Telemedicine Protocol and Telemedicine Operating System

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Introduction

Telemedicine can be defined as:

- The investigation, monitoring and management of patients and staff using systems which allow ready access to expert advice and patient information, no matter where the patient or relevant information is located.
- The use of electronic information and communication technologies to provide and support health care when distance separates the doctor / patient and the Specialist
- The delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities.
- Any healthcare related activity (including diagnosis, advice, treatment and monitoring) that normally involves a professional and a patient (or one professional and another who are separated in space (and possibly also in time) and is facilitated through the use of information and communications technologies.

For the practical purposes it is sometimes useful to define telemedicine through the established applications, such as those presented in the table below:

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Targeted population Type of Interaction	Typical Application	Technologies Used
Medical staff <-> Medical Staff [1] LIVE STORE & FORWARD	Expert Opinion, 2 nd Opinion (Teleophthalmology, Teledermatology, Telepathology, Teleradiology)	Videoconferencing and multimedia, EMR over VSAT, ISDN, and Internet, web, securities technologies
Medical staff <-> Medical Staff 1 + patient LIVE	Teleconsultation in conservative care (teledermatology, Telepsychiatry); Telerobotics, (telesurgery, Telementoring)	Videoconferencing over VSAT, ISDN; teleguided robotic technologies
Medical staff <-> non-medical staff + patient LIVE	Teleconsultation in emergency care	Videoconferening, transmission of vital signs over mobile communications
Medical staff <-> patient LIVE STORE & FORWARD	Lifestyle counseling, home care (disease management, eg:- diabetes, pain & palliative care)	Video telephony and conferencing over VSAT, ISDN, Internet, interactive TV, multimedia chat session / messenger
Medical staff <-> Healthcare organization LIVE STORE & FORWARD	Teleworking (teleradiology, telepathology)	Videoconferencing, multimedia software over VSAT, ISDN, Internet
Medical staff <-> Virtual University LIVE STORE & FORWARD	Teleconferencing, tele-training	Videoconferencing, multicasting, video on demand, over VSAT, ISDN, Internet, virtual reality technologies, data mining

1: Medical Staff = Physicians, Nurse, Technicians, etc.,

Telemedicine services could be categorized as follows:

- Initial urgent evaluation of patients, triage decisions and pre-transfer arrangements;
- Medical and surgical follow-up and medication checks at the point of need;
- Supervision and consultation from primary-care encounters;
- Routine consultations and second opinions based on history, physical examinations and available text data;
- Transmission of medical data;

- Transmission of diagnostic images;
- Extended diagnostic work-ups or short-term management of self-limited
- Management of chronic conditions at the point of need;
- Preventative medicine and patient education
- Pre-admission assessment
- Long duration follow up
- Rehabilitation at the point of need
- Home drug delivery
- Help and education to the families and NGOs
- Patient electronic medical record information
- Repository of personal files

