T@LEMED: Medical imaging tele-cooperation technologies providing medical services in Latin America

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Abstract— **Developing countries have very high patients-per-doctor ratios that are a common indicator of the amount of healthcare that exists in a region. As a point of comparison, developed countries such as the US have one doctor for every 200 to 500 people, while developing countries in East Africa have as little as one doctor for every 40,000 people. In Brazil and Colombia the situation is not completely different according to WHO charts. The state of health of a population is a direct determinant of its development, and investment in health is a prerequisite to economic and social progress. Developing countries need low cost, sustainable solutions for the local delivery of primary healthcare and efficient access to medical expertise when needed. T@LEMED project introduces an e-health model to the provision of health services in strongly underserved regions in Colombia and Brazil. The implementation of this model is supported on telehealth technologies as well as on evidence based medicine. The target clinical applications include typical infectious diseases for the region such as malaria and tuberculosis, and general ultrasound applications such as pregnancy control, urology and cardiovascular diagnosis. In this paper we are going to provide information about the deployed medical network and utilization information for the field trials in Brazil and Colombia.**

I. INTRODUCTION

Almost half of the human mortality in developing countries is caused by infectious diseases. These deaths occur primarily among the people with the most reduced or impaired access to medications and health facilities necessary for prevention, diagnosis, and treatment and they are very strongly related to poverty and social problems. In many developing countries the epidemiological profiles have dramatically changed over the last decades. In Colombia the incidence of tuberculosis (TB) was 26.5 per 100,000 populations, and mortality was 3.4 per 100,000 in the year 1996. The Colombian Pacific coast is the region with the highest endemic incidence of malaria in Colombia with approximately 30% of the cases produced in about 2% of the country population. The European Latin-American telemedicine demonstration project T@lemed [1] aims to help combat malaria in Colombia by implementing a special telehealth system and respective telemedicine services provided by high level healthcare centres in Bogota and Cali for healthcare facilities in endemic rural regions.

In Brazil there exists a two-tiered system of healthcare access. Those with sufficient means have access to a private system of healthcare that provide quality treatment on demand, while the reminder of the country relies on the overburdened system of public clinics and hospitals. The ever increasing size of the poor, elderly population as well as the increasing cost of treatment for a limited supply of public healthcare services suggest that the public healthcare structure will become even more heavily used in the coming decades. At the same time the poorest segments, which are generally perceived to be rural, black and mixed-race Brazilians are loosing access to healthcare. Comparing health services provided in rural and urban areas, overall it has been found that utilisation is lower in rural areas. A significant factor in lower utilisation is that rural residents have less access to health services and that only very reduced specialist care is provided. The different healthcare needs of large urban cities and tiny rural villages are one of the country's greatest challenges. It is also evident that Brazil's urban poor have slightly worse health than their

rural counterparts, prompting demands for improvement in the timeliness and quality of health care. In order to improve this situation T@lemed project has implemented a tele-imaging platform and respective services for ultrasound examinations in rural regions in Brazil

II. METHODOLOGY

A. Colombia

In Colombia two telehealth networks have already been established that provide teleconsultation services to low level healthcare centres in rural and remote regions for the early diagnosis and treatment of malaria and other infectious diseases. The networks link experts in Cali and Bogota with low-level healthcare facilities in endemic, underserved regions at the Pacific Coast and in the Colombian upcountry. The expert evaluates diagnostic information such as microscopic images, medical device data and case reports in order to advice and supervises the local healthcare staff in diagnoses and treatment of the infected patients, in particular in severe cases. As the technical backbone an extended version of the telehealth platform TOPCARE is used, that has been developed by Fraunhofer IBMT and the Greek partners ICCS and Datamed in the context of the European Commission's research and development programme *Technologies for the Information Society (IST)* [2]. The TOPCARE platform has been extended respectively in order to serve the local medical needs on infectious diseases. In particular, a special Telehealth Kiosk for infectious diseases has been introduced for rural hospitals and out-patients health centres.

B. Brazil

In Brazil tele-consultation services for medical ultrasound examinations such as OB/Gyn, pregnancy control, urology and cardiovascular diagnosis were implemented for rural hospitals using the tele-imaging platform, called TeleConsult, developed by Fraunhofer Institute IGD and the German partner Medcom GmbH. TeleConsult provides a wide spread of possibilities. It is able directly to acquire ultrasound images from an ultrasound device, to enrich a given image material with additional informations and to send it as a message to distant expert doctors connected to the medical network over Internet. This could in particular save unnecessary transfers of patients from rural healthcare sites to the rare high quality and high cost resources in the cities while on the other hand rural healthcare centres with less expertise in ultrasound examination are trained and encouraged to introduce medical ultrasound examinations in their facilities.

