A Telemedicine Network Using Secure Techniques and Intelligent User Access Control

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Abstract
This paper reports the development and design of the State of Santa Catarina's telemedicine network in Brazil. The resources concentration, like hospitals and clinical staff, in Brazilian large cities have been a problem in public healthcare policies improvement. Telemedicine technology for large scale telediagnostic, processing of routine outpatient examinations, the electronic delivery of examinations results integrated with the decision process of wetter to provide further treatment for a patient, is the way to overcome the difficulties imposed by healthcare concentration. The State needs to reduce costs like patient transportation, improve the quality of healthcare service and the origins control of these examinations, motivated the creation of this medical knowledge network. As a result it promoted better patient care, making faster diagnosis, creating a patient information history, reducing the examinations redundancy, maximizing this way, the social welfare and the health technological park on the Santa Catarina State.

1. Introduction
The telemedicine was proposed in the early sixties [1] as a way to provide health care from far health reference centers for isolated or not assisted people or communities. The use of telemedicine technology is commonly for reduce in costs for patient transport, minimize the service queues or to prevent the concentration of patients in large cities because most reference health centers are there [2]. Some advanced features are now built on most common telemedicine systems since the computers technological jump [3]. The latest technologies in artificial intelligence, computer network, security, process classification and images recovery now let the telemedicine systems advance to a new age. The major telemedicine works are related to "teleconsultation", a doctor interacting from distance with the patient, or, teleconference between doctors for a complex case analysis. For some time works like that was developed and used in countries like United Kingdom, as a government target for health improvement. Although widely used on developed countries, the telemedicine still needs a lot of work in most under developed countries.

The excellent potential to increase access to health care by the population living far from the health centers is one of the best sides of the telemedicine, particularly in populations from countries that are not fully developed [3,4,5,6,7]. These under developed countries presents clear objectives for telemedicine applications development for support of their population.

The telemedicine aims to reduce costs like patient transportation, improving the quality of healthcare services and the origins control of these examinations. The objective is to promote better patient care, making faster diagnosis, resulting on a patient information history and also reducing the examinations redundancy. All these objectives can’t be reached without a security system working together as a way to ensure the integrity, authenticity and reliability of the entire data that is exchanged across the internet between the system and users.

2. Related Work
This section will present related telemedicine works and studies. They are: The Telemedicine and Teleconsultation System Application in Clinical Medicine [8], Standardization through Information Management and Technical Applications [9], A Proposal for Telemedicine Reference Model for Future Standardization [10], Evaluation of the Low Cost Telemedicine System in Taiwan [11] and Telemedicine
in Sub-Saharan Africa: A Proposed Delphi Study [12].

The Telemedicine and Teleconsultation System Application in Clinical Medicine is a study comparison among common conference software like Microsoft NetMeeting and the effectiveness of telemedicine and teleconsultation compared with traditional consultation and supervision.

The Telemedicine and Teleconsultation System Application in Clinical Medicine is a work that describes the application of these standards in the health care industry, and future development directions of telemedicine standards, the need for telemedicine standards and classify various standards of telemedicine.

A Proposal for Telemedicine Reference Model for Future Standardization is a related Indian work that shows different interfaces on different medical equipments used for telemedicine and the needs for standardization.

Evaluation of the Low Cost Telemedicine System in Taiwan is field experience on telemedicine that shows one example of a telemedicine network constructed with low cost technology available, like ADSL and common computers, to enhance the access to healthcare services on mountainous region and the lack of physicians on such area.

Telemedicine in Sub-Saharan Africa: A Proposed Delphi Study shows that telemedicine, even if it will not solve all the Sub-Saharan Africa’s medical problems, is a start point to make health care reach Africans that live in areas with limited medical facilities and personnel.

3. Telemedicine Network

The University Hospital of UFSC (Federal University of Santa Catarina), in partnership with the Santa Catarina’s Secretary of State for Health (SES/SC) developed a research project to create the Rede Catarinense de Telemedicina (RCTM). The main role network gives access to images, signs and medical findings generated from health centers distributed all around the state.

The cost reduce for patients transportation to health reference centers, provide fast diagnosis for the patient findings, give access to health services that was too far from some part of the population was some of the motivations to create this knowledge network.

