# PROPOSED ARCHITECTURE: CLOUD BASED MEDICAL INFORMATION RETRIEVAL NETWORK

Vikram Jeet Singh
Research Scholar
Department of Computer Science
Himachal Pradesh University
Shimla, India
vikramjeetsingh@live.in

Dharam Pal Singh
Research Scholar
Department of Computer Science
Himachal Pradesh University
Shimla, India
dharampals88@gmail.com

Dr. Kishori Lal Bansal
Associate Professor
Department of Computer Science
Himachal Pradesh University
Shimla, India
kishorilalbansal@yahoo.co.in

**Abstract— The latest developments and advancements in the computer science and information technology promise a massive potential that can be harnessed for the improvement of healthcare services especially in the developing countries, this being one of the most challenging issues faced by them. With the advent of cloud computing, distributed databases, robotics, data mining and knowledge discovery mechanisms, the healthcare services can benefit in a great way. Medical or Health Informatics as a sub-domain of Computer Science has a long way to go.**

**In this study, latest trends in different nations, various areas of application where technology can prove helpful, the potential benefits, the techniques and the related implementation issues underlying them have been figured out. Finally, a nationalized framework from India's perspective wherein the biggest healthcare institutes of the country can be connected to the statewide leading hospitals which are further connected to those in the districts along with the primary health centers has been proposed. Such an arrangement can really help the masses that cannot possibly benefit from the best quality of health services being typically concentrated near larger cities due to financial or geographical constraints. In this way, they can get their ailments studied by specialized physicians all over the world in a more logistical manner. Moreover, a national repository of information over a network will contribute in the research for providing even better healthcare services to the citizens of the country.**

**Keywords-** cloud, data mining, developing countries, healthcare, ICT, medical informatics

## I. INTRODUCTION

Improving health is central to the Millennium Development Goals, and the public sector is the main provider of healthcare in developing countries [1]. According to [2], there is the problem of availability, accessibility, affordability, sustainability of services and weak referral systems. Even the World Health Report 2006 [3] reveals an estimated shortage of almost 4.3 million doctors, midwives, nurses and support workers worldwide. The shortage is most severe in the under-developed countries but many developed nations also report doctor shortages, especially in rural areas [4]. One of the main reasons for this phenomenon is that the physicians find better earning opportunities and working conditions in the urban localities. As a result, most of the quality healthcare centers are concentrated near the metro cities. The situation is not too different in our country as well, India ranks 67th in the list of 133 developing countries in the doctor-patient ratio [5].

The use of latest technology can greatly help in improving the scenario as also claimed by [6]. The reach of the existing physicians can be widened through networking in order to reach the patients far away from their physical location. Patients can discuss their problems with the specialists through video conferencing. Even the

specialist doctors in different cities can collate their knowledge to save the life of a patient at a distant place. Through a meaningful implementation, technology can prove out to be a real life-saver.

Maximum population in developing countries like India lives in rural areas often having difficult terrain. Due to lack of resources, such people cannot benefit from the best of healthcare services which are often situated near urban centers. With developments in the different information and communication technologies, it is possible to cater to the needs of such a large sized rural community and offer them the best of services remotely.

In this study, the main focus is to develop an architecture based on the fusion of different technologies in order to address the problem.

## II. MATERIALS AND METHODS

The latest developments in the following listed technologies have a huge potential for improving healthcare services:

### *A. Cloud Computing*

In earlier times, there used to be a big worry about how and where to save the data but now the concept of cloud computing provides an efficient and economical way to deal with the same issue. Flexiant, a Scotland based company is working on this idea in association with the Edinburgh Napier University [7].

Cloud computing provides for different kinds of services. Through platform-as-a-service or PaaS, consumers can build and deploy their applications on the cloud provider's platform as and when needed. Through software-as-a-service or SaaS, consumers use software services provided by the cloud providers. And finally through infrastructure-as-a-service or IaaS, consumers are provided with computing power and disk storage via virtual environments.

In a public cloud, an enterprise can offload its computing tasks to the external cloud provider whereas, in a private cloud, the computing services and resources remain within the perimeters of the organisation's private network, so that it retains control of the computing tasks. A hybrid cloud is a combination of both private and public computing.

A hybrid model has been proposed in [8] to be used by organisations in the healthcare domain. It has been shown in Fig 1. The approach retains a private cloud for sensitive research activities but employs a public cloud for other services.

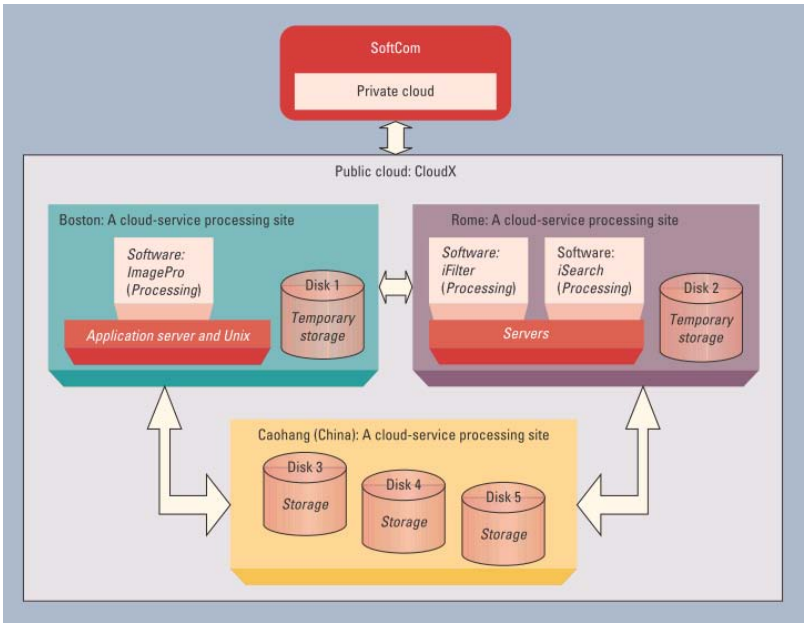



Fig 1: A hybrid cloud computing architecture as proposed in [8]

### *B. Data Warehousingand Data Mining*

The huge amount of information that is gathered over the years in the form of medical records and case histories shall provide the much needed knowledge that could be used in the treatment of patients in the future. This could easily be achieved through a specialised data warehousing system and efficient data mining models.

