Integration of Multimedia Communication into Tele-medicine and Tele-consultation

Apurva Narayan
Dayalbagh Educational Institute
Agra, India
apurvanarayan@ieee.org

Gursaran Srivastava
Reader
Deptt. of Mathematics
Dayalbagh Educational Institute
Agra, India
gursaran.db@gmail.com

Satish Kumar
Professor
Deptt. of Physics and Computer Science
Dayalbagh Educational Institute
Agra, India
skumar_db@ieee.org

***Abstract*—Telemedicine and teleconsultation are key areas that address the problem of shortage of medical professionals and experts in remote locations by leveraging remote expertise for local problems. Here in this paper we address a real time and non-real time communication system simulataneously between health care professionals for providing expertise and informal/formal recommendations. Such computer mediated systems can bridge the gap between doctors in rural regions and the medical expertise worldwide. It uses social networks as a basic framework of design upon which existing technologies such as video conferencing, tele-conferencing, video broadcast can be integrated easily to enhance the user interactivity with the system.**

***Index Terms*—Telemedicine, teleconsulation, video-conferencing, remote consultation**

I. Introduction

Many studies have already shown the value of store and forward telemedicine and remote consultation in serving populations limited in financial and medical resources. In particular, telemedicine has a central role to play in health care provisions for developing countries which suffer from conditions such as intermittent electricity, limited technical resources and expertise. This solution can be effective in allowing the healthcare professionals to communicate with each other.

There are many kinds of *telemedicine*, from continuing medical education to patient monitoring, but *remote medical consultation* - knowledge sharing between health care workers, focussed on specific cases - is the variant most frequently proposed to improve access to specialist expertise in areas where adequate number of specialists are unavailable.

It has been seen in [1] that any Telemedicine system can be partly or wholly described by a three tier client-server framework. It is observed that any telemedicine system involves collection of data, either remotely by sensors worn by a patient or by a medical practitioner at a fixed location. The collected data is transmitted to the central server via the Internet or other communication channels available such as GSM, 2G, 3G or satellite or even ferries as mentioned in [2]. The transmission of data shall be done in real-time, non real time or opportunistically. Medical personnel retrieve this data via a GUI based system on their PCs, mobile devices or other interactive media. Tier-1 encompasses a network of sensors that perform the actual sampling of signals, Tier-2 encompasses data aggregation devices like a PDA or a smart phone in patient monitoring Telemedicine system or local medical care provider PC in case of patient records management system. Tier-3 is made up of the intergrated telemedicine centre which is the heart of the telemedicine system. Based on the type of service offered by a Telemedicine system, mode of data collection, technologies integrated, deployment architecture and target user group, Mirembe [1] categorizes Telemedicine systems into two categories: Patient Record management Systems (PRSs) and Patient Health remote monitoring Systems (PHSs). We are going to discuss here a system which combines features of both the systems. The Fig. 1 below shows the three tier architecture.

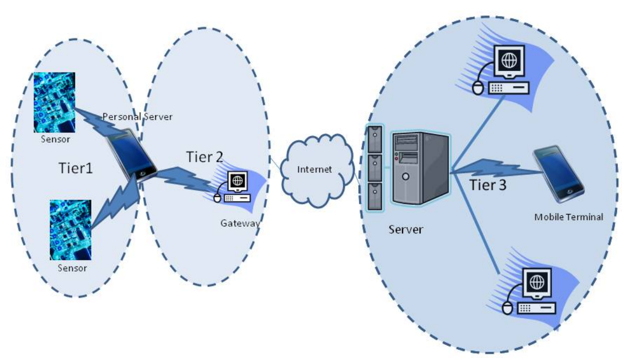

Fig. 1. Three tier architecture of telemedicine systems

The store-and-forward telemedicine systems do offer a unique cost effective service but the major bottle neck of such systems is the turn-around time. For example as mentioned in [3], a telemedicine system deployed in Africa had a turn around time of over 11 days for a new referral where approximate number of referrals arising in a month were around 1510. Some medical cases are time critical and need immediate attention and hence its is clear that there is a more intense scope of research in optimizing the turn around time of such systems and increasing the frequency of interaction of the experts with the remote center.