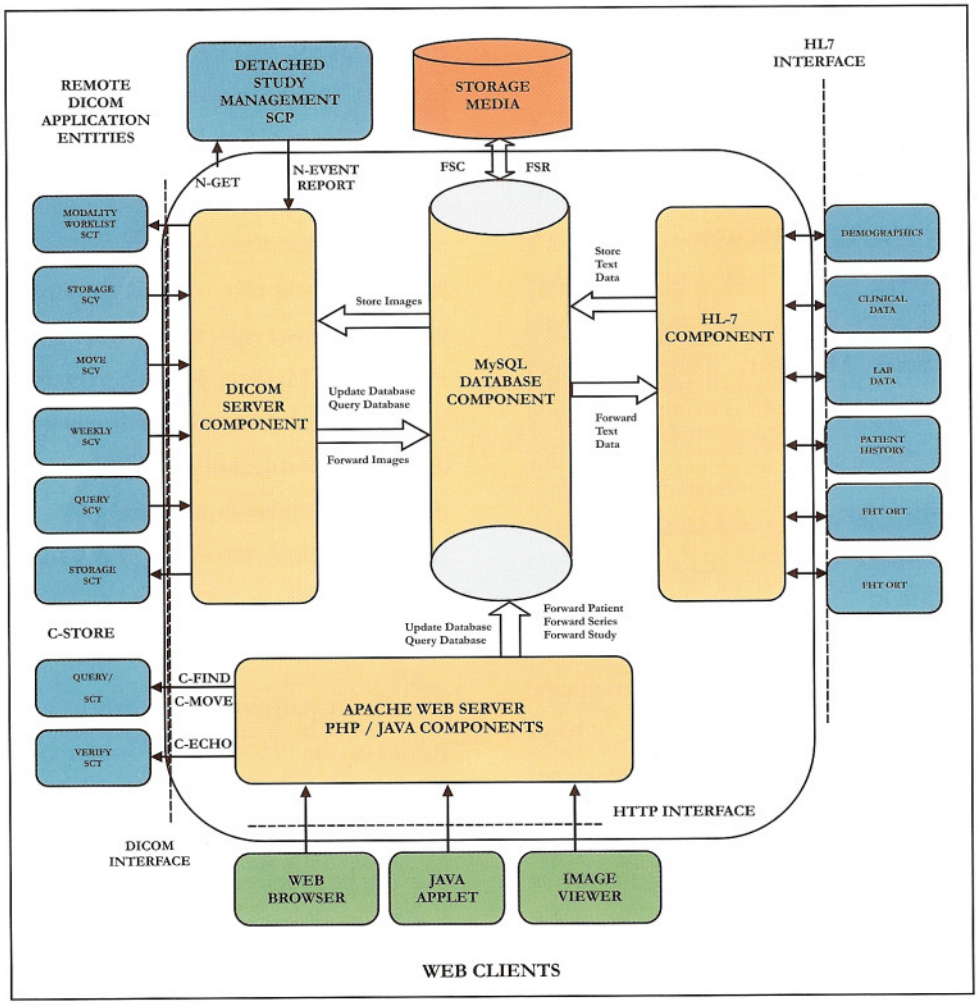


Figure 1: Typical Telemedicine System with DICOM & Hl7 Interface

Elements of Telemedicine System

Telemedicine system consists of an interface between hardware, software and communication channel to eventually bridge two geographical locations to exchange information and enable teleconsultancy between two doctors.

The **HARDWARE** consists of (a) medical equipments b) Computer, (c) Videoconferencing equipment (d) Communication Hardware

(A) Medical Equipments:

It consists of 12-Lead Digital ECG, X-Ray Digitiser, Document Scanner, Ultrasound, Pulmonary Function Test machine, Portable X-Ray machine, Fetal Heart Rate Monitor, Tele-pathology microscope including CCD Camera, Digital Camera, etc.,

(B) Computer:

It consists of Desktop PC / Laptop, Workstation at the Telemedicine Consultation Centre (Doctor End), Desktop / Rack mount Server at the Telemedicine Specialist Centre (Specialist End). Other options are Palmtop PC, PDA, Dedicated set-top-box, etc.,

(C) Video-conferencing Equipment:

It consists of (1) Standalone, (2) PC Add-On Card, (3) Small camera with built-in encoder, and accompanying software for decoding, control and configuration, (4) Software based desktop conferencing using using web camera.

(D) Communication Equipment

It is required for the transmission / exchange of diagnostic images / data between Telemedicine Systems. Communication hardware consists of Terrestrial and Wireless/Satellite links. The terrestrial can further be divided into LAN, WAN, PSTN/ POTS, ISDN, INTERNET, etc., Wireless / Satellite links consists of VSAT, Wireless LAN, CDMA, GSM / GPRS / 3G Network

The **SOFTWARE** consists of Telemedicine software, operating system, database that enables the capture of radiology data (like images, reports, films, etc.,), Patient Electronic Medical Record consisting of demographic data, patient history, clinical data, details of examination, investigations, diagnosis, attachment of audio files (heart sounds), video files (angiography, echocardiogram, etc.,), treatment plan, reports, etc.,