Health care data is massive. It includes patient centric data, resource management data and transformed data. Health care organizations must have ability to analyze data. Treatment records of millions of patients can be stored and computerized and data mining techniques may help in answering several important and critical questions related to health care.

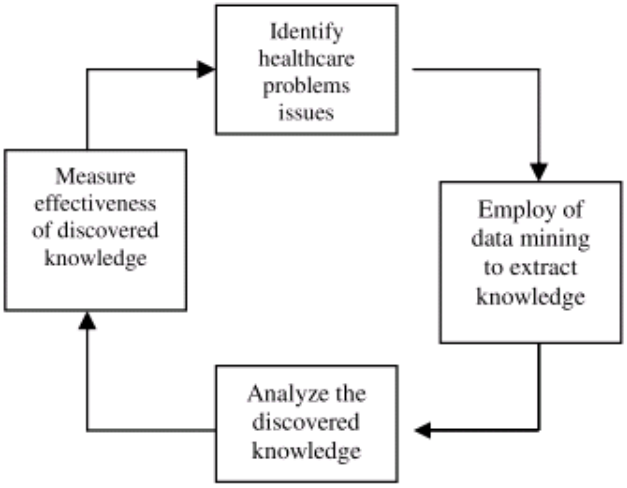



Fig 2: Data Mining Cycle

For health care organization to succeed they must have the ability to capture, store and analyze data (Fig. 2). Online analytical processing (OLAP) provides one way for data to be analyzed in a multi-dimensional capacity. With the adoption of data warehousing and Data analysis/OLAP tools, an organization can make strides in leveraging data for better decision making [9]. The OLAP data has a multidimensional framework that can be represented as a data cube which contains dimensions or types of information stored in the data warehouse as shown in Fig 3. A data warehouse design has been proposed in [10] with three levels of grain to support multiple levels of analysis and improve the decision making process.

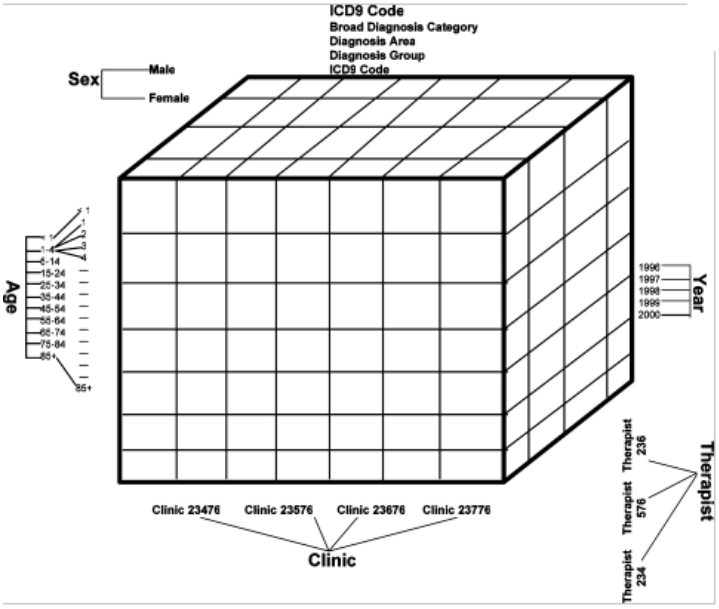



Fig 3: A multi dimensional OLAP cube

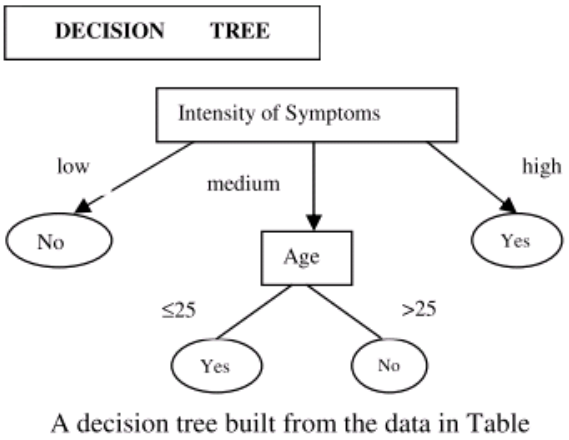
A few classification based data mining techniques have been presented in [11] for a data set related to diabetic patients. Extraction of rules in the form of IF…THEN statements has been illustrated in Fig 4.

**Example :** If_then_rule induced in the diagnosis of level of alcohol in blood

IF Sex = MALE
AND Unit = 8.9
AND Meal = FULL
THEN
Diagnosis = blood_alcohol_content_HIGH.

Fig 4: An example for Rule based classification

Similarly, decision trees can easily be constructed from the given data as the decision tree models are best suited for data mining as shown in Fig 5.