III. T@LEMED PLATFORMS

A. TOPCARE

TOPCARE is a modular and secure telemedicine and e-homecare platform that serves not only for bringing co-operative tele-healthcare to patients with chronic diseases at home but also for providing tele-consultation service in telemedicine scenarios. The TOPCARE Platform takes advantage of Internet technologies and makes use of the Internet itself to communicate medical data in a secure and trustful way between patients and their physicians as well as between healthcare facilities and expert centres. The backbone of the TOPCARE Platform is an e-health application server, the TOPCARE Telehealth Server. It stores the patients' medical data received from home monitoring systems and telehealth Kiosks, manages the access of the health professionals to the patients' health records and administers the telehealth networks. The content of the patient's health record is presented in a WEB browser. The access to trend curves, tables with measurements, medical images and case reports is given to authorised health experts, who evaluate the patient's medical information and give appropriate treatment recommendations. A cryptographic e-Token is used together with state-of-the-art cryptographic software in order to access the patient's data and to ensure privacy and data integrity.

A special TOPCARE Telehealth Kiosk for infectious diseases has been introduced in T@lemed. The TOPCARE Telehealth Kiosk is a Linux based PC with an easy-to-use and self-explaining application that supports a set of connectable medical devices for the point-of-care (i.e. a blood analyser), a digital consumer camera that can be mounted on a microscope, an X-ray scanner and an integrated web cam and application sharing module. For each new patient a health record is created on the kiosk. With the camera and the microscope a microscopic picture set from a blood sample is taken with the help of the kiosk application. Together with other available diagnostic information such as measurement results from connected devices and a case description about the patient's status and symptoms, the picture sets are sent to the TOPCARE telehealth server for evaluation by an expert. His recommendations are sent back to the kiosk. In an online mode video conferencing and desktop sharing of the kiosk application is also possible in order to discuss in particular urgent cases.
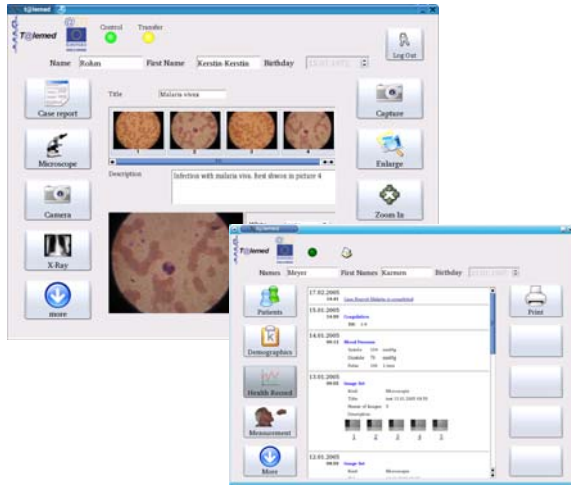
Figure 1: TOPCARE User graphical interface

B. TeleConsult/TeleInViVo

TeleConsult [3] platform provides physicians with a wide spread of functionalities. For example, the doctors working with it are able to make annotations on the digital medical image and send it to the expert doctor. That could happen either in offline-mode (messages will be sent at a favourable date and time, for example during the night) or in online-mode (real-time tele-consultation). Moreover, the online-mode gives doctors the opportunity to communicate with a given partner in real time. In this case, both doctors share the same image data set and through a chat window and transferred mouse actions they can interactively discuss a medical case. In Figure 2, the graphical user interface of the imaging tele-consultation platform is depicted.
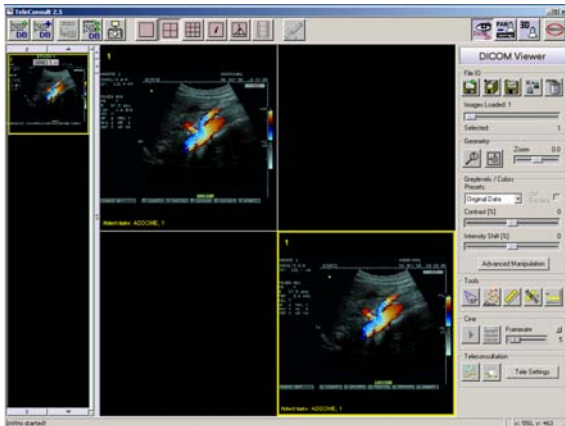

Figure 2: TeleConsult user interface

TeleConsult has a modular structure that can be easily extended by "plugging in" additional modules. For instance, TeleConsult's medical acquisition module acquires ultrasound images. Even portable computers, having an external USB video grabber board, are in the position to acquire ultrasound image frames through the ultrasound video output. Additionally, TeleConsult provides a DICOM client/server module for transaction with DICOM enabled

devices. The acquired data is stored into the local database on system. If it's needed, the stored data can be uploaded to PAC server over the DICOM client/server module. The application supports a very wide spectrum of medical applications varying from gynaecology to abdominal scans and cardiology. In fact, it's able to handle any medical image. In addition, very easily the system can reconstruct 3D dataset [4] with the help of a magnetic tracking system if a medical application requires so.

