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A Case for using Grid Framework for Indian Rural Healthcare to Meet the Millennium Development Goals (MDGs)

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Abstract - As per the September 2010, Annual Report of Department of Health and Family Welfare, Ministry of Health and Family Welfare, GOI, 75% of human resources and advanced medical technology,70% of hospitals and 40% of beds are in the private sector and mostly in the urban areas. Due to poor Infrastructure, insufficient supply of skilled doctors and dispersed populations the people living in the rural areas do not get any specialist care ,advice and treatment plan resulting in high MMR (Maternal Mortality Rate per 100,000 live births) and IMR(Infant Mortality Rate).We have proposed a HealthGrid Framework using the SWAN as an IT backbone and also formation of a Data Grid EHR to be shared by specialist doctors to provide better medical services to the rural poor which in turn helps us to meet the MDGs by 2015.

Key words - *IMR,MMR,MDGs,EHR,GRID,HealthGrid*

I. INTRODUCTION

Health is the heart of Millennium Development Goals [1] and an important measure of human wellbeing. There is a pressing need for India to meet these goals by 2015 because of many reasons. The Indian Healthcare has two faces, one that provides high quality middle care to middle class Indians and medical tourists and the other (in which majority of population lives) limited or no access to safe, quality care is available.

As per the September 2010 Annual Report of Department of Health and Family Welfare, Ministry of Health and Family Welfare, GOI[3] 75% of human resources and advanced medical technology,70% of hospitals and 40% of beds are in the private sector and mostly in the urban areas. Due to poor Infrastructure, Insufficient supply of skilled doctors and dispersed populations the people living in the rural areas do not get any specialist care ,advice and treatment plan resulting in high MMR (Maternal Mortality Rate per 100,000 live births) and IMR(Infant Mortality Rate).

The MMR(Maternal Mortality Rate per 100,000 live births) national average is 254,IMR(Infant Mortality Rate) in urban areas is 36 compared to rural areas which is 58 and child(0-4yrs) mortality rate per 1000 children is 74[3]. A per the survey report of registrar general of India 2008 [4] at least 77,000 women per year die during child birth partly due to poverty and malnutrition and partly due to poor RURAL HEALTH CARE DELIVERY SYSTEM.

The UNICEF report “the state of the world children report 2008 [5] says that India is number one in children’s death across the globe and 30,000 children a day die for PREVENTABLE or TREATABLE causes such as pneumonia or diarrhea or measles .Every year 2.1 million children in India do not survive to celebrate 5th birthday and one out of every five children under age of 5 dying worldwide is an INDIAN.

Under these circumstances to meet the MDG goal 4A target of reducing by 2/3 rds between 1990 and 2015 the under 5 mortality rate and MDG goal 5A of reducing by 3/4 ths between 1990 and 2015 MMR and MDG goal 5B to achieve by 2015 universal access to reproductive Health seems to be difficult and needs use of ICT in the HealthCare sector due to rapid growth of Information Technology being used in Developed countries and some of the Developing countries.

This paper proposes a Health Grid Framework for the rural healthcare delivery system in different phases:

Phase I:

Enabling Rural Health service from a Distance: - All the Indian States have implemented SWAN (State Wide Area Network) and will be the Infrastructure backbone for connecting a doctor in a Rural PHC (Primary HealthCare Center)to that of a specialist in a specialized hospital either at the district HeadQtrs or Sate HeadQtrs via the HealthGrid Framework for provision of PREVENTIVE HealthCare services by a specialist to a rural patient.

Phase II:

DataGrid Formulation: - How a DataGrid can be formulated for having to store patient EHR (Electronic Health Record) which can be shared by the participating hospitals over the grid framework thereby facilitating examination performed in one location with diagnosis and better treatment plan by the specialists at the other location.

Phase III:

Distributed Data Mining: - The EHRs stored at the different locations in the grid framework can be analyzed by using the Distributed Data Mining (DDM) techniques for better decision making and timely treatment plan to meet the MDGs.

The rest of paper is organized as follows: Section II presents GRID and HEALTHGRID. Section III describes the overview of GRID work. Section IV presents the proposed frame work and Section V concludes the paper.