Telemedicine has got many varied applications as mentioned in [4]. There may be teleclinics [5] where interaction is between doctor-to-patient or doctor-to-practitioner, other instances of telemedicine in action can be seen in [6] and [7] where it is being used for continuing and initial medical education and also for patient telemonitoring and home care as mentioned in [8]. One of the more interesting techniques is found in doctor-to-doctor remote consultation [9] which focusses on specialist consultation using asynchronous computer mediated communication. A comprehensive technical viewpoint has been explained in [10], where such asynchronous remote consultation systems have been divided into message, storage and discussion centric systems. [10] discusses that message centric systems provide email like functionality which ensures doctors and specialists communication easy. These systems are easy to deploy but lack in content management features which are important for establishing social communities. Storage centric systems, such as Web based or message based picture archiving systems, more often used in teleradiology [11] have basic search and storage capabilities. Finally as explained by [12], the discussion centric systems try to replicate the functionality of a web based bulletin board systems. iPath is one such example of discussion group model as specified in [12]. Our system builds upon ipath as the software substrate, adding new interaction metaphors such as live video conferencing etc.

In this paper we focus on the deployment of such a Telemedicine systems in India incorporating various modes of communications ensuring effective teleconsultation. We discuss in detail the architecutre of the basic system with real time communication and service model which gives a broader perspective of the overall telemedical network deployment and its advantages.

The rest of the paper has been divided as Section II discusses the architecture of ipath and its features. Section III describes the integrability of ipath with Video conferencing using opportunistic communication, Section IV discusses about the deployment strategies of the system. Section V explains the experimentation, surveys and test deployment conducted and areas of further research.

II. iPath Preliminaries and Architecture

ipath is an open source telemedicine system running on six servers across the globe. The server in Norway serves a health network in Western Africa and the server in Dresden functions as a centre of field study about breast carcinoma organised by the German state of Sachen [12]. iPath development began in 1991 and was started by the department of pathology at the University of Basel, Switzerland with the objective of facilitating remote diagnosis of intraoperative frozen sections at a hospital in Samedan, Switzerland. After 10 years of development, in 2001, iPath was rewritten and released as an open source telemedicine platform mainly supporting pathology consultation among medical practitioners. Given the 15 years of development, iPath is relatively mature and has a higher user base than most of the telemedicine systems developed [12].

A. Architecture of iPath

The architecture of ipath is described as a multi-modular client server architecture, since it is composed of three main subsystems namely, the iPath-server, the communication channel, and the iPath-client [12]. The server and client rely on the following modules to deliver their services: the database, content management, interface, web service, and security. While the ipath-client relies on the client interface and security. It is observed that the architecture spans over the tier-2 and tier-3 of our general telemedicine framework [1]. Since the main objectives of the system is provision of reliable and user-friendly services, the iPath-server is positioned within the Internet with access restriction from a firewall. This design is to guarantee easy access for authorised users from any location in the world at any time.The client interface of the iPath-client subsystem forms a client application, which can be a remote microscope session controller, a standard web browser, or simply a mail client. The security module of the iPath-client provides secure session establishment and confidentiality of the transmitted data [12].

The iPath-server provides system services like user authentication and authorisation, and data confidentiality by the security module, data definition by the database, data management by the content management system, and web services by the web server module.

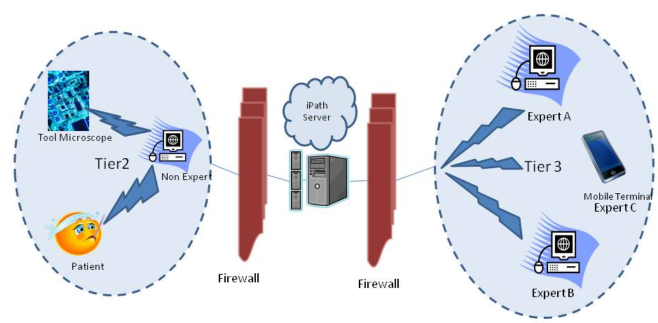

Fig. 2. Architecture of iPath

B. iPath Technologies

Technically iPath is a web-based system developed in PHP and mySQL. The system relies mainly on Internet and Web technologies. High-speed communication links such as optical fibre, satellite, wireless technologies, and others to deliver its services [12].

