The Role of Service Oriented Architecture in Telemedicine Healthcare System

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Abstract

Interoperability in telemedicine system is one of the major concern in telemedicine health care system. It is difficult to design exact and flexible interoperable architecture in telemedicine which transmit data and exchange information between systems to systems. The Service Oriented Architecture (SOA) is playing major role in the development of such system which helps to exchange the information between similar and dissimilar telemedicine applications. Using SOA and external web services, the issue of interoperability can be resolved. The aim of this paper is to describe the importance of SOA in telemedicine through distributed system architecture design and implementation, which is developed in .Net platform using external web services. The architecture of telemedicine system which we have developed is comprises of three layers that are Presentation Layer, Business Logic Layer and Data Layer.

1. Introduction

Healthcare is about prevention from illness. The term healthcare system refers to a country's system of delivering services for the prevention and treatment of diseases. Healthcare systems are now changing due to the dynamic nature of technological and scientific medical practices. The healthcare providers are now swiftly adopting the technology into their health care procedures such as modern surgery that helps to create the modern hospitals. Due to the advancement in medical technology the cost of treatment becomes unbearable. Lots of health care providers, especially hospitals cannot manage to pay for high cost equipments to take care of diseases and wounds. Some complex kind of treatments like bypass surgery of heart, surgeries, trauma care and other complex procedures need expert medical teams including equipment and facilities. Such resources are only available at hospitals and surgical centers with expert doctors. Therefore people who are disable or living in rural areas need to travel huge distances to access more costly and complex levels of care.

Telehealth is a method of treatment by using telecommunication technology such as telephones, cell phones, text messages, Personal Digital Assistant (PDA's), the Internet and video conferencing. Telehealth care systems are becoming more popular due to its mobility. Nowadays the word telemedicine is well-known among physicians, medical experts, biomedical engineers, and others. But what exactly does telemedicine mean? The following statement on telemedicine is fairly informative[1].

> "Telemedicine utilizes information and telecommunications technology to transfer medical information for diagnosis, therapy, and education [2]"

Telemedicine provides the facility for patients to receive medical treatment from their own desired place. It helps to save the time and money for such people who can not afford the travel along with the factor of cost. Telemedicine helps in providing significant services to those areas where medical facilities are not available commonly. Apart from benefits of telemedicine, there are such obstacles that exists in this area. Those barriers are legal issues of physician, patient confidentiality and so on.

Currently telemedicine systems involve an integration of networking technologies with healthcare processes. The interoperability problem in telemedicine is clear in patient monitoring, diagnostic, decision support and communication systems needed at the point of care. Different telemedicine systems are made by different vendors and they apply different technology, standards and information

978-0-7695-3575-3/09 $25.00 © 2009 IEEE
DOI 10.1109/CISIS.2009.181

interchange. When these systems are used by the users, the problem of interoperability occurs because of its scattered state of existence. If that problem is solved, then the development and maintenance of these systems could be restructuring with reusability [3]. The SOA is playing major role to solve the problem of interoperability. Interoperability is consisting of three major parts which are Physical interoperability, Data-type interoperability and Specification level interoperability.

In this paper we explain the role of SOA through the design of telemedicine healthcare system architecture that we have developed. The system is implemented for support of doctors, nurses and patients. In addition it is designed for those patients who are aged, disable and can not move without stinting from their places. Using our design, the nurse will visit the patient; establish third generation (3G) connection from cell phone to our designed architecture/prototype in order to treat the patient. In case of not establishment of 3G connection, nurse can also send Multimedia Messaging Service (MMS) messages to doctor which will be received directly to our designed prototype.

Figure 1 is showing the overview of designed architecture through high level context based diagram. It consists of three main different layers. Internet layer of a system works as a presentation tier including presentation logic of a system. Web server is located between the Internet and firewall tier where the server communicates with the web services and application server when it is needed. Middle tier holds the application and database server with all the modules of a system installed. It creates a channel for communication between application server and its modules. It also plays an important role to share the information whenever it is required. Database server communicates with the application server through a specific module and store and fetches the information when it is requested.