Data set used to build decision tree

| Age | Gender | Intensity of symptoms | Disease |
|---|---|---|---|
| 25 | Male | medium | yes |
| 32 | Male | high | yes |
| 24 | Female | medium | yes |
| 44 | Female | high | yes |
| 30 | Female | low | no |
| 21 | Male | low | no |
| 18 | Female | low | no |
| 34 | Male | medium | no |
| 55 | Male | medium | no |

Fig 5: An example for Decision Tree based classification

Also, artificial neural network is one of many data mining analytical tools that can be utilized to make predictions on key healthcare indicators. Neural networks are known to produce highly accurate results. They have been successfully applied to various areas of medicine, such as diagnostic aides, medicine, biochemical analysis, image analysis and drug development [12].

The applications of artificial neural networks in the fields of cardiovascular medicine, diagnosis of cervical cancer, tumours, retinal damage and dentistry have been given in [13], [14], [15], [16] and [17] respectively.

*C. Distributed Computing*

With the developments in the DBMS technology, it has now become possible to easily access and query data that is stored at different sites. This gives an improvement against drawback of using centralised databases for sensitive applications in case of a site/system failure.

A method for processing healthcare related transactions through a common interface in a distributed computing environment using remote procedure calls has been discussed in [18].

Another approach to sharing electronic health care records, developed as part of two European Union funded projects Synapses and Synex has been studied in [19]. An overview of Synapses is shown in Fig 6. It provides an integrated view of patient data from heterogeneous and distributed information systems. The client issues a request for a record component and the server decomposes the request into individual queries to the feeder systems that store the requested data. The feeder systems process these requests and pass the responses back to the server. The server integrates the responses and returns the result in the form of a record component to the client.

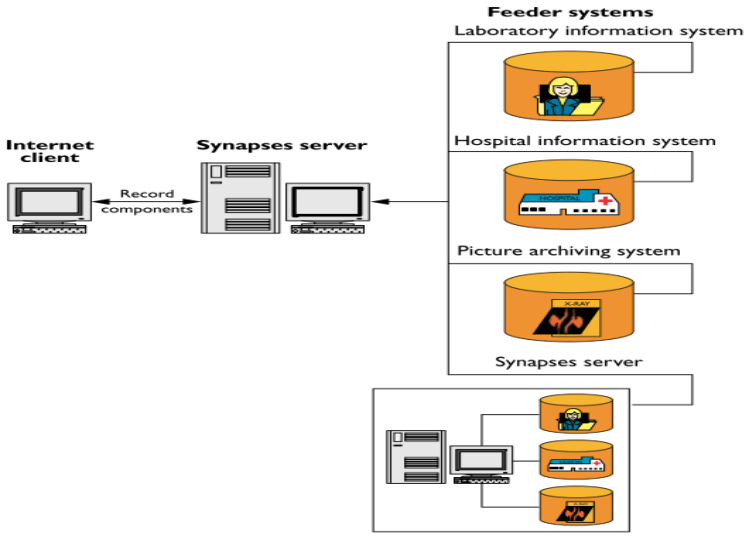



Fig 6: An overview of Synapses

*D. Computer Graphics*

It has been years since the computers were first employed to visualise the medical problems through MRI, CT scan and ultrasound technologies. By collaborating computer graphics with artificial intelligence, simulation and data mining, the field of medical imaging could be brought to an entirely new level even for conducting complicated surgeries remotely.

The developments in the field of medical visualisation have been traced in detail in [20] along with the application of techniques of filtering and segmentation and the related algorithms.

*E. Artificial Intelligence*

With the ongoing research efforts in the field of AI and robotics, it has become possible to undergo surgeries remotely in addition to the techniques like computerised diagnosis and automatic prescription for the diseases. The MYCIN expert system is well known since the 1970's.

The history, development, latest applications of robotics in surgery and the possible roles of robotic surgery in future have been discussed in [21].

*F. Wireless Sensor Networks*

Existing processes for patients' vital data collection require a great deal of labour work to collect, input and analyze the information. These processes are usually slow and error-prone, introducing a latency that prevents real-time data accessibility. This process can easily be automated using sensors attached to existing medical equipment.

A system for real time monitoring of vital statistics of patients using WSN's has also been proposed in [22] and has been shown in Fig 7.

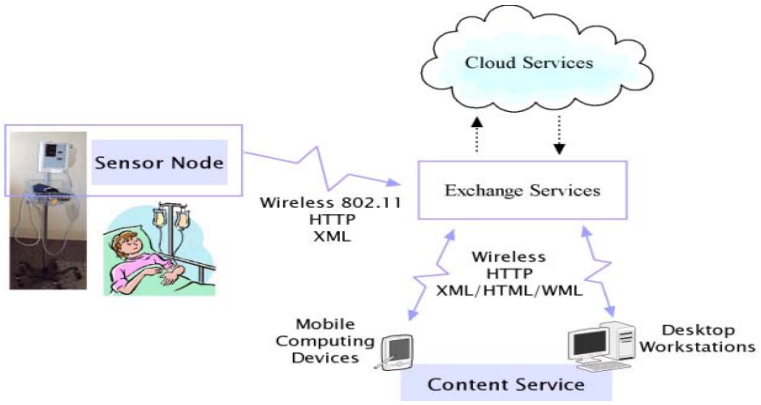



Fig 7: WSN used for monitoring real time patient data

*G. Other Related Work*

The International Medical Informatics Association (IMIA) is the world body for health and biomedical informatics. As an 'association of associations', IMIA acts as a bridging organization, bringing together the constituent organizations and their members. IMIA provides leadership and expertise to the multidisciplinary, health focused community and to policy makers, to enable the transformation of healthcare in accord with the world-wide vision of improving the health of the world population. IMIA plays a major global role in the application of information science and technology in the fields of healthcare and research in medical, health and bio-informatics [23].

