notes, past diagnosis and family medical history.

2.4 Service-Oriented Architecture (SOA)

The Service-Oriented Architecture (SOA) [35] design style defines the use of loosely couple software services to support the requirements of distributed applications. SOAs achieve loose coupling among interacting services by employing a small set of simple and ubiquitous interfaces to all participating software entities, together with descriptive messages constrained by an extensible schema delivered through the interfaces.

2.5 Web Services

According to the W3C’s Web Services Architecture Working Group, a Web service [38] is a software application identified by a URL, whose interfaces and bindings are capable of being defined, described and discovered as XML artifacts. The web service architecture consists of following main components in figure-3

![Web Services Architecture](image-url)
with the establishment and release of the Service Provider and the classification and search by the Service Broker, the Service Requestor can easily locate and use this service [39]. The service provider publishes its service details to the service details to the service broker. A service consumer inquires about the service available. If the published service meet service consumer’s requirement then the broker return the end point URL of the service. The service consumer then can bind the service and perform execution of the business function.

2.6 Cloud Computing
Cloud Computing[45] can be defined as a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

Figure 4

Cloud computing service models stack

Current cloud computing models are available in three main implementation options as shown in fig.5 -

Figure : cloud computing types

2.7 Conclusion
Literature survey reveals that globally information technology have penetrated in healthcare industry. Many efforts were done or ongoing for healthcare integration. It is observed that not only developed countries using the information and communication technology for better patient care but developing countries are also adapting these technologies. The study of service-oriented architecture reveals that it not only encompasses the services from a technology perspective, but also includes the policies and practices by which the services are provided and consumed. Healthcare system have complex, distributed and decentralized in nature for that in large-scale it difficult to develop. The service-oriented architecture facilitates the development of such systems by supporting modular design, software reuse and application interoperation and integration. For these reasons, the service-oriented architecture is an appropriate model for developing healthcare systems, but if this service-oriented architecture combines with cloud computing then it will become more powerful, productive and cost effective to healthcare sector.
3.2 Detailed System Description
The proposed system stores and facilitates exchange of medical data, patient’s demographic details, diagnosis details, medications, test reports, procedure and discharge summaries among clinicians. The goal is for all healthcare organizations to have real-time clinical information for treating patients. In proposed systems as a measure of security users will have to verify their ID multiple times to access their medical data.

3.2.1 System Architecture
The eHealth system is based on N-Tier architecture which involves three software layers: The client web browser through which user interacts with the eHealth application, the application server where eHealth services are deployed and the database server where the data is stored. In N-Tier systems much of the data processing and business logic reside on the application server. The application server communicates directly with the database server, processes this information and then delivers the processed information to the Client. This architecture is scalable. Fig 14 shows the layered architecture of the proposed eHealth platform.

3.2.2 Functional architecture
The proposed eHealth platform can be divided into interconnected modules. They are patient portal, physician portal, hospital information system (HIS) , mobile health application, health insurance service and Tele-ambulatory service. Fig.15 shows the detailed functional architecture of proposed eHealth platform.

1) Patient Portal: Initially patients are registered through the system and they are provided with a unique Patient ID through which the system tracks patient records. Patient portal manages the health records of all patients registered to the system. These are details regarding the patient’s demographics, pathological and radiological test reports. Demographic details consist of the patient’s personal information, the clinic from where he/she was referred and the hospital where the patient had received treatment. Using the patient portal, patients can view test results, consultation notes and medical history including current and past medication. With the help of this patient can also take appointments with the physician.

Fig.
automatically to other physician using e-referral. This will improve continuity of care and patient handover.

1) Tele-Ambulatory Service:
Regular ambulance contains life-saving devices and trained hospital staff. In addition to this tele-ambulatory service will also contain communication devices through which it will be connected to the eHealth platform.

2) Mobile Health Application: This application includes the use of mobile devices in collecting clinical health data, delivery of healthcare information to physicians and patients.

3) Health Insurance: The proposed system provides a common platform to all the stakeholders to smoother working of the health insurance. Stakeholders of health insurance system are patient, hospital insurance companies and government.

NOVEL FEATURES OF THE PROPOSED SOLUTION

4.1 Drug Interaction Checking
Many medications, when given in combination, interact, leading to a variety of possible adverse results including direct toxicity, or under activity of one or both of the interacting medications. These interactions are frequent, and can be dangerous. However, automated alerting systems can be effective at reducing both the rate of interacting medication orders, and harmful adverse sequel.