The **Telemedicine Software** is a smaller subset of the "Hospital Information System (HIS)", which has detailed capabilities of DICOM & HL7 functionalities and all that may not be required in that elaborate manner for Telemedicine system in view of the cost. Basic Telemedicine Software should be capable of performing the following functions:

1. Acquisition of the following in the modular way:-
    i. Patient Medical Images from the various biomedical devices like X-Ray Digitiser, Document Scanner,
    ii. Pathology images, Dermatology images from Digital Camera,
    iii. ECG from ECG machine,
    iv. Heart beat sounds from Digital Stethoscope, etc.,
2. Capture the Patient Electronic Medical Record with Visit Management capability
3. User Management, Administrative Tools, etc., should be incorporated
4. Transmission of all these patient information over any communication link
5. Storage of the Patient information
6. Display of the Patient information according to their visits
7. Report in PDF format along with Print capabilities
8. Scheduling of Specialist appointments
9. Status Reporting of the Tele-consultation at both doctor and specialist side
10. Diagnosis and expert opinion including treatment plan, prescriptions, follow-up actions to be taken.

The new digital X-Ray machine with DICOM compatible outputs the DICOM image, which is directly transmitted for the Teleconsultation. The old X-Ray machine that generates the analog output and generates the X-Ray film is digitised using the X-Ray digitiser to JPEG image which is dicomized using the DICOM conversion software to LOSSLESS JPEG COMPRESSED DICOM image, which is transmitted using DICOM communication (DICOM SEND) to the DICOM Server.

The Telemedicine software should be twain compliant and DICOM compatible so that X-Ray digitiser is able to digitise the X-Ray film to DICOM image.

Patient Electronic Medical Record (EMR)

The Patient Electronic Medical Record consists of the following fields: -

1. Patient Demographics
    i. Name
    ii. Universal Electronic Medical Record Identifier
    iii. Address
        a. Street
        b. City
        c. State
        d. Pincode / Zipcode
    iv. Gender
    v. Date of Birth
2. Patient History
    a. Past illness
    b. Present Illness

c. Medication
d. Past Hospitalisation
e. General Examination
f. Physical Examination
g. Systemic Examination
h. Attachment of Audio files (Heart Beat Sounds)
i. Attachment of Video / Images (DICOM Files / AVI files)
j. Attachment of reports / lab results (document / text files)

3. Report
   a. Structure
   b. Non-structure
4. Specialist Diagnosis and Treatment plan

Data Exchange / Interchange Standards

For exchange of clinical information and diagnostic data like X-Ray, CT, MRI, Ultrasound, etc., between disparate Telemedicine Systems, it is recommended that the communication take place-using DICOM. The messaging between the Telemedicine systems is done through the recommended Health Level - Seven standard.

OBJECT CATEGORIES	STORAGE FORMAT	ACQUISITION SOURCE TO EMR	TXM B/W USERS
AUDIO DATA	WAV / MPEG	-	HTTP/FTP/SMTP
STILL MEDICAL IMAGES	DICOM 3.0	DICOM 3.0, JPEG	DICOM 3.0
MOVING MEDICAL IMAGES	DICOM 3.0	DICOM 3.0	DICOM 3.0
STILL GENERAL IMAGES	JPEG / PREFERABLY CONVERT TO DICOM	JPEG	FTP/HTTP/DICOM 3.0
MOVING GENERAL IMAGES	MPEG, MPEG2/ PREFERABLY CONVERT TO DICOM	MPEG	FTP/HTTP/DICOM
TEXT DATA	ASCII, HTML	HL7	HL7 / HTTP
BINARY DATA	BINARY STRING / BLOB	P1073	HL7/ FTP / HTTP

Recommended Storage and Transmission Formats

1. Support of Interoperability across Systems from different vendors and should be able toexchange elements of the Patient Electronic Medical Record (EMR) between them.
2. Protocol for the exchange of these elements of the EMR should be formulated by the committee for the transfer to EMR. Internationally recommended protocol is DICOM for the Medical Images and Health Level Seven for textual data.
3. Table below shows the corresponding objects, their storage format, their acquisition source and the transmission between systems.