In March 2009, US President Barack Obama convened a health-care summit in Washington to identify programs that would improve quality and restrain burgeoning costs. The flagship proposal presented by the president at this gathering was the national adoption of electronic medical records - a computer based system that would contain every patient's clinical history, laboratory results, and treatments. This, he said, would save some $80 billion a year, safeguard against medical errors, reduce malpractice lawsuits, and greatly facilitate both preventive care and ongoing therapy of the chronically ill [24].

Denmark is one of the world's leading countries in the use of health care technology. Virtually all primary care physicians have electronic medical records with full clinical functionality. Their systems are also connected to a national network, which allows them to electronically send and receive clinical data to and from consultant specialists, hospitals, pharmacies, and other health care providers [25].

Health Infoway, an independent, federally funded, not-for-profit organization is involved with the development of electronic health records (EHR) across Canada. By the end of year 2008, there were about 276 EHR projects

under way in Canadian hospitals, pharmacies, laboratories and other health-care facilities amounting to around $1.5-billion [26].

In India, Center for the Development of Advanced Computing (C-DAC), Noida in accordance with the Arogya Online Project of the Government of Rajasthan has taken an initiative in this direction by moving its well established e-Sushrut Hospital Management Information System (HMIS) into the cloud computing architecture. They are in the process of rolling it out in seventeen district hospitals of Rajasthan, five hospitals associated with SMS Medical College in Jaipur, Regional Institute of Medical Sciences in Imphal and GGS Govt. Hospital in Delhi [27].

To augment health services in the state of Himachal Pradesh, a project Telemedicine is being implemented [28]. Due to its inapt terrain, Himachal Pradesh is very sparsely populated. People have to trek large distances on foot or by road to avail the medical facilities in rural areas. Indira Gandhi Medical College and Hospital (IGMC) at Shimla is the biggest medical institution in the state. The project Telemedicine aims at providing access of Medical Specialists/ experts from PGI-Chandigarh or IGMC-Shimla to common man even at a primary health center level remotely. Under the project, it has been proposed to connect 20 remote locations to IGMC-Shimla which will be further connected to PGI-Chandigarh.

Most of the work mentioned above leads in the direction of building healthy cloud architecture and getting the patient records online in a digital form. The HMIS solution is being offered as a software as a service (SaaS) package over the cloud as in the case of C-DAC Noida. It has modules like patient registration, billing, out-patient management, in-patient management, laboratory information system etc. Such a system will cater to the needs of a single hospital. As a result, different hospitals will have their own HMIS solutions over the cloud. Although this will benefit in terms of reduction of infrastructure cost for each hospital but there is not much for the actual patient's use.

Also, the Telemedicine project of Himachal Pradesh aims at providing video conferencing facility to specialists at a remote location either at IGMC-Shimla or PGI-Chandigarh for some particular cases. The patient data from PGI-Chandigarh is transferred every Wednesday for the use of resident doctors and post graduate students at IGMC-Shimla.

Overall, there has been less focus on the integration and coordination of different technologies like data warehousing, data mining, artificial intelligence, computer visualisation, cloud computing, distributed DBMS etc. and real time health monitoring as far as the Indian scenario is concerned.

## III. DISCUSSION

Based upon all the points raised so far in the study, a framework is proposed through which the different healthcare related institutes in the country could be connected together, such that essential information about every medical case being reported at any place is stored electronically and made available for access to any other hospital in the country or abroad irrespective of the geographical restrictions for analysis purposes. This shall help in building a knowledge base over a period of time that could be helpful in improving the quality of healthcare services being offered to the masses.

Fig 8 shows a typical patient treatment cycle. Whenever a patient approaches a hospital, his initial vital tests are taken, report observed and interpreted to gain information about the patient's health which is then classified in order to diagnose the disease and plan the path of the treatment. The cycle goes on repeating till the treatment lasts.

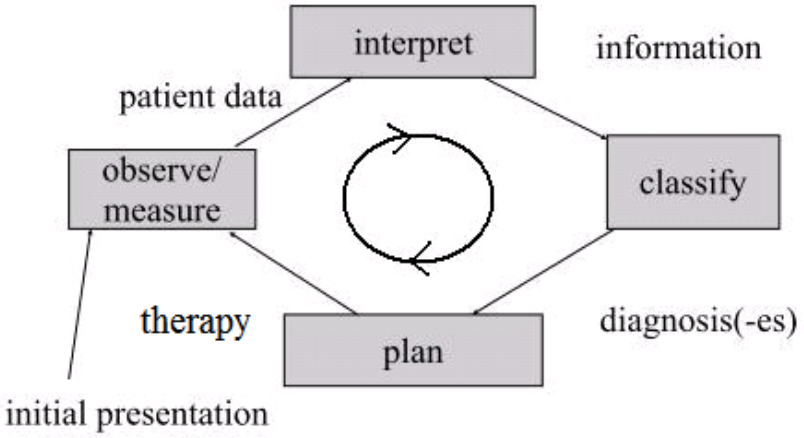



Fig 8: Patient Treatment Cycle

Let's imagine a scenario: a patient is immediately rushed to a trauma centre of a hospital because of a severe head injury. There is no much time with the physicians to refer to books and cause any further delay. When connected intelligently, the results from a CT scan machine could be automatically compared to those stored in the distributed databases scattered over many places to list the case details of patients with similar injury along with the physician details, previous medical history, symptoms, complications faced, medications prescribed, their repercussions and their respective success rates. Also, the contact information of all the specialists in the field of Trauma and Neurology could be made available instantly. All this could be achieved within seconds. How beneficial could this information be to the physicians undertaking the treatment of a patient in the ICU or on a ventilator who is just falling into the jaws of death?