2. Research Methodology

Design Research is used and implemented as a standard methodology. Design research is also called as 'Improvement Research' [19]. It emphasizes on problem solving. In this research, we have proposed and implemented software architecture of telemedicine, in which there are several problems such as interpretability and so on. To evaluate this problem we considered several aspects of telemedicine applications in order to fill the information gap of current problem.

In order to carry out this research, the study of the previous work in the field of telemedicine is needed, a survey of the existing applications and comparison is done deeply to propose and analyze the suitable software architecture for the telemedicine healthcare system which will be free of several problems.

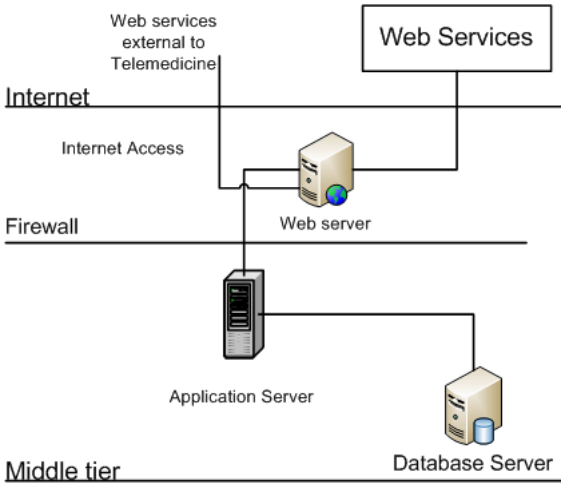

Figure 1. Context diagram of desgined application

3. Service Oriented Architecture Design

In order to propose our SOA design (Figure 2), we considered previous architectures exist in the market.

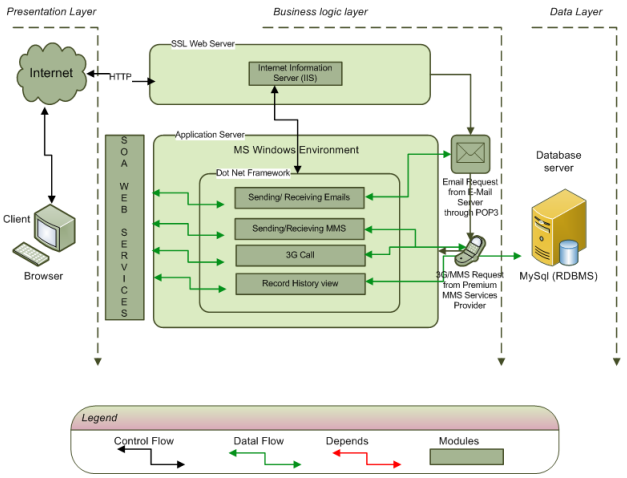

Figure 2. SOA Design

As far as our findings are concern, very few telemedicine applications are using Service Oriented Archiecture [3, 7, 8]. This detailed design is consist of an architecture which is SOA that is easily extendable to other telemedicine applications (similar and dissimilar). This will help to resolve the information gap i.e. interoperability between two or more telemedicine systems. The design includes an application and architecture that is easily extendable and interchangeable to other telemedicine network in order to solve the problem of consistency.

3.1. Detailed Description

The designed software architecture is consist of modeling concepts of the application. The presentation layer deals with the presentation logic where the information will be exchangeable between nurse and doctor. The 3G connection will be established from nurse end to the doctor's end. The doctor will be available to our designed telemedicine application and write the medical prescription to the patient. Simultaneously the doctor will be responsible to log on our one of offered web service in order to upload the patients history and medical prescription. In this way the doctor will upload the medical prescription of the patient to database and that will be delivered to nurse end as well.

The business logic layer is used for the communication among the modules, databases and external web services including 3G connection providers. Our application would be deployed on Visual Studio .Net Framework with Internet Information Server (IIS) and MySql is used as a database. Receiving MMS, 3G call module will receive the MMS and video call from our premium service provider, then it separates images, video's, and other data in order to save into windows file system. Similarly it will collect the patient's description as a text and store all those information into databases. Receiving Email will also work like receiving MMS and 3G but it receives email from external email server and stores all those information in to databases. When those MMS, videos and Emails will be received on application server and stored into the database then doctor and specialist will be able to look on patient's data according to their latest history of prescription available. The patient videos shall be presented in such a way that they can easily be compared on computer screen. Doctors can also search for patient's history record on the basis of their general description and telephone number.