II. GRID AND HEALTHGRID

Grid computing aims at the provision of a global ICT infrastructure that will enable a coordinated, flexible, and secure sharing of diverse resources, including computers, applications, data, storage, networks, and scientific instruments across dynamic and geographically dispersed organizations and communities (Virtual Organizations or VO). The generic grid Software architecture consists of 1.Grid Resource Infrastructure, 2. Grid Middleware, 3. Grid applications.

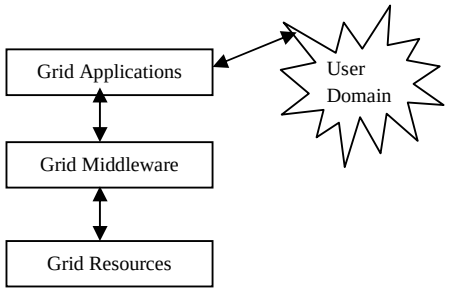


Fig. 1: Generic Grid Software Architecture

HealthGrid is an environment where data of medical interest can be stored and made easily available to the different actors of HealthCare, Physicians, HealthCare centers and Administrators.

HealthGrids are Grid infrastructures comprising applications, services or middleware components that deal with the specific problems arising in the processing of medical data. Resources in HealthGrids are databases, computing power, medical expertise and even medical devices.

Health Grids combine the information from a wide population to extract the knowledge that can lead to the discovery of new correlations between symptoms, diseases, genetic features or any other clinical data. Management of Distributed Databases and Data Mining capabilities are important tools for many medical applications in fields such epidemiology, drug design or even diagnosis.

In summary HealthGrid has impact on every aspect of HealthCare from diagnosis, treatment, primary/acute care to social services so as to meet the MDGs.

III. RELATED WORK

As far as we know there is no similar project in India which uses Grid technology for enabling EHR (Electronic Health Record) sharing among different Hospitals using the existing SWAN backbone. However there are many medical related projects worldwide that utilize the computing grid platforms such as

Mammogrid Project [8] : A Grid-enabled European database of mammograms so that a set of important healthcare applications using this database can be enabled and the potential of the Grids can be harnessed to support co-working between healthcare professionals across the EU.

GEMSS [9] : The GEMSS (Grid-Enabled Medical Simulation Services) is an innovative Grid middleware to support several medical service applications including Maxillofacial surgery simulation, neuro-surgery support, radiosurgery simulation, inhaled drug delivery simulation,cardio-vascular system simulation and advanced medical image reconstruction.

eDiaMoND [10] : The eDiaMoND (on digital mammograph) is a UK's e-Science project to deliver a prototype which can support breast screening in the UK for screening, computer-based training, epidemiology study and computer aided detection of breast cancer.

CLEF [11] : The CLEF (CLinical E-science Framework) is a UK e-Science project is a scalable generic architecture based on grid technology for capture, integration, interpretation and use of clinical

data with genomic data and images within practical clinical systems.

BIRN [12] : The BIRN(Biomedical Informatics Research Network) focuses on brain imaging of human neurological disorders and associated animal models.

BioGrid [13] : The BioGrid project is an initiative for the Construction of a Supercomputer Network in Japan with a focus on grid applications on medical science and biology.

The EUAsiaGrid project[14] aims to promote the use of e-Infrastructures for research, in particular the EGEE Grid,[15] in the AsiaPacific region.

DREAMS_ASIA : Development of grid EnAbling technology in Medicine & Science for Central ASIA.

IV. PROPOSED FRAMEWORK

a) HealthCare delivery system in India:

Ministry of Health & family Welfare is instrumental and responsible for implementation of various programmes on a national scale in areas of Health & Family Welfare,prevention and control of major communicable diseases. Public Health, Hospitals, sanitation fall in the state list. Family welfare and population control, medical education are included in the concurrent list. Rural Health Services: The Health & Family Welfare programme in the country is being implemented through PRIMARY HEALTH CARE SYSTEM.

In rural areas primary health care services are provided through a network of 14,5894 sub-centers,23391 Primary Health centers and 4510 Community Health centers as on march 2009[Annual Report 2010-11 of Ministry of Health & family Welfare,GOI[16].

