Evolution of Knowledge Engineering Infrastructure at SGPGIMS, Lucknow Network Application in Hospital Environment

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***Abstract*: There is a need to develop a hospital wise enterprise network which can be used to exchange medical data/ medical tele-conferencing and to integrate telemedicine network to existing Hospital Information and PACS Network. Current advances in Tele-communication technology has brought in IP Communication at affordable cost and is readily available. TCP/IP based transmissions now has sufficient bandwidth to exchange medical multimedia data. Telemedicine is a rapidly developing application of clinical medicine where electronic medical information (Multimedia Data) is transferred through any communication media for the purpose of delivering consultation to remotely located physicians and e-learning content to knowledge seekers. While designing the enterprise telemedicine infrastructure at any advanced medical institution having vision of providing tele-healthcare and tele-education services several factors have to be taken into consideration such as scope of services offered, existing Information Technology based applications, media used and human resources besides the provision of budget. SGPGIMS had developed and deployed Hospital Information Management System in the year 1998. In the following year a standalone Telemedicine platform was deployed. Since then the telemedicine infrastructure has been expanded to reach a hospital wise enterprise network having global accessibility. The engineering and technology part of this evolution forms the basis of this article.**

Keywords: **Enterprise Telemedicine network, Knowledge Engineering, Medical informatics, Telemedicine**

I. INTRODUCTION

Tele-health is the use of electronic information and communication technologies to provide access to health care services, education in the field of health and any health related issues like governance between geographically dispersed locations. It is a typical example of fusion of diverse scientific disciplines i.e. electronic, communication engineering and health science having enormous social impact on health system development. Information originating in healthcare environment is very much unique and complex (Multimedia Data) consisting of Electronic Health Record (EHR), medical diagnostic images, surgical video, audio etc. Second opinion during patient care or operative / interventional procedures need to be obtained from remote experts if not met with local expertise. Advancement in Telecommunication and Information technology provides an opportunity to bridge the knowledge gap by networking academic medical centres of excellence with peripheral medical colleges to practice distance learning in the form of interactive virtual class room, teleconference of operative procedures, accessing library and web enabled teaching activities etc. There is a need to develop a network which can be used to exchange medical data/ medical tele-conferencing and to integrate telemedicine network with existing Hospital Information and PACS Network. TCP/IP based transmissions now has sufficient bandwidth to exchange medical multimedia data. Telemedicine is a rapidly developing application of clinical-medicine where in medical information (Multimedia Data) is transferred through any communication media for the purpose of specialist's review before delivering tele-consultation. Various Intra-operative Tele-consultation Module, Tele-Radiotherapy Network[8], Mobile Telemedicine System, Operation Theatre Integration with existing intra-hospital network are the parts of knowledge engineering infrastructure which has to be built in the academic medical institutions involved in education and training. Availability of free satellite and terrestrial bandwidth from various Indian government agencies for national programmes, Information technology professionals, necessary hardware and software, and the emerging technology of grid computing, the country is now in a position to afford such kind of advanced network for health [1][2].

II. AN ACCOUNT OF PHASE WISE DEVELOPMENT OF KNOWLEDGE ENGINEERING INFRASTRUCTURE AT SGPGI, LUCKNOW

A. Tele-Surgery Workshop (1999)

Telemedicine activities at SGPGIMS were started in year 1999 with knowledge sharing module. It was initiated as a proof of concept leading to a pilot to study the digital telecommunication engineering for provision of high bandwidth to facilitate visual communication integrated with live surgical video content and multiparty collaboration in real time and study the impact of information and communication (ICT) in tele-surgical education. Endocrine surgery workshop held for five days was transmitted from

SGPGI, Lucknow to P.V.S.Memorial Hospital, Cochin and a city hospital in Lucknow. Integrated Service Digital Network (ISDN) at 384 Kbps. could be deployed though the nearest digital telephone exchange was located seven km away. Desk top computer (Pentium III) based videoconference using VCON(R) hardware, webcam and Cathode Ray Tube (CRT) monitors was used for the desired purpose. Auditorium display was carried out with Liquid Crystal Display (LCD) projector.