The two main services are offered that are 'InsertData' and 'GetData'. 'InsertData' is used to enter the data into databases (physician prescription) and 'GetData' is used to collect the data. In order to use these services, the physician need to log on first. Afterwards the written medical prescription will be added automatically. Same data can be retrieved by a physician from any other telemedicine application with certain restrictions. This strategy is solving the problem of interoperability as the data can be interchanged between similar and dissimilar applications.

Figure 3 is displaying the graphical user interface of table 3 where physicians can insert and get the data though proposed scheme and the server will provide the response. Simultaneously the data code will also be generated in order to identify the service used; sample code for GetData set is shown in figure 4.

Service	*Server Response*
Login to service	Service log on to centralized Database
InsertData	Inserts data into specified table in Database
GetDataset	It returns a dataset from service
Logout from Service	Logs out the user from database

Table 1. SOA Web Service and Server Response

3.2. Assessment of the proposed architecture

Some advantages of our proposed architecture are:

3.2.1 Location Free

The proposed architecture eliminate all the limitation of the location and it can be efficiently employ the valued services of presented doctors.

3.2.2 Low Cost

The proposed architecture will also improve the efficiency in healthcare delivery by standardizing electronic data interchange.

4. SOA Web Service Functions

A service-oriented architecture is basically a collection of services. These services can communicate with each other in order to exchange information. The communication between these services can involve data interchange. At the moment, the technology of Web services built on existing and emerging standards such as HTTP, Extensible Markup Language (XML), Simple Object Access Protocol (SOAP), Web Services Description Language (WSDL) and Universal Description, Discovery and Integration (UDDI). Designing an effective architecture especially for the problem seems like a promising solution[12].

In our approach, we have created two main web services InsertData and GetDataset. These services are automatically generated by designed application. For each service there is server response(Table 1). This will help the doctor to insert and get the data from any other place as the database will be available over public network (Internet) with certain security requirements. The role of external web services in our application is quite important in many senses due to that lot of web services we have used in our application. SOAP has been used as an XML based message

Figure 3. SOA SERVICES [6]

binding protocol, the primary protocols of SOAP are HTTP and HTTPS but for communicating with the external email server (Figure 5).

5. The role of SOA in our designed application

We chose service oriented architecture for our telemedicine application because in today's world most of telemedicine systems are designed for a turnkey solution. Normally, it is quite hard to design such system architecture by different manufacturers that interchange the data with other. For example clinic 'A' is not interoperable to clinic 'B' and can not retrieve the patient's history. In the same way telemedicine system frequently does not integrate the clinical data with other organization's infrastructure.

Furthermore doctors and physicians manually maintain the history of patients in order to give better treatment for future. Firstly, numerous specialists from multiple clinical communities share the data of patient's record. Secondly, electronic communication is more popular rather than manual communication and it is also reliable. So physicians rely on electronic data interpretation more than human interpretation. Thirdly, the intercommunication of different telemedicine creates the issue of interoperability. This issue is important when the procedure of health care system becomes distributed with rising communication between professionals from one sector to another. In this time, there is a need of such system which can easily handle the issues efficiently. In general the purpose of telemedicine is the arranging and integrating the data in such way that the people of healthcare sector should access that data outside the surroundings. According to medical informatics handbook [9]