Cross Platform / Operating System:

LINUX, WINDOWS, UNIX, HP-UX, AIX, SUN-SOLARIS, etc.,

WINDOWS 2000, XP and above versions are popular but attracts license fee.

LINUX is available free and might need some training. All corresponding driver files should be available.

Driver files for the Videoconferencing unit, X-Ray film digitiser, Document Scanner, Digital Camera, ECG machine, Digital stethoscope, CCD Camera for the Telepathology, PFT machine, video-capture card, CD / DVD writer, printer, ISDN and dial-up modem,

Database:

The various databases and their corresponding cross platform support are shown below.

Health Level - Seven

HL7, an ANSI standard for Messaging in the Clinical environments, is the identified standard to interchange Clinical Message among disparate Telemedicine Systems or Healthcare entities. HL7 is the highest level of the Open System Interconnection (OSI) model of the International Organisation for Standardization (ISO).

CROSS PLATFORM	DATABASE
WINDOWS / LINUX / UNIX	MYSQL
WINDOWS / LINUX / SOLARIS	ORACLE
WINDOWS / LINUX / SOLARIS	SYBASE
WINDOWS / LINUX / HP-UX /SUN / AIX	DB2
WINDOWS	MS-SQL SERVER

The suggested version of HL7 is version 2.3 or above. In the interest of interoperability, support of HL7 version 2.3 is mandatory. The issues addressed by the HL7 standard are the definitions of the application data to be exchanged, the timing of the exchanges, and the communication of certain application specific errors between applications. In the HL7 v2.3, the chapter-2 explains Control/Query, chap-3 details "Patient Administration", Chap-4 describes "Order Entry", Chap-6 details "Financial Management", "Chap-7 explains "Observation Reporting", "Chap-8 describes "Master Files", Chap-9 talks about "Medical Records", Chap-10 describes "Patient Scheduling", Chap-11 explains "Patient Referral" and Chap-12 describes "Patient Care". Technical Working Group strong recommendation of all HL7 communication between the Telemedicine systems should be done using TCP/IP.

HL7 v3.0 encodes messages using XML. It takes the advantage of benefits of XML to increase interoperability. HL7 had developed the Patient Record Architecture (PRA), an XML-based clinical document architecture that provides an exchange model for documents of varying levels of complexity. HL7 v3. 0 also supports the component technologies of ActiveX and CORBA, bringing the robust interfaces of these component-based models to vendors and health organisations.

HL7 Data Interchange Details: The Telemedicine Systems should publish the following message events (1) ADT-A04, (2) ADT-A08 (3) ORU-R01 It is recommended that the Clinical Document Architecture (CDA) version 2.0 be supported and the same be exchanged with other systems using ORU-R01 or MDM-T02 events.

Digital Imaging and Communications in Medicine (DICOM)

The National Electrical Manufacturers Association (NEMA) facilitating the exchange and processing of medical images in digital form created the Digital Imaging and Communications in Medicine (DICOM) standard. Image acquisition devices (eg. CT, MR), image archives, hardcopy devices and diagnostic imaging workstations from different vendors can be connected into a common information infrastructure and integrated with other information systems (e.g. PACS, HIS/RIS). Part 10 of the standard describes a file format for the distribution of images. The recommended DICOM version is 3.0.

Every DICOM device describes its DICOM implementation through a document called the Conformance Statement; this document must be public and all the users must read it to understand the services involved.

DICOM Supplement number 30 on waveforms has been developed to integrate waveform storage into DICOM. This

includes ECG, electrophysiological and hemodynamic curve data, such as pressures flow signals, independent from sampling frequency, amplitude and system sensitivity. Furthermore, audio signals such as voice comments can be entered.