B. Integration of ISDN telephone line with hospital telephone exchange (2000 till date)

Videoconference could be set up at any location in the hospital where in the hospital telephone network was available. Accordingly the conference, workshop and other educational activities undertaken at the main and mini auditorium and department seminar rooms could be shared with remote institutions by switching the network at the telephone exchange. Though the use of ISDN for videoconference is done rarely now following migration to IP video platform but this network is still functional to cater the remote locations having ISDN media only.

C. Further advancement of engineering infrastructure under project funding from Department of Information Technology, Ministry of Communication & IT, Indian Space Research Organization & National Informatics Centre, Govt. of India (2001-2010)

Besides the enhancement of videoconference platforms the ISDN usage charges could be met from this funding for a period ten years. High speed X-ray film scanners, Digital pathology, Digital Stethoscope, Digital ECG were integrated in telemedicine softwares developed by C-DAC, Mohali and Pune. Communication network was further extended inside the institute campus using hospital IT network. Two auditoria of the Institute were connected to telemedicine centre initially by CAT-05 cable which was later upgraded to fiber based network for sharing conference with remote partners. Media convertors were used to convert optic cable signals into Ethernet.

1) Tele-Consultation in Hilly region (2000)

Pithoragarh District Hospital, in the Kumaon region of Uttarakhand got linked through PSTN and PC based telemedicine system developed by Online Telemedicine Research Institute (OTRI), Ahmedabad was used to transmit patient data using Netmeeting module-(store and forward telemedicine). Most of the telemedicine session held during this proof of concept (POC) experiment was point to point information exchange. Client-Server based Telemed 500(R) software in Pentium was used to transfer medical data.

Figure: ISDN based Videoconferencing using Desktop System

2) Studio-Based Video Conferencing System along with Satellite based broad band communication, supported by National Informatics Center (NIC), New Delhi (2002)

Satellite communication based tele-educational platform using studio model video conferencing system with 29" CRT was introduced for knowledge delivery to NIC state nodes located in North-East States. This project was supported by National Informatics Center (NIC), New Delhi which was the hub for this project providing the video bridge support to connect all the seven states nodes in a point to multipoint mode. This was the first such venture to use satcom for knowledge sharing using real time collaborative e-learning technology.

3) Further expansion of satellite based telemedicine technology infrastructure supported by Indian Space Research Organization (2003)

Very Small Aperture Terminal (VSAT) provided by Indian Space Research Organisation (ISRO) using extended C band for telemedicine applications at SGPGIMS, Lucknow was established in the year 2003. Three medical colleges of Orissa located at Cuttack, Burla & Berhampur were connected with SGPGI, Lucknow subsequently by satellite based telemedicine network. Quality and reliance of communication improved a lot compared to ISDN.

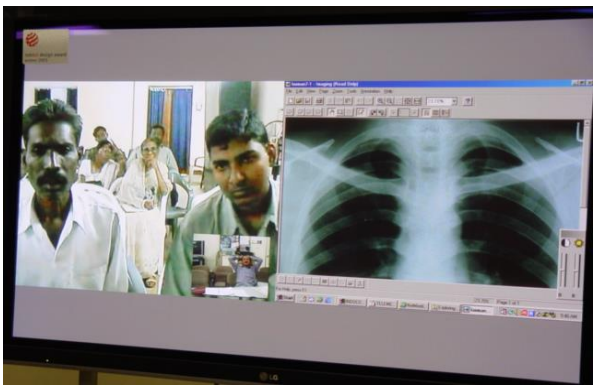

Figure: Screenshot of ongoing telemedicine session through VSAT linkage

4) Introduction of IP based Video Conferencing Network

In the year 2003 while designing the ICT infrastructure for the upcoming building for the School of Telemedicine and Biomedical Informatics (STBMI), enterprise IP-VC network was conceptualized with future integration with the hospital LAN. The network was deployed in STBMI in the year 2005 having the IP-VC network hub which was connected with the hospital server there by giving access to nodes in hospital LAN. The IP-VC enterprise network includes core IT equipments like CISCO(R) 3725 Router cum Gatekeeper, CISCO(R) Catalyst L3 & L2 Switches, CISCO(R) IPVC 3540 Chassis including MCO6A (MCU) Card, Application Server (AS) Card, Enhanced Media Processing (EMP3) Card, CISCO(R) 3540 BRI Gateway, PIX(R) Firewall 515E, Starbak(R) Video Conferencing Gateway (VCG)[3]. All the major communication media like ISDN[4], Public Internet IP, ISRO-VSAT, BSNL 100 Mbps Fiber to Home (FTTH), South Asian Association for Regional Cooperation (SAARC) Multi-Protocol Label Switching (MPLS) Virtual Private Network (VPN) Networks etc all are connected to the common network.