GetDataSet
Test
The test form is only available for request from the local machine
SOAP
The following is the sample SOAP request and respons. The placeholder shown need to be replaced with actual value.

```
POST /test/TeleMedicine/CRUD.asmx HTTP/1.1
HOST: 80.244.65.132
Content Type: text/xml; charset=utf-8
Content-Length Lenght
SOAPAction:
"http://tempuri.org/TeleMedicineCRUD/Service1/GRUD_GetDataset"

<?xml version="1.0" encoding="utf-8"?>
<soap:Envelope xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance" xmlns:xsd="http://www.w3.org/2001/XMLSchema" xmlns:
SOAP="http://schemas.xmlscap.org/soap/envelope;">
  <soap:Body>
    <CRUD GetDataset xmlns="http://tempuri.
org/telemedicineCRUD/Service1">
      <strQuery>String</strQuery>
    </CRUD GetDataset>
  </soap:Body>
</soap:Envelope>

HTTP/1.1 200 OK
Content Type: text/xml; charset=utf-8
Content-Length Lenght
<soap:Envelope xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance" xmlns:xsd="http://www.w3.org/2001/XMLSchema" xmlns:
SOAP="http://schemas.xmlscap.org/soap/envelope;">
  <soap:Body>
    <CRUD GetDatasetResponse xmlns="http://tempuri.
org/telemedicineCRUD/Service1">
      <CRUD_GetDatasetResult>String</CRUD_GetDatasetResult>
    </CRUD GetDatasetResponse>
  </soap:Body>
</soap:Envelope>
```

Figure 4. SOA SERVICES [6]

there are such rules that say:

- The communication should be managed in better way between dissimilar organizations.
- There should be a certain rights on external resources in order to integrate the patient's data over the public networks.

Despite of all issues, SOA can play major role in these conditions. With the help of SOA, we made our designed architecture to integrate with business drivers, common business and technical goals, and recurring technical challenges business driver. Our telemedicine application is using common programming interface and interoperability protocol. By using SOA we will get following benefits.

- **Reuse:** Through this feature our telemedicine application will create the service which can be used for other applications.
- **Efficiency:** By this benefit, our telemedicine application gets the ability to make the services and new application using a mixture of new and old services. This service provides the facility to the application to focus on data to be joint instead of implementation underneath.

- **Loose technology coupling** Through this benefit the telemedicine application can model services separately of their implementation environment and creates messages that can be sent to any other services [11].

The services used in our approach are basically implemented as a software entity that relies on a single instance and interrelates with application through loosely coupled, message based communication model. The terminology behind the services is quite same as component based development, only the different is of defining the terms used in elements with in web services. Let us briefly explain that how some of technologies in our designed telemedicine application are used. Using figure 5, there is a interaction of designed application with WSDL services through certain messaging protocols. Those services are described below:

- **Service:** A logical unit; which is used for published interfaces.

- **Service Provider**: A software unit that acquires a service requirement.

- **Service Broker:** A particular type of service supplier used in Telemedicine application to pass service request to one or more providers

- **Service Locator:** A particular type of service supplier used in telemedicine application to perform like registry and look up for service providers and service location.

- **Telemedicine application :** The software that requests services. Normally it is a client which calls the service provider.

In most of cases, there is a misconception that all web services employ XML messages with Simple Object Access Protocol (SOAP) over HTTP (Hypertext Transfer Protocol). That is false. Web services messages can employ XML; it is done mostly through SOAP headers, but usually that is not necessary to use SOAP indoctrination for body of message. For the web services there are two well distinct principles: WSDL (Web Services Definition Language) and UDDI (Universal Discovery, Description and Integration).

XML web services are part of this Telemedicine application and in this regard there is a wide range of vendor support available with rising number of platform and tools to organize web service [12].

With the consideration of all above services, our designed architecture has flexibility in formats and transport protocol with interoperability of web services.

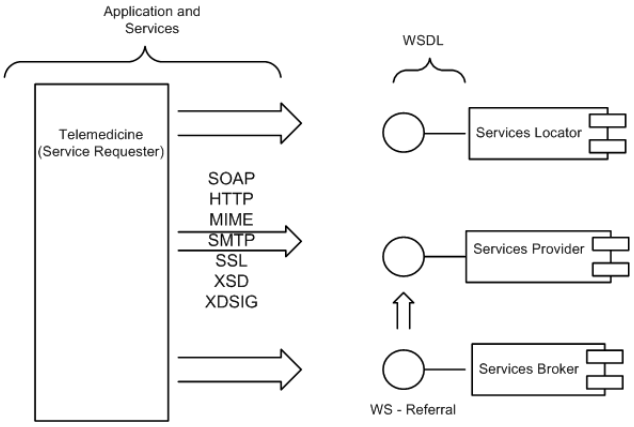

Figure 5. XML web services used in our application [12]