4.2 e Prescribing
Emerging technology in healthcare is the concept of e-Prescription, wherein physician can send their prescription through a computer network to pharmacy store. So that patients do not have need to carry their prescriptions to the pharmacy store and waits there to fill the prescription. This helps avoid errors that can occur due to various reasons such as ambiguity in the prescription due to illegible handwriting. This integration of e-Prescription in healthcare will be able to reduce medical error.

4.3 Referral
The study suggested that for improvement of quality of patient care, there is a need for keeping patient records that are available easily and providing accurate information during patient referral to another healthcare facility. These objectives can be achieved by eHealth solutions. Traditionally, patients are referred from one healthcare center or physician to another mostly by using paper documents and the rest are referred over telephone. In the case of referral based on paper documents, the quality of information flow depended on the past history of the patient and respondents further conveyed that an accurate record of patient history was not available in most of the case. In the case of telephone referral, the quality of referral is based on the doctor’s knowledge about patient medical history and also depends on the extent of time spent on phone to provide the history.

4.4 Security and Privacy
Building a secure, reliable and effective electronic health environment is a critical issue to ensure medical and health information achieve confidentiality, completeness, identity authentication, and no repudiation in internet transmission. Hence, the information platform minimizes the risk of theft of account numbers and passwords and also provides a common certification and authorization mechanism and maintaining multiple account numbers and passwords for different healthcare service systems.

4.5 Integration
For the designing patient-centric interconnected healthcare system one of the crucial requirements is information. The efficiency of healthcare delivery improves by saving lives, preventing medical errors, and improving the efficiency of healthcare delivery. In healthcare ecosystem it is difficult to share patients’ health and clinical information because
currently it is fragmented and largely inaccessible. The health information system have central objective of Integration.

4.6 Interoperability
At any level- from national and regional e-health systems to a single organization interoperability between a growing numbers of independent nodes is one of the major architectural challenges for e-Health initiatives. The major factor of successful eHealth platform is making the integration easier and providing security and privacy to existing service. However, a service-oriented architecture(SOA) helps such native interoperability to exist across a much broader range of platforms, as these are compliant with the industry standards.

6.1 Conclusion
In this paper, integrated architecture is proposed for interoperable and integrated healthcare delivery. In this strategy integrates cloud computing technology with an SOA to provide eHealth services. The objective of proposed architecture is to provide quality health services which can contribute to the improved health and well-being to all. eHealth can boost patient’s quality of care by reducing medical errors, improving clinical decision making and helping to eliminate redundant and unnecessary tests and costs. The use of the proposed architecture is also expected to enhance the current health information systems to increase clinician productivity and reduce the risk of medical errors, improve the quality of care, and patient safety.

The objective of proposed architecture is to provide quality health services that contribute to the improved health and well-being to all. The proposed eHealth platform improves clinical decision making, helps to eliminate redundant and unnecessary tests and costs and reduce medical errors. The proposed architecture can be implemented in a modular fashion. Different facilities can be accessed on need basis and it can provide an integrated platform to deliver healthcare at anytime, anyplace by the same or different healthcare professionals by providing the EHR in minimum time. Availability of the EHRs in minimum time can have a significant impact on proper health care of the patients. It is feasible to implement the proposed architecture as a private cloud of as a public cloud. The public cloud can be implemented for a group of hospitals while its implementation as public cloud can facilitate the regional/national telemedicine grid.

6.2 Future Enhancements
The proposed architecture can be implemented in a modular fashion. There are five proposed modules in this architecture. In this work physician portal module has been implemented and tested. After implementing all other modules of this architecture i.e patient, pathologist, mobile application development and hospital portals, this system can be deployed as a cloud application to improve the quality of healthcare for citizens, lower the costs of health services, and promote more effective health policies. The physician portal currently developed to handle clinical and pathological data; it could be further upgraded to handle large data like radiology. Incorporating standards like HL7 and DICOM is subject to future work. Accessing health records through mobile interfaces using mobile health application will also be future work. Since most of the consultants carry PDAs or high-end mobile devices implementing that would be more convenient for them. Uploading images and audio/video conversations to the system requires high-speed internet connectivity. Research has to be done on the usage of appropriate compression techniques with optimized protocols in order to increase the speed of data transfers. In future clinical decision support system would also be aggregated into physician portal so that physician has additional support in decision making based on repository containing the electronic Health Records and the Health History of its patients.
REFERENCES


15. “Telemedicine, a confluence of communication and information technology is reaching rural India to provide quality healthcare”. ICT in the Health Sector, Infodev,2006