Fig 9 shows the proposed setup at a primary health center (PHC). As soon as a patient approaches for treatment, his or her unique identification number (UID) is entered on a terminal and a query is generated. All the reports pertaining to that UID from multiple locations are returned in response to the query. Now, the doctors at the PHC already have the past history of the patient. A wireless sensor node is also planted externally to the body of the patient to constantly monitor the real-time vital statistics of the patient. The output results of the medical equipment like CT scan images are automatically compared to the data already stored in data warehouses over the cloud. On the basis of the symptoms being faced by the patient, another query can be generated automatically on the basis of WSN data and the response to this query may contain the detailed information about the cases of patients facing similar symptoms and their line of treatment along with the possible complications. As soon as the vital statistics exceed a critical level, the doctors are automatically alerted. Even the complications associated with the side-effects of the drugs being prescribed and the details of the experts/ specialists in the field along with their contact details are presented. As a result, the information extracted can be really beneficial for the proper treatment of the patient as compared to the traditional process.

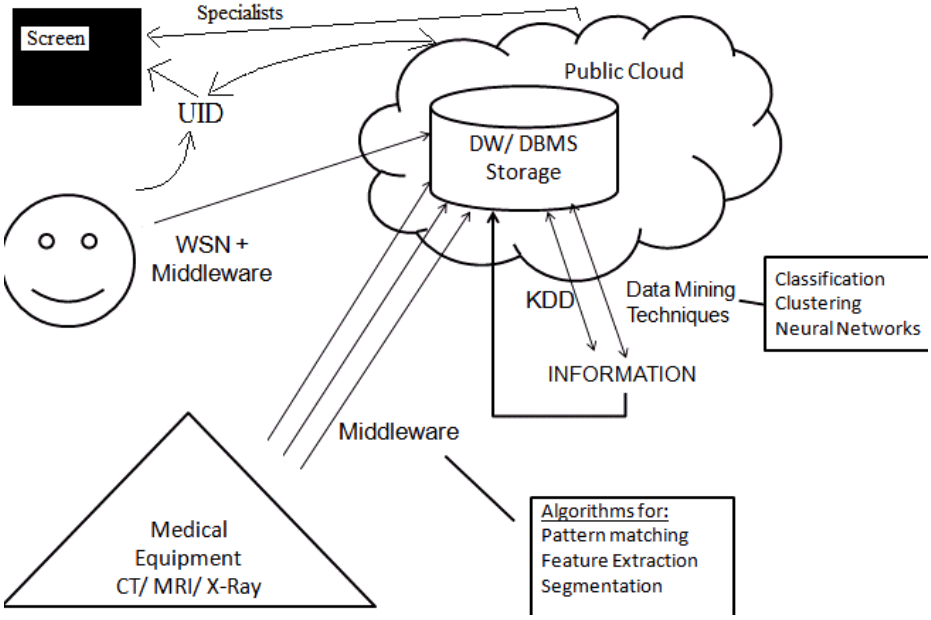



Fig 9: Proposed setup at a Primary Health Center

Fig 10 shows the proposed architecture showing both the vertical as well as the horizontal segments.

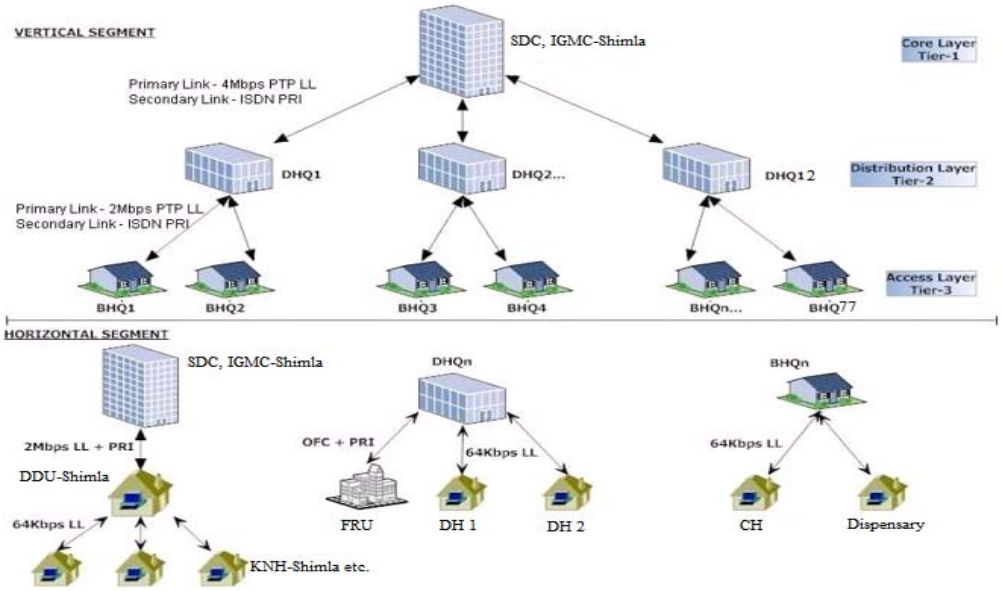



Fig 10: Proposed architecture for state wide area networking

Fig 11 shows the proposed interface on the client machine at each implementation on every tier of Fig 10.