5.1. Interoperability

Interoperability is the ability to transmit data and exchange information between systems to system and allowing each other to process information independently. The transformations of the patients records through patient to doctor's end are based on a predefined communication protocol for data interchange, which is used to control and maintain connection between the two sites, thus ensuring portability, interoperability and security of the transmitted data [5]. The interoperability could be evaluated by the following perspective.

5.2. Physical interoperability

Physical interoperability is usually attained by transferring information through electronic media such as electronic files on any storage media. In our designed telemedicine application system, the problem of keeping the patient records (pictures and videos of their diseases) would be occur when the data will be exceed and there will be no alternative volumes for replacing. The above approach of interoperability is very important for the application as performance point of view, as the information must be entered into the applications using different interface.

5.3. Data-type interoperability

Data-type interoperability focuses on the type or the structure of the data which would be transferred from user end into the application end. Our telemedicine application is a web based application and designed for the aged patients so that the videos and pictures of the infected area of the patients should be presented which would be accessible on web.

5.4. Specification level interoperability

Specification level interoperability gives us high-level, representation-independent approach to combining software components that are written in different languages or that are run on different machines. Specification level interoperability approach thereby attains information hiding for interoperating programs, encouraging the use of entity descriptions (type definitions) that promote the overall organization of a software system. [10]. Using XML, our software components are reusable and can be fixed to other language.

6. Related Work

In this section, we discuss the present and existing work related to our domain. Broad research has been undertaken regarding e-healthcare system [14, 15] but there is lack of work done in the field of telemedicine influenced by SOA. Previous telemedicine architectures were different then presents one [18]. Most of the telemedicine applications were stand-alone, which are currently in use. In today's plug-and-play world telemedicine systems are virtual more then physical while system components are interconnected with the perspective users, while the records of each user could be easily reside on remote computer situated somewhere on internet. For example a doctor is in travel may carry with him set of apparatus including his mobile device. The architecture allows that mobile device to connect with infrastructure available in visited room. In this regard the doctor can view and control the devices of hospital using his personal devices.

"A system design for telemedicine healthcare system" [13] discuss the problem encountered by distributed telemedicine systems by emphasizing the issues regarding vendor lock-in and data integration. They define a solution of data integration, vendor lock-in through the design of the system by adopting SOA but the interoperability is not explained widely. "A distributed e-healthcare System based on the service oriented architecture" [15] provided the concept of distributed e-healthcare system that used SOA design and implementation of e-healthcare service. Their e-healthcare system focuses on the relationship between patient, physician and nurses. The source is using common open standards such as XML, SOAP, WSDL and UDDI. "Service Oriented Architecture (SOA) Implications for Large Scale Distributed Health Care Enterprises" [16] describe scalability and availability enhancing the integration and interoperability, the paper explained about characteristics of SOA-based components. "A Service Oriented Architecture for a health research data network," discussed about control over access, use of resources and confidentiality protection [17].

7. Conclusion and future work

In this paper we have discussed the importance and the role of Service Oriented Architecture in telemedicine system. Telemedicine is widely important topic nowadays and there is lack of such system that is using Service Oriented Architecture in telemedicine, while our intention is to present the importance of SOA in telemedicine through the design of architecture. Telemedicine requires latest solutions, architecture designs and implementation with those technologies which are widely popular and easily reusable after certain period because patient history is quite important to keep.

Presently our system is based on our own designed web services, which are accessible to every one related to our system through server. In future we would like to work on semantic interoperability which is automatic interpretation of the data from system to system. We are intended to resolve this problem by using SOA and our design. That goal can also be achieved through SOA using web services. Initially we are focusing on semantic interoperability between our designed systems and then we will cover towards different heterogeneous telemedicine systems.

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