Table 1: The population norms for SC/PHC/CHC

Centre	Plain area	Hilly/tribal area
SC	5000	3000
PHC	30,000	20,000
CHC	1,20,000	80,000

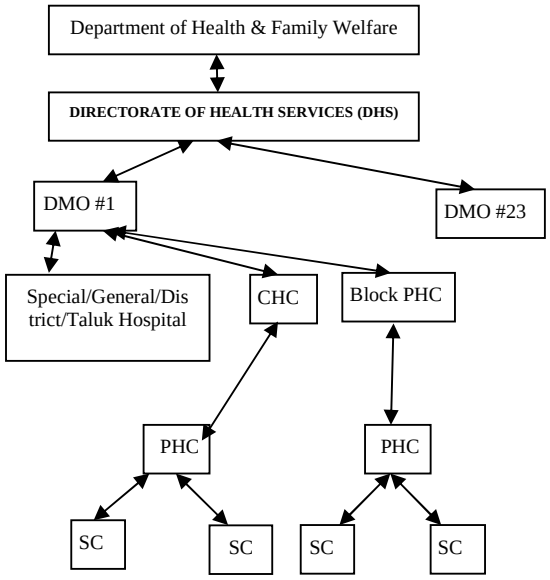
Sub-Center (SC) : It is the first peripheral contact point between PHC system and the community. It is manned by one female(ANM) and one male Health worker and LHV for 6 such SC. SC are assigned the tasks related to maternal and child health, family welfare, nutrition, immunization, diarrhea control and control of communicable diseases.

Primary Health Center (PHC) : It is the first contact point between village community and the medical officer. It is manned by medical officer and 14 other staff. It acts as a referral unit for 6 SC and has 4-6 beds for patients. It performs CURATIVE, PREVENTIVE, PROMOTIVE and FAMILY WELFARE SERVICES.

Block PHC/CHC : It is manned by 4 medical specialists ie surgeon, physican, gynecologist and pediatrician supported by 21 paramedical and othet staff. 30 indoor beds, one OT,X-Ray and Labor room and lab facilities and serves as a referral centre for 4PHCs.Taluk Hospital may provide the entire basic specilality services expected at the first referral level. District Hospital provides all types of tertiary level services. Expected to provide super speciality services like Cardiology, Neurology, Plastic Surgery, Urology and Pediatric surgery and orthodontic.

General Hospital provides super specialty services in addition to that of the services of a district Hospital.

Speciality Hospitals like Women and Child Hospital, District TB center, Leprosy, Mental Hospital etc.



DMO = District Medical Officer

CHC = Community Health Center

PHC = Primary Health Center

SC = Sub-Center

Fig. 2 : HealthCare Delivery System

b) IT connectivity backbone in the Indian states

SWAN : The network would have a minimum bandwidth 2 Mbps connectivity between the state head quarters and the district head quarters, the network

would provide high uptime (>99%), redundancy, backup etc. The SWAN deployment takes place both vertically and horizontally. The main backbone of SWAN connects the State Head quarters PoP(Point of Presence) with the PoPs at district head quarters which in turn are connected to the respective PoPs at sub district/ Mandal level headquarters. Moreover the various state offices are also connected horizontally with the closest respective PoPs. State Wide Area (SWAN) has been implemented in 30 states and following is the functional diagram of APSWAN as an example [17].

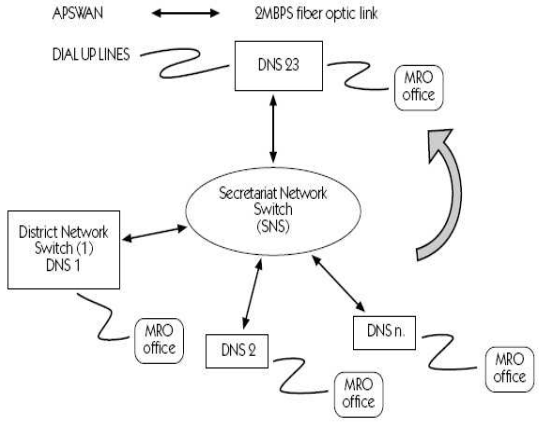


Fig. 3 : APSWAN Functional Diagram

APSWAN Architecture[17]:

Entire APSWAN is logically divided into two network segments. 1. Vertical segment 2. Horizontal segment.