C. iPath Security Implementation

In iPath, patient data resides on the iPath server and on local medical personnels personal computers. Thus, any security implementation must cover three scenarios:

- Data on users local computers
- Data in transit
- Data on the central iPath server

To access data on the iPath server, users authenticate themselves using passwords and are authorised by the moderator of a community of a usergroup. The assumption is that patients data on the local computer is part of the iPath system and that the local user implements all the necessary standard security controls governing processing of medical records as required by law. Confidentiality of data in transit is maintained by end-to-end encryption provided by SSL and digital certificates for key exchange. In the current version of iPath, integrity is through a non-edit policy, i.e., users can only comment on cases but they cannot modify the entries. In addition, patient privacy is maintained by use of pseudonyms i.e., users do not submit patient's personal identifiable details to the iPath server. We note that, the architecture of iPath makes the system prone to denial of service attack [12].

III. iPATH INTEGRATION WITH VIDEO CONFERENCING

The preliminary architecture of iPath was based on a Apache Web Server which handles web based queries from doctors, experts, consultants via web where the design resembled more like a social networking environment. The backend databases are managed using MySQL and scripts laid out in PHP. The figure below shows the iPath-Architecure where the central server has got connectivity to remote consultation centres and provides then a web interface to access the system.

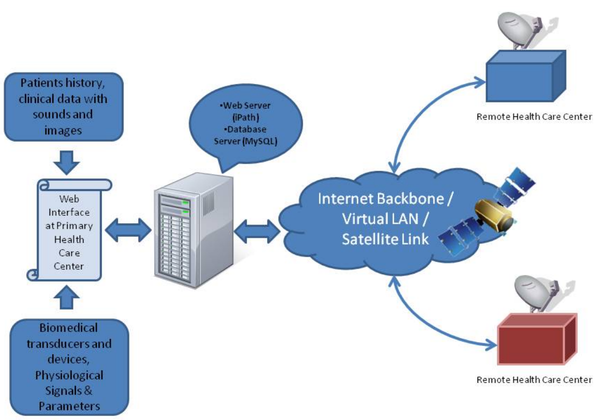

Fig. 3. Ipath Architecture

This system did not have any real time interaction of the patient or the remote consultant with the doctor or the expert in the urban area or anywhere in the world. In places where opportunistic communication could be used to provide real time communication channel between the patient and the doctor using both flaky connections as WiFi, WiMAX, dial-up, GPRS etc and reliable connections as ISDN, Broadband, DSL, Satellite, VSAT etc has been implemented in the system.

A. *Delay Tolerant Network and Opportunistic Communication*

In order to deploy such a system in a remote location we need to combine the concepts of Delay Tolerant Networking(DTN) and Opportunistic Communication. The former mentions that the system is so robust that it can tolerate disconnection without loss of data and can restore data transfer on reconnection. The idea of opportunistic communication states that the connection to a network may not be available all the time so whenever the connection is available through any channel the system should connect and transmit information. The concept of DTN can be used in case of offline or non-real time communication where the time is not so critical. On the other hand for making real time communication we need to have some reliable connection available. In places where both reliable and flaky connection channels are available the system chooses the link depending upon the kind of application to ensure reliable and cheap service.

B. *Video Conferencing and Live Meeting Integration with iPath*

In this regard the same webserver which is used for hosting iPath can also be used for running a streaming server using a different port and protocol. We integrated the feature in the iPath system using a open source web meeting application *DimDim* which runs separately as a server for webstreaming/broadcasting. All authorized users of iPath will be able to schedule a web meeting with other authorized user of iPath using their personalized secure home page. It enables the users to use various features such as Audio/Video Broadcast, Audio/Video Conferencing, Desktop Sharing, Application Sharing etc. The figure below shows how the access to the services by the iPath are secure by firewalls since confidentiality of medical and personal records play a significant role in such a system.