Figure 1: Ongoing IP based telemedicine session at SGPGI

5) Intra-operative Tele-consultation Network (2005)

Intra-operative tele-consultation module was tested using IP based video conferencing system; Java enabled IP Camera, computer system for camera navigation and large display screen. A Sony network camera was mounted over a stand in the Endocrine Surgery operation theatre which was connected over the Ethernet (CAT-5) cable to the network switch connected to video-conferencing and IT platform located at telemedicine center. Web interface allowed control of the camera angle and zoom at the local and remote telemedicine nodes. After technical trials, few surgical sessions were transmitted to Telemedicine node located at S.C.B. Medical College, Cuttack and to the venue of an International Telemedicine conference held at Bangalore [4]. IP Network is accessed in the telemedicine room where desktop computer is used to set the direction of camera with the help of navigation keys in the web interface. Audio is one of the important components during intra-operative tele-consultation. This system can also be used to guide trainees during the surgery from remote location. Ability to move the device within the environment rather than just observe the environment from multiple fixed camera angles gave the surgeon a feel similar of true presence.

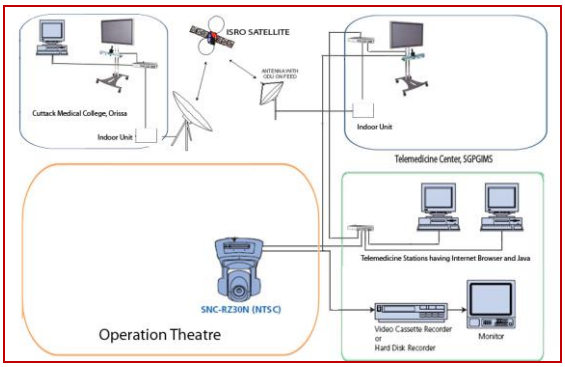

Figure 2: Network layout of Intra-operative Tele-consultation Module

6) Knowledge Management System (2007)

It constitutes 125 Seater Lecture Theatre, Production Control Room (PCR), Media Control Room (MCR), Video editing rooms, Audio voice over, Apple Servers, Storage & B4M Production Suite interlinked with other knowledge capture resources likes digital operation theatre, telemedicine enabled video conferencing suites & seminar rooms of the various department of SGPGIMS.

Figure 3: Inner view of lecture theatre

125 Seater Hi-Technology Lecture was created with a vision of sharing live continual medical education (CME) programmes or workshop. It has curvilinear large screen, Three Projection Display with multiple high definition LCD screens, Sony G70 Video Conferencing System, Electronic Podium and two Sony DXC-D55 hi-end cameras. DXC-D55 cameras are connected to server via Triax cable for direct hard disk recording. It has multiple cameras to capture videos from multiple angles. Two Sony G70 video conferencing was placed in cascading mode. Other items like visualisers, PTZ Camera, Sony Cameras were connected to Sony AWS-G500E Anycast video switcher. All components were controlled by Creston auditorium solution. Promise V-Track Raid storage in two locations one in MCR and another in the data-center of STBMI. Ready content was archived in the

storage located in data center whereas day to day recording before editing stored in storage located near MCR. B4M production suite with an option of capturing multiple live surgical feed was installed in Apple X-Serve Servers.

Figure 4: Integrated Operation Theatre at SGPGIMS

Two way communications between operation theatre and the hospital network is the necessity of the today's world for continuous medical education. Storing video data in the data centre of school of telemedicine and two way transmission of video between Operation Theatre (OT) video hub (located adjacent to the OT) & School of Telemedicine were implemented. Streaming of live video from the telemedicine network can be accessed anywhere in the hospital. Data can be stored, archived and retrieved from any part of the hospital. Transmission of surgical procedures to remote location takes place from the telemedicine video hub of school of telemedicine. The networking is going to be integrated with the Hospital Information System allowing simultaneous data and video traffic from any part of HIS network. Such intra-hospital Telemedicine network will facilitate tele-consultation and tele-education from any point in the hospital [5][6].