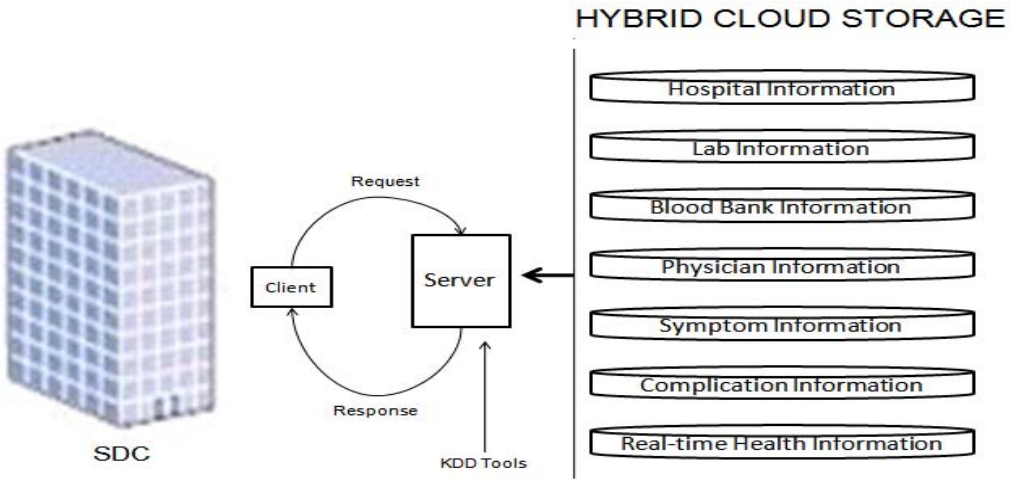



Fig 11: Proposed interface at each implementation site

It may be mentioned that most of the underlying technical infrastructure is already in place in the form of State Wide Area Networks (SWAN) for most of the states in India. In order to consolidate the G2G, G2B and G2C services, a State Data Centre project has also been proposed under the National e-Governance Plan (NeGP). The HIMSWAN framework for SWAN in Himachal Pradesh is shown in Fig 12.

In the HIMSWAN project of Himachal Pradesh, the HP Secretariat, different administrative departments along with their district, sub-divisional and tehsil level offices are linked with one another for immediate availability of data for queries and reports. The different services are rendered by the state through a common delivery platform seamlessly supported by the core connectivity infrastructure extended up to the village level. Integrated Community Service Centre (i-CoSC) or SUGAM is being set up in the state for providing one-stop information resource and service center for the people ensuring greater transparency, effectiveness, neutrality, responsibility and speed. A number of SUGAM centers have been setup at all Tehsils/ Sub-Tehsils, Sub-Divisions and District Headquarter of Shimla District and now are being rolled out in other districts as well.

Twenty remote locations of the state have already been connected to IGMC-Shimla under the project Telemedicine. Connectivity to these locations has been made over ISDN from Bharat Sanchar Nigam Limited (BSNL) [28]. The following infrastructure has been provided at every Telemedicine location/ primary health center:

- 4 PC’s

- 1 TV,
- 1 Microscope,
- 1 X-Ray/ Document Scanner and
- 1 ECG Machine

The existing technical communication infrastructure can be incorporated and further enhanced to support the requirements of the proposed system.

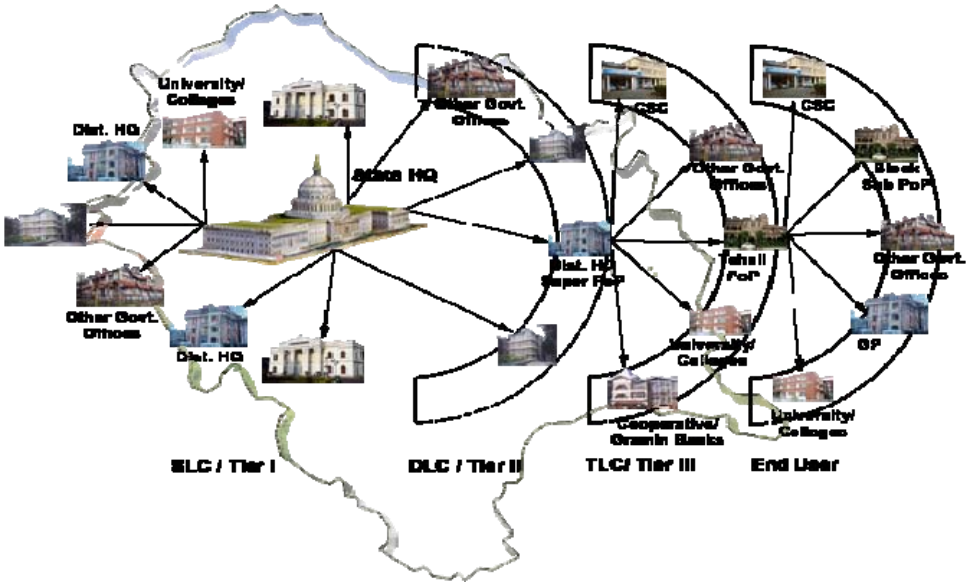



Fig 12: HIMSWAN Network Framework

Fig 13 shows how information is gathered from various sources and collected over the cloud and how the system would look like in the Indian context once implemented.