DICOM standard covers the details of transfer of data on media (floppy disks, CD-ROM, DVD, Magneto Optical Drives, etc.,), or across the network. DICOMDIR should be supported for the DICOM Data transfer through media. DICOM Part 18 "Web Access to DICOM Persistent Objects (WADO) specifies a web-based service for accessing and presenting DICOM persistent objects (e.g. images, medical imaging reports). This is intended for distribution of results and images to healthcare professionals like the Web-based Telemedicine System. It provides a simple mechanism for accessing a DICOM persistent object from HTML pages or XML documents, through HTTP/ HTTPs protocol, using DICOM UIDs (Unique Identifiers). Data may be retrieved either in a presentation-ready form as specified by the requester (e.g. JPEG or GIF) or in a native DICOM format.

There are many advantages to using the DICOM format. By having a standard way of storing information it insures that any transfer of the data will be concise and accurate across different platforms since both will be storing and receiving the data in the same way. There have also been additions to the standard, which regulate the transfer of information over the Internet, structured criteria for reports on a study, and supplements that take into account any new modalities or changes that occur. Continuing additions guarantee that the standard will be able to achieve the goals that were set in place by the founders of the DICOM Standard.

DICOM Transfer Syntaxes

The table 'C' shows the DICOM Transfer Syntax and the default and recommended transfer syntax.

Dicom Services

DICOM C-STORE Services should be supported with the transfer syntaxes as mentioned above. Using DICOM C-STORE

DEFINITIONS	TRANSFER SYNTAX UID
IMPLICIT VR LITTLE ENDIAN (default)	1.2.840.10008.1.2
LOSSLESS JPEG COMPRESSION (recommended)	1.2.840.10008.1.2.4.65 - 70
LOSSY JPEG COMPRESSION	1.2.840.10008.1.2.4.50 - 64
EXPLICIT VR LITTLE ENDIAN	1.2.840.10008.1.2.1
EXPLICIT VR BIG ENDIAN	1.2.840.10008.1.2.2
LOSSLESS RUN LENGTH ENCODING	1.2.840.10008.1.2.5

Table 'C'

Services, it is possible to send data or to receive the data. The system sending the data will play the role of Service Class Provider (SCP) and the system receiving the data will play the role of Service Class User (SCU).

DICOM APPLICATION ENTITY TITLE (AET), DICOM PORT NUMBER AND SYSTEM IP-ADDRESS are required to be configured for the transfer of images between the Telemedicine Systems.

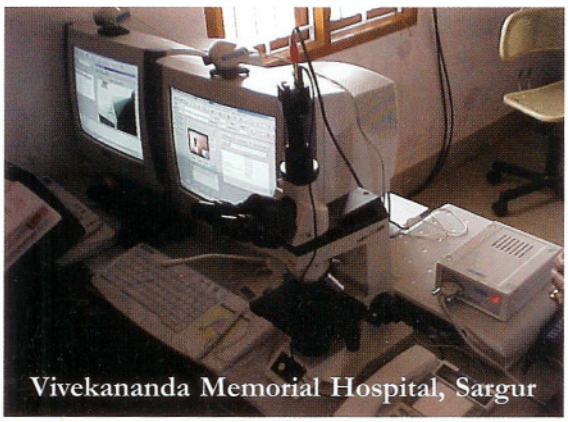
Dicom Compression

The following are the DICOM COMPRESSION Schemes:

(1) RLE
(2) JPEG - LOSSLESS & LOSSY
(3) JPEG-LS: More Efficient and fast Lossless
(4) JPEG-2000: Progressive and ROI encoding
(5) Deflate (zip / gzip): for non-medical objects

Conclusion

Indian Space Research Organization, Ministry of Communication & Information Technology, Healthcare providers, Media Lab Asia, and several other organizations are actively involved in setting up the standards of Telemedicine systems in India and promoting the same, which is internationally accepted and aimed at Interoperability between the Telemedicine systems. The challenge of Telemedicine lies in the proper motivation & training of the End Users. Successfully overcoming this challenge through a determined collaborative effort will be vital. Only then can the promise of Telemedicine be converted to a reality that improves healthcare delivery and outcomes for our underserved populations.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