Both on-line and off-line data transmission is supported by TeleConsult. In case of an on-line tele-consultation, after data transmission both experts will be linked on-line over the telecommunication channel performing "virtual echography" on the 2D/3D-data replicated in each site and viewing the identical images on the screen in real-time and without lag even through narrow-band telecommunication channels. Thereby the TeleConsult executable is the main application, which is responsible for the acquisition and display of the images, as well as for the Online-Tele sessions between two TeleConsult users. The Database Client is used by the main application to store and load images to and from the database. In addition, the Database Client is used to send and receive messages from other TeleConsult users in the offline mode and to import images from the DICOM interface. Thereby there are two modes in which someone can use the Database Client. In the local mode, the Client directly accesses the data, which is then stored on the PC where the software is running. In the Client/Server mode, the Client stores and retrieves the images to and from the Database Server. This mode is usually used, when two or more workstations shall access the same data basis. The Client/Server mode will mostly be used by hospitals with a local area network, where more than one employee is working with TeleConsult.

IV. PLATFORM DEPLOYMENTS

In Colombia, two telehealth networks have been implemented with expert centres in Cali and Bogotá. The Centro Internacionale de Vacunas and the Universidad Nacional in Bogotá are providing telemedicine services to the remote and rural areas of the Pacific Coast and the Colombian upcountry.

The TOPCARE Server was installed in the Universidad Santiago de Cali, where the medical data of the Pilot networks are administrated. Technical support, training and installation of the Kiosk System are provided by the involved universities of the consortium.

Figure 3: System deployments in Colombia

Three Kiosk Systems were connected to the network Cali - Pacific Coast namely in the Malaria center of Buenaventura, the San Andres Hospital in Tumaco and the San Augustin Hospital in Puerto Merisalde.
The experts of the Universidad Nacional de Colombia in Bogotá are providing remote services to a Kiosk System in the San José del Guaviare Hospital. The network advises Radiology and dermatology cases beside Malaria. This network will be extended by a Kiosk installation in the Riohacha hospital in the Guajira department, soon.

The feedbacks from the medical users, who are using the telemedicine services, are continuously positive. More than 2100 patient cases were treated by the established pilot networks from August 2005 until the end of August 2006. The statistics show that picture sets are very important for remote diagnoses. The network Cali – Pacific Coast reports about 2271 microscopical pictures during the mentioned period.

In Brazil, ten (10) installations took place in Rio Grade do Sul and Espitos Santos prefectures. TeleConsult application has been deployed in Santa Casa hospital, which is the referral hospital of four (4) remote clinics in rural areas, in Rio Grade do Sul.
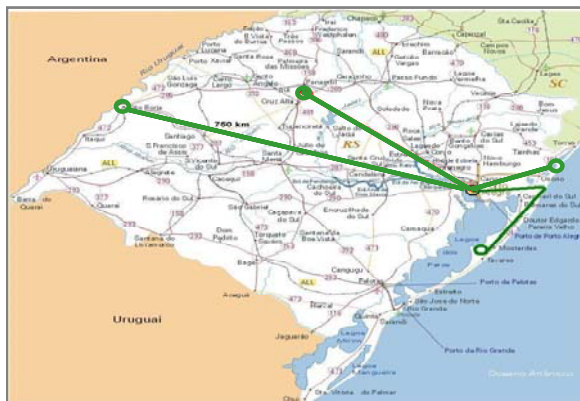

Figure 4: System deployments in Rio Grande do Sul

Furthermore, the system deployed has been deployed in FAHUCAM hospital, which is the referral hospital of four

(4) remote clinics in rural areas of Espiritos Santos prefecture.

Figure 5: System deployment in Espiritos Santos

V. RESULTS

T@lemed project was launched in October 2003. In a first phase the telemedicine concepts for the healthcare improvement in the target regions was developed while the telehealth platforms TOPCARE and TeleConsults were adapted to the local needs and new user requirements.

Presently there are two expert centres under operation in each country.

In Brazil, the Excellence Hospital Centres Santa Casa Hospital, in Porto Alegre, Rio Grande do Sul, and FAHUCAM Hospital, in Vitória, Espírito Santo have been implemented and provide tele-ultrasound diagnosis service on a regular base to three rural hospitals that are:

- Lagoa dos Três Cantos Hospital - Lagoa de Três Cantos - RS
- Fundação Ivan Goulart Hospital - São Borja - RS
- Hospital São Luiz – Mostardas -RS
- Hospital - Cidreira - RS
- Hospital - Colatina - ES
- Hospital Santa Casa - Cachoeiro - ES
- Hospital - Barra de São Francisco - ES
- Hospital - São Mateus - ES

During the first 140 days of the network operation in Rio Grande do Sul, 89 ultrasound acquisitions took place and more than 560 medical discussions performed. The generated traffic occurred from Lagoa dos Três Cantos and Fundação Ivan Goulart clinic in São Borja. The data (mainly videos) transmission time varied between 10 minutes to approximately 50 minutes depending on the available bandwidth.

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