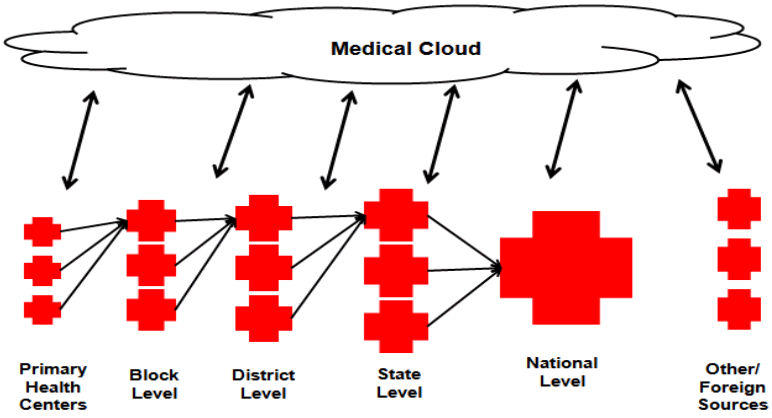



Fig 13: Proposed setup in the Indian context

Fig 14 shows how the gathered information can be utilized for different needs and studied multi-dimensionally for different purposes as per the requirement of the user.

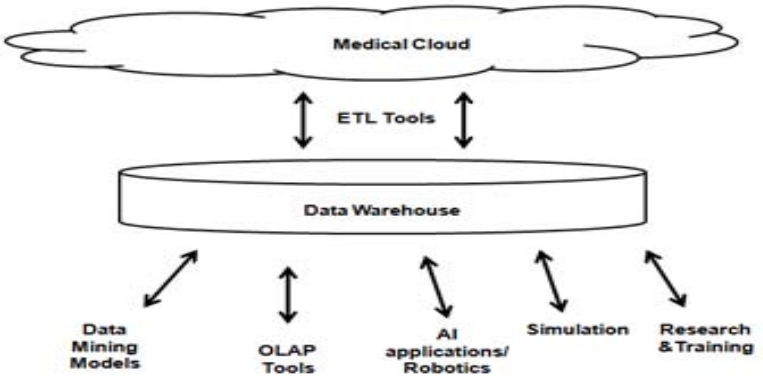



Fig 14: Potential uses of data

## IV. CHARACTERISTICS OF THE PROPOSED SYSTEM

The proposed system shall prove to be beneficial in the following ways:

*A. Digital Medical Records*

The manual files are prone to human errors. They can carry irregularities in recording the information. If the system is computerised, the digital medical records shall be high on the correctness parameter with minimal scope for human generated errors. There shall be no need of carrying bulky files around anymore during an appointment with the doctor. Just a unique universal patient ID number would be all that is required.

*B. Ease of Access*

Through digitisation, the medical records can be put onto a server open to be accessed by those in need. This will ensure full time availability of reliable data irrespective of any geographical constraints. Just a device connected to the internet would be all that is required.

*C. Data Repository*

The bulk of handwritten case files stored in the hospital record rooms can prove to be a great source of knowledge that could be employed by the practitioners, if digitised and stored in a data warehouse. Appropriate data mining procedures will then be able to extract useful information from records which are presently seldom referred.

*D. Ease of Management*

Having a sound, technically advanced system shall benefit in easing the management of the different departments involved in a healthcare institution. Those involved can concentrate more on their efficiency instead of worrying about the minor issues like locating files and storehouse keeping which shall then be taken care of by the computer system.

*E. Quick Reference*

The full time availability of information about patients suffering similar medical conditions i.e. problems, symptoms, complications etc along with the details of their physicians can actually help in better diagnosis both for the doctors as well as the patients. They can even interact with each other on request through video conferencing, phone calls or emails and thus suggest available optimal treatment paths along with the possible complications and the success rate in cases of an emergency. Even an expert could be engaged for his or her opinion on a case easily.

*F. Standardisation*

The use of technology shall be able bring about standardisation in the use of healthcare facilities to help ensure easy interfacing and connectivity to build a worldwide system and pool the information from many different regions together without any conflicts.

*G. Verification*

Having the medical records available over the internet shall help in easy verification by the agencies such as insurance companies, police, courts of law, those responsible for the medical charge reimbursement and related issues. This shall even keep a check on the employees seeking false medical leaves from their employers.

*H. Transparency*

The use of information and communication technology shall help in bringing about transparency in the system. As the stored information is open to all, it will help in easy cross-referencing. Any malpractices shall easily be brought to notice and add an element of accountability to the conduct of all those involved.

*I. Paper friendly*

Having digital records shall induce a decline in the use of paper and thus help adhere to the Green Computing norms.

*J. Prediction of Epidemics*

An analysis of the recorded data can help in predicting the spread of epidemics and thereby assist in preventing it through precautionary measures in advance.

## V. CONCLUSION AND FUTURE WORK

Based upon all the points raised in the study, the proposed system shall minimize the scope for human generated errors and prove out to be a boon for the betterment of healthcare services around the world especially the developing countries where health is still a major concern from the economical as well as technical viewpoint. There is a need to structure an efficient cloud based platform which would be more effective than the existing ones as regards the reliability, availability and security aspects; a specialized data warehouse architecture and efficient data mining models and pattern recognition algorithms for medical use. Research is required to handle the security related issues so that the stakeholders feel free to use the system without any reluctance. Besides, development of standards is also required to ensure a systematic and smooth interfacing around the world. Technology could only be useful if handled in a productive manner.

Moreover, we believe that this study contributes to both scientific and social fields. On the scientific field, it generates new knowledge and applications for utility computing, cloud computing, sensor networks and mobile computing. These areas are being extensively explored by the academic community. There are many lines of research involved in this development, such as information systems, system modeling, networking, mobile service development, service management, computational security and quality of service.

In addition, there is a contribution to the social field, as the proposed service helps to improve the quality of medical assistance delivery, especially in needy communities. It is difficult to gather medical staff with varying expertise in a single place, and it is even more challenging to enable medical assistance to remote patients located in remote communities. In addition, expert medical staff has restricted time and cannot monitor patients or collect additional data from patients at bedside. Thus, the proposal presents an innovative solution that addresses the problems of integration, such as medical staff from one institution being able to monitor patients located at another. It also helps with releasing support staff workload that can use of saved time to focus on assistance. Finally, due to its pragmatic approach it results in a cost-effective solution to address the requirements for modernization of health-care system in developing countries.