In Brazil the establishment of a public health network have some problems, as a result of health professionals that are unprepared to deal with computer interfaces, since they doesn’t had, in their education, suited training to interact with this kind of technology. Another important issue to be considered is that the patients have more than one credential to access the Public Health System, resulting in inconsistent patient data and comprised history integration between health institutions. To solve this issue, the federal government took the initiative to create the National Health Card or SUS Card that consists on a personal document that identifies a user of the Single Health System (SUS) with full personal information data on performed clinical procedure, prescribed medication, and all the other relevant information.

The creation of a telemedicine public network has some basic requirements like examinations must be easy and agile to access through the global network and it has to be secure against non authorized access.

The designed toolset needs to be user friendly and intuitive, requiring just a few hours of training for user assimilation, making possible to access the system from any location that has a computer with internet.

The philosophy behind the creations of this network is the decentralization of health care giving access to specialized physicians to various types of examinations made far from the main health centers, providing better secure and fast patients data access and avoiding the patient transportation to these reference centers for health care. Another important goal of this network is the decision-making agility since the physicians can access the findings directly through the web. Thus, the network was designed to ensure the large-scale diagnosis services for assistance routine examinations in a public health system, expanding and improving the patient assistance with quality results on the health care process. With these requirements and developing a new way of patients care, was designed a pioneer state model, which includes the production of large-scale routine reviews like electrocardiogram, ultrasonography, computed tomography, magnetic resonance, and others.

The telemedicine public network was designed with some tools like the Telemedicine Portal that is a secure web tool developed to access the entire patient data available in a relational database. DICOM Server, a server for medical images that can be used to store and/or retrieve images and/or other types of examinations defined in the DICOM 3.0 standards. It was designed to work in Picture Archiving and Communications Systems (PACS) environments, within the health institutions, such as hospitals and radiological clinics. Parenteral Nutrition software is a client-server application for calculation in parenteral nutrition and remote persistence of prescriptions. And DICOMIZER is a software that capture images for radiological equipment that doesn’t have the standards
for DICOM image.

### 3.1. Telemedicine Portal

Basically the portal of Telemedicine is a secure PHP system that accesses relational database where the data of all patients, health institutions and physicians, who interact directly with RCTM, are stored. Because it’s a web tool, we can say that it have access virtually from anywhere, a user just need a computer with a web browser and internet link, that’s why the security issue is so important. When the system was designed ergonomic and cultural concepts (Picture 1) were taken into account to make easier and more attractive the use of this tool. The portal has the ability to work with a heterogeneous dataset like video, images, audio, text, XML and DICOM files. This dataset is the standards used in many different exams types that are stored on the relational database.

**Picture 1 The Telemedicine Portal’s main interface**

#### 3.1.1. Portal Security

Most web systems commonly use the tuple User/Password and Secure Socket Layer (SSL) to secure data exchange around the internet. The First part is to identify the correct person accessing the system giving to this person some privileges, the second is just to secure that the data coming from server to client and vice versa cannot be intercepted or even if it is intercepted, it will be almost impossible to understand the content of these messages. In some cases it is enough, but if your system have important data and can be aimed for data robbery you will need to improve your security, mainly because the most fragile part on the system is your user that can have the password stolen with the use of some very common tools like Trojans or simple like putting the users birthday on the login area. With that in mind we improved the system security using first the tripod of security (Picture 2), the SSL that give reliability, digital protocol that provide integrity/trust and digital signature for authenticity. But even with all these tools, you still can have your key stolen and used to get all the data you have permission to access. Thinking on these problems, we are using pattern recognition on user behavior to improve the identification of possible intruders.

**Picture 2 The tripod of security [13]**

First we mapped the entire system (Picture 3) to ensure that all steps made by some user will be correct logged, the data stored is basically the IP address, user name, action (step) on the system, time and status (if the action was succeeded or failed). All these data analyzed with Instance Based Learn [14] to make the user “signature”, after that we use every time this user use the system to compare the behavior on the system with his signature stored on the database, for similarity comparison we use the Markov similarity that is most used on behavior analyses on web systems [15].
3.2. DICOM Server

The DICOM server works with storage and retrieval of medical images and / or other types of examinations specified in the DICOM 3.0 standards, it was designed to work in PACS environments, inside of health institutions, such as hospitals and radiological clinics. It is a fully multiplatform system that can run on any operating system available on the market, like Linux, Solaris, IRIX, Windows and others. Its operation requires some programs infrastructure on the operating system such as a specific virtual machine, and a database manager.