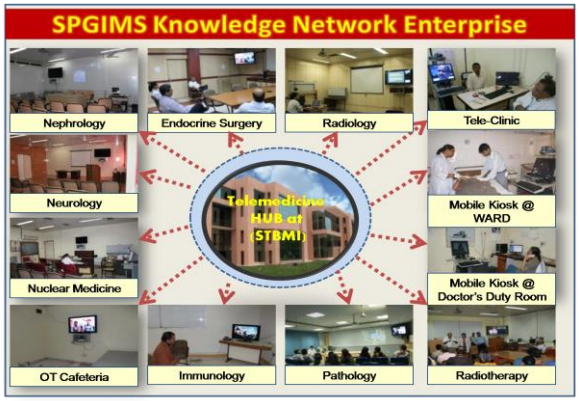

Figure 5 : SGPGI Knowledge Network

7) Surgiplex(R) : OT Tele-presence System (2010)

Surgical video hub in the OT complex was converted into surgical tele-presence suite for interactive surgical education using tele-presence concept. Eight nos. of 46" high definition liquid crystal display (LCD) panels with a feature of digital video wall were installed with video controller hardware for large view of activities undertaken inside the operation theatre. Operation Theatre was converted to form an integrated surgical operational theatre. It consists of networking multiple video feeds like room camera, in-light video, PTZ videoconference camera etc. through a video router. VC system with two HD video camera was installed inside the video hub. Curvilinear sitting arrangements made inside the surgiplex where a video wall was erected using HD display monitors. Each display monitors were connected to the server machine using virtual desktop computing system. Surgical skills were shared with remote partners as well using IP technology. Entire surgical procedures were stored in storage systems at the data centre of STBMI for future reference. [7]

Figure 6: Inner view of OT Tele-presence System at SGPGIMS

8) Medical Data Center

Medical Data Center is a central repository centre. It consists of Videoconferencing Products like RMX 2000, RSS 2000 with CMA 4000 for enterprise Telemedicine Networks, and various communication links, Blade Servers hosted with various telemedicine applications and software based videoconferencing system. Pan-African eNetwork servers like application servers, Archive Servers, tape library and firewalls mounted in the rack. Hospital Information System (HIS) servers were placed with redundant connectivity. STBMI was recognised as National Resource Center for Telemedicine by Ministry of Information Technology (MIT), Govt. of India. Envisaging the requirement of the future, embedded Multi-party video bridge was configured that supports upto 40 video sources in Standard definition (SD) and 10 in high definition (HD). CMA 4000 gatekeeper was integrated with video bridge and recording streaming server (RSS-2000) for the management of enterprise video conferencing. users can connect from desktop by CMA client software. Temporary / permanent user id and password were given to the user for attending the conference or for establishing point to point conferencing with other registered user. RSS 2000® was configured with Static IP for public access. Streaming can done live or may archived for webcasting to worldwide. Users can view webcast with Windows Media player or RealPlayer and simultaneously

access archived content. Users were created for viewing content through web based interface. Ordinary and administrator levels were adjusted. Administrator can create/delete users, delete recorded data & modify internal settings. It supports Microsoft multimedia streaming/system (mms) streaming control protocol used with Microsoft windows media player and Windows media services. Video formats asf and wmv were created. Video format asf was used for live streaming and wmv format was used for viewing recorded video. 1800 and 1801 ports were used for view live streaming of session eg. (mms://xx.xx.xx.xx:1800)

III. CONCLUSION

- Enterprise Hospital wide telemedicine network can piggy back the HIS network which is being built on 10g capacity. Overall capital and operational investment can be minimized if the same network is utilized for accessing patient data and telemedicine.
- Seamless activity can be carried out simultaneously from multiple points of the hospital if backbone of the hospital is on fibre.
- Doctors can provide their services from their offices or OPD chamber instead of coming to the telemedicine center with the help of mhealth & IPVC solutions.
- Hospital data stored in the HIS data center can be archived for telemedicine purposes.

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