## REFERENCES


[1] World Bank Data Report, URL: http://data.worldbank.org/topic/health : [cited Nov 20, 2012]

[2] Chudi IP, 'Healthcare problems in developing countries', Medical Practice and Reviews, Vol. 1(1), pp. 9-11, April 2010.

[3] The World Health Report 2006 by the World Health Organization, URL: http://www.who.int/whr/2006/en/ : [cited Nov 20, 2012]

[4] Remirez Marc, 'Rural doctor shortage called "a crisis" in Washington', ST Newspaper, URL:http://seattletimes.com/html/health/2009078934_ruraldocs18m0.html : [cited Nov 20, 2012]

[5] Vedantam V, 'More doctors Ok; but we need more para-medical staff too', DH News, URL: http://www.deccanherald.com/content/189280/more-doctors-ok-we-need.html : [cited Nov 20, 2012]

[6] 'Evidence on the Costs and Benefits of Health Information Technology', A Congressional Budget Office Paper, The Congress of the United States, May 2008

[7] Official Website, Flexiant, URL: http://www.flexiant.com/news/flexiant-providing-cloud-platform-for-e-health-pilot/ : [cited Nov 22, 2012]

[8] Khan KM et al., 'Establishing Trust in Cloud Computing', IEEE Computer Society, September/October 2010.

[9] Shams K and Frashita M, 2001: 'Data Warehousing Toward Knowledge Management: Topics in Health Information Management', 21: 3.

[10] Parmanto B et al., 'A Framework for Designing a Healthcare Outcome Data Warehouse', Perspectives in Health Information Management, 2005; 2: 3. URL: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2047311/ : [cited Apr 23, 2013]

[11] Kaur Harleen et al., 'Empirical Study on Applications of Data Mining Techniques in Healthcare', Journal of Computer Science 2 (2): 194-200, 2006

[12] Miller A, 'The application of neural networks to imaging and signal processing in astronomy and medicine': Ph.D. Thesis, 1993, Faculty of Science, Department of Physics, University of Southampton.

[13] Itchhaporia Dipti et al., 'Artificial neural networks: Current status in cardiovascular medicine', Journal of the American College of Cardiology. 1996; 28(2):515-521.

[14] Romeo M et al., 'Infrared micro spectroscopy and artificial neural networks in the diagnosis of cervical cancer', Cell Mol Biol (Noisy-le-grand), 1998 Feb;44(1):179-87.

[15] Ball G et al., 'An integrated approach utilizing artificial neural networks and SELDI mass spectrometry for the classification of human tumours and rapid identification of potential biomakers', Bioinformatics Oxford Journal, 2002 Mar;18(3):395-404.

[16] Aleynikov S et al., 'Classification of retinal damage by a neural network based system', Journal of Medical Systems, Volume 22 Issue 3, June 1998, pages 129 – 136.

[17] Brickley MR et al., 'Neural networks: A new technique for development of support systems in dentistry', Journal of Dentistry, Volume 26, Issue 4, May 1998, Pages 305–309.

[18] Swanson ML et al., 'Method and apparatus for processing health care transactions through a common interface in a distributed computing environment', US Patent: US6112183 A

[19] Grimson Jane et al., 'Sharing Health-care Records over the Internet', IEEE Internet Computing, Vol. 5, no.3, pp. 49-58. 2001.

[20] Vidal FP et al., 'Principles and Applications of Computer Graphics in Medicine', Journal compilation 2006: The Eurographics

Association and Blackwell Publishing Ltd. Volume 25 (2006), number 1 pp. 113–137
[21] Lanfranco AR et al., 'Robotic Surgery: A Current Perspective', Annals of Surgery, 2004 January; 239(1): 14–21.
[22] CB Westphall et al., 'A Cloud Computing Solution for Patient's Data Collection in Health Care Institutions', Network and Management Laboratory – LRG, Federal University of Santa Catarina, Brazil
[23] International Medical Informatics Association, URL: http://www.imia-medinfo.org/new2/ : [cited Nov 21, 2012]
[24] Groopman J and Hartzband P, "Obama's $80 Billion Exaggeration", The Wall Street Journal, URL: http://online.wsj.com/article/SB123681586452302125.html : [cited Nov 21, 2012]
[25] Protti D and Johansen I, 'Widespread Adoption of Information Technology in Primary Care Physician Offices in Denmark: A Case Study', The Commonwealth Fund, March 2010.
[26] Official Website, Canada Health Infoway, URL: https://www.infoway-inforoute.ca : [cited Nov 22, 2012]
[27] Srivastava P et al., 'Cloud Computing in Indian Healthcare Sector', C-DAC Noida URL: http://www.cdacnoida.in/ascnt2011/Presentations/HIS/HMIS_Cloud_Computing.pdf : [cited April 24, 2013]
[28] Official Website, Government of Himachal Pradesh, URL: http://hp.gov.in/hp/page/Status-of-Telemedicine.aspx : [cited April 23, 2013]
[29] Q&A: Electronic medical records, BBC News, URL: http://news.bbc.co.uk/2/hi/health/8559817.stm : [cited Nov 22, 2012]
[30] Shah Shahid, 'Column: Why MDs Dread EMRs', Journal of Surgical Radiology, URL: http://www.surgisphere.com/SurgRad/issues/volume-1/1-july-2010--pages-1-60/119-column-why-mds-dread-emrs.html : [cited Nov 21, 2012]