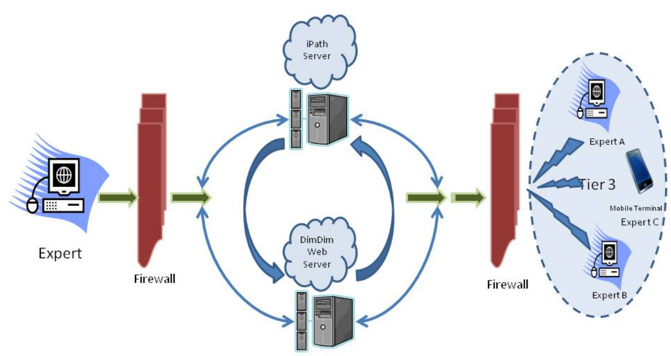

Fig. 4. Ipath and DimDim Architecture

Here in this scenario a user accesses the account on iPath and if the user has scheduled a meeting with another iPath user then the web conference can be initiated from the user's personalized secure home page. The meeting is secured using a passcode which is shared among the attendees of the conference. Any presenter in the meeting can have maximum upto 100 recepients and can vary depending on bandwidth constraints. The presenter can share documents, presentations, portable document files, applications with all other recipients. The users have a option to do private and public chat with the attendees of the meeting. Besides broadcasting it can also be used for one-on-one video conferencing, where a doctor can remotely inspect and diagnose a patient.

C. Audio, Video and Application Sharing Features

Integration of video, audio and other real time interactive features in iPath led us to survey a couple of options. As the entire architecture of iPath is implemented on Linux platform we have the option of integrating a red5 open source streaming server on the same iPath server and build applications to provide Video Conferencing and other feature to the users. The server has capability to cater multiple web meeting simulataneously.

Video Recording can be done offline as well, so in cases where reliable connection link is not available a recorded video can be sent across to the other end using the available link. Now in places where we have constant and reliable connectivity we have a lot of features available, not only we can do live video conferencing but experts at various locations have options of giving live seminars which can be broadcasted. They also have a option of sharing applications on their computers as in they can share documents, images etc online and get feedback instantly.

Any registered iPath user will be able to access the system using a web browser with the flash plugin installed. He needs to log on to the system using his credentials, once logged on he will be able to initiate medical cases, comment on ongoing cases, send email across to other users of iPath, start a discussion. All these services need not necessarily require the system to be online and hence whenever a connection is made available the information gets transmitted. For other real time services like video conferencing, application sharing, the user should have constant connectivity.

IV. Deployment Strategy and Test Setup

A central Telemedicine system is set up where a iPath server and Streaming server are running and have accessibilty through various networks such as Satellite, WiMAX, WiFi etc. Various remote consultation centers have access to the central teleconsultation network through any of these mentioned channels. The connectivity via WiMAX and WiFi gives easy access to places which are in rural areas but do not have access to direct internet. In highly remote locations in India, such as tribal tribal bets of India where connectivity is only available opportunistically via satellite connections or through DTN based service as mentioned in [2].

The system will enable medical experts around the globe to have specialized group meetings which will give a better knowledge sharing platform as well as give them ability to discuss and poduce new findings. The figure below shows the connectivity of the central iPath server with various remote consultation centres through various links.

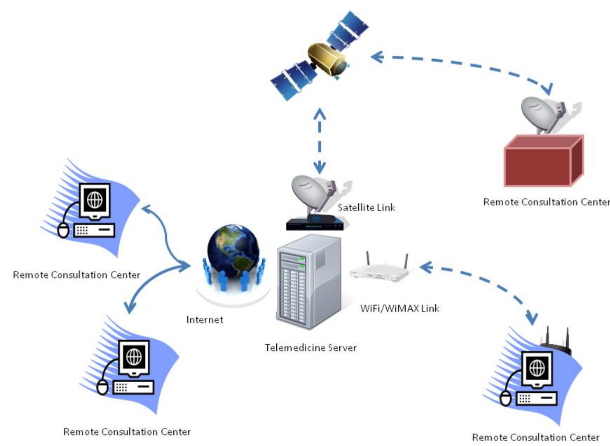

Fig. 5. Deployment and Functionality of Telemedicine Server

A test setup was implemented at Multimedia Laboratory, Dayalbagh Educational Institute, Dayalbagh, Agra. We installed two servers one as the iPath web server running Fedore Core 8 and on another machine running CentOS, an open source operating system for running the *DimDim* open source web meeting application. The two servers were available on the internet as well as on a Satellite connection. We tested consultation on a case between the Multimedia Laboratory and a remote consultation center located in Pune, India. The connectivity was tested using 2 kinds of links i.e. Internet and satellite. We went through a complete cycle of teleconsultation using the social networking channel as well as the real time video conference. Both the connections seemed to be reliable to carry a real time and non-real time consultation.