3.3. Parenteral Nutrition

The first parenteral nutrition system module, made in 2002, provided parenteral prescriptions improving time for both physicians and the hospital’s pharmacy. The first version just registered information of newborns and new prescriptions were daily made, since then it just improved in features, usability, extensibility and portability extending its initial focus on parenteral nutrition (PN) calculation. These new features allowed different PN formulas on every hospital it is installed. The integration with the Telemedicine Portal brings PN prescriptions to web, allowing registered users to visualize PN prescriptions created on their respective hospitals. The PN prescription suggestion engine applies artificial intelligence to stored prescriptions to suggest inputs for initial PN prescriptions.

4. Results and Conclusions

With 63 municipalities, 12 of examinations modalities, 62,400 registered patients, 1,300 physicians and a total available volume of more than 70,000 examinations stored on the database, and approximately 6,000 new examinations each month, the Santa Catharina’s telemedicine network is a reality. Daily more than 600 people use the Telemedicine Portal to send or respond an examination. With the consolidation of this knowledge network the patient can be examined on their own city and the review is published directly on the Telemedicine Portal for instant access. The time between publishing an examination and the report from the physicians located on the health center almost never exceed 24 hours, this is quiet relevant because in the earlier times before the telemedicine, in some cases the patient needed to wait months to have the result. The fast answer or discussion on an examination prevents the patient to be moved to a health center to perform a simpler
procedure that can be done on the patient’s city or a closer reference city. It also prevents examinations and results to be sent by common mail, savings time and money for the State and the patient.

The idea behind this project is to reduce cost of deployment using national technology without great changes on the work method for doctors and technical staff on the health centers. The Telemedicine Network integrates on a single secure online platform data and image collection from an examination, manages the results, the request for hospitalization, discussions around the examination, the decisions to be taken, grouping together all the features of Telemedicine care.

All the hospitals that carry out examinations for the SUS, a government institution, became part of the Santa Catarina’s telemedicine network improving the network growth. Henceforth, these entities are now enabled to pass their examinations to the Telemedicine Portal, which enables greater agility to provide findings, because the exams can be reached instantly by nearly a dozen doctors on the health reference centers that are paid by the State. Services of telecardiology are incrementally growing and present rates of hundreds examinations per month for each city on average. Assessments made show that when a city is included on the telemedicine network, the examinations are no longer forwarded for approval by the secretary of health through common mail, and now it is sent to the Portal, in a quick, economic, secure and efficient way.

At the time when a town became a regional reference for a type of examination, the counties around it, have a displacement of patients reduction to other far reference health centers, which now targets the new closer micro-pole of this examination specialty.

The security technology used is the most advanced and more strong then the defined by Brazilian laws, that just obligate to have SSL with digital protocol. Doing this improvement in security we also provide trust, authenticity and reliability even if a user loses his password for some Trojan or computer virus, protecting, this way, all the important storage data against malicious users that will probably made an improper use of this knowledge. The behavior detection not just secures the system against non authorized personal but also secure the authorized personal not to use or not to access not allowed data. The behavior detection module still experimental but in a fill days getting information and acquiring users “signatures” it detected a couple of simple uncommon behaviors like a massive numbers of login tries without success configuring a possible try to break the password by brute force. In the future the system will gain a response behavior module that will react for every uncommon behavior detected. Some action like send an e-mail to the user warning him about the access and the behavior, send a warning to the system administrator with the held operations, or simple blocking the user, will be part of this module.

On the next months other cities around the Santa Catarina State will be integrated to the Telemedicine Network, expanding services like remote diagnostics, electronic findings through the portal, digital electrocardiogram examinations, diagnosis by images and laboratory finds. Along with new deployments, health professionals involved will receive training and support to improve the software use.

Now we have an agile, easy, high-quality, with self technology secure public telemedicine network, that provides greater access to patient data, helping in medical decisions, cutting unnecessary costs to the State, which finally provides a high impact on the population welfare as a whole.

6. References