The audio-video based real time consultation and broadcasting of video lectures and sharing of documents for medical education to far flung regions is highly efficient and useful. The satellite link was robust and provided constant link between the 2 stations for a consultation of about 1 hour. We had a 2 way audio video session with application sharing and the system was found stable. The database access time varied depending upon the type of link used for connection to the main server and the network traffic. We believe that providing video conferencing as a plugin to iPath application should make the system more userfriendly and robust.

V. Conclusion

The potential of Telemedicine services is particularly high in countries where specialists are localized, and where distances and the quality of the infrastructure hinder the movement of physicians or patients. In most developing countries, populations are sparse, energy is in short supply, Internet connectivity and bandwidth are low though expanding fast, and the majority of population is poor, hence making the implementation and sustainability of resource intensive, but critically needed telemedicine services is essential.

In this paper, we have demonstrated the utility of an integrated social networking approach with real time communication channel for remote consultation. The system can be used for consultation as well as referral. We further plan to deploy a pilot setup in some triba locations in India, which will give us a real insight into more problems and issues which may be needeed to be improved upon.

ACKNOWLEDGMENT

The authors would like to thank Prof. S. Keshav, Canadian Research Chair, University of Waterloo for providing initial insight into the sytem. We would also like to thank Rowena Luk, Graduate Student at University of California, Berkeley for helping in the functional description and setup guidlines. Her pilot deployment in Ghana has been a source of inspiration for us.

REFERENCES

[1] D. P. Mirembe, "Design of a secure framework for the implementation of telemedicine, ehealth, and wellness services," *Masters Thesis, Radboud University Nijmegen Security of Systems*, 2006.

[2] S. Guo, M. Falaki, E. Oliver, S. U. Rahman, A. Seth, M. Zaharia, and S. Keshav, "Very low-cost internet access using kiosknet," *ACM Computer Communication Review*, 2007.

[3] P. Swinfen, R. Swinfen, K. Youngberry, and R. Wootton, "A review of the first years experience with an automatic message-routing system for low-cost telemedicine.," *Journal of Telemed Telecare*, 2003.

[4] P. Whitten and B. D. Sypher, "Evolution of telemedicine from an applied communication perspective in the united states," *Telemedicine and e-Health*, 2006.

[5] M. Biemans, J. Swaak, M. Hettinga, and J. Schuurman, "Involvement matters: The proper involvement of users and behavioural theories in the design of a medical teleconferencing application," *Proc. GROUP (ACM)*, 2005.

[6] Y. Gul, A. Wan, and A. Darzi, "Use of telemedicine in undergraduate teaching of surgery," *Journal of Telemedicine and Telecare)*, 1999.

[7] T. Groves, "Satellife: Getting relevant information to the developing world," *BMJ 313)*, 1996.

[8] J. Bardram, C. Bossen, and A. Thomsen, "Designing for transformations in collaboration a study of the deployment of homecare technology," *Proc. GROUP ACM)*, 2005.

[9] S. Kaplan and G. Fitzpatrick, "Designing support for remote intensive-care telehealth using the locales framework," *Proc. DIS ACM)*, 1997.

[10] D. Vassallo, P. Swinfen, R. Swinfen, and R. Wootton, "Experience with a low-cost telemedicine system in three developing countries," *Proc. Telemed. Telecare)*, 2001.

[11] M. Jirotka, R. Procter, M. Hartswood, R. Slack, A. Simpson, C. Coopmans, C. Hinds, and A. Voss, "Collaboration and trust in healthcare innovation: The ediamond case study," *CSCW 14*, 2005.

[12] K. Brauchli, D. OMahony, L. Banach, and M. Oberholzer, "ipath a telemedicine platform to support health providers in low resource settings," *Journal of Information Technology in health Care*, 2005.