The Vertical segment of APSWAN is composed of a total of 1112 PoPs spread across the State. These PoPs are classified as: a. 1 SHQ PoP (State Head Qtr) b. 23 DHQ PoPs (District Head Qtr) c. 1088 MHQ PoPs (Mandal Head Qtr)

Under the Vertical segment of the APSWAN:

1. SHQ PoP shall be linked with all the DHQ PoPs using Point to Point (PTP) 8 Mbps Leased circuits from Bandwidth Service provider.
2. Each DHQ PoP shall be linked with all the respective MHQ PoPs over Point to Point (PTP) 2 Mbps Leased circuits from the Bandwidth Service Provider.

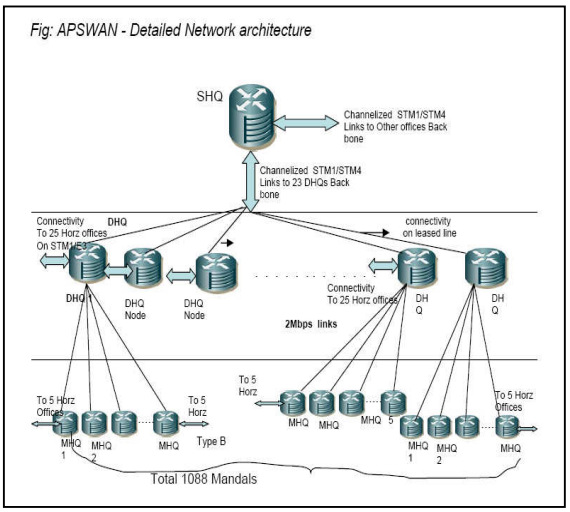


Fig. 4 : APSWAN Detailed Network Architecture

2. Horizontal Segment :

The Horizontal segment of APSWAN is composed of horizontal offices spread across the State. All vertical PoPs of APSWAN will have various Horizontal connectivity facilities.SHQ – 75 offices , DHQ – 25 offices at each DHQ , MHQ – 5 offices at each MHQ , Wi-Max Radio connectivity min.9 Nodes. Types of Connectivity for Horizontal Offices: Type I: CAT 6 Ethernet ,Type II: Optical Fiber - Type III: Leased line ,Type IV: WiMax

c) State Data Center:

SDC will support consolidating the services, applications and infrastructure to provide efficient electronic delivery of G2G,G2C and G2B services. SDC is operational in 14 states in india including AP and by September 2012 all other remaining states will implement SDC.AP SDC is equipped with sertvers,SAN storage of (50TB expandable upto 200TB),dedicated Internet B/W of 42Mbps in redundant mode,connectivity to APSWAN at 155Mbps. Applications of Treasury&Accounts,state audit,Works&projects and IT&C Department been migrated tom SDC.Civil supplies migration is under progress.

d) Supply and Demand of Health services in India :

As per the RHS march2010 report[18] the number of SCs are 1,47,089 ,PHCs are 23,673 , and CHCs are 4535.At SC level the HW(F)/ANM shortfall of 8.8% of total requirement due to major shortfall in the states of Bihar, Chattisgarh, Gujarat, HP, J&K, Kerala ,Orissa, Tripura and UP.A total of 10.3% of total requirement shortfall in Doctors at PHCs in the states of Assam, Bihar, Mp, Orissa, Uttarkhand and UP added to this a 20.7% Doctors posts are vacant.

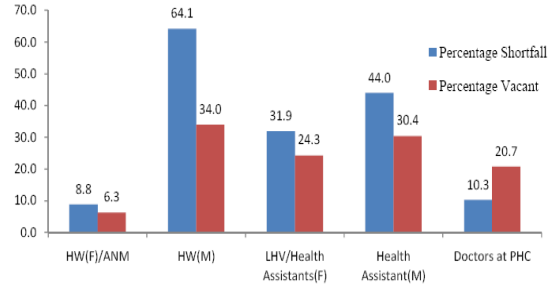


Fig. 5 : Doctors Shortage at PHC

At CHC level shortfall of 62.8% of Surgoens,55.2% of Obstetricians&Gynaecology,72% of Physicians and 69.5% of Pediatricians resulting in overall 62.6% of shortfall with 42.3% vacancy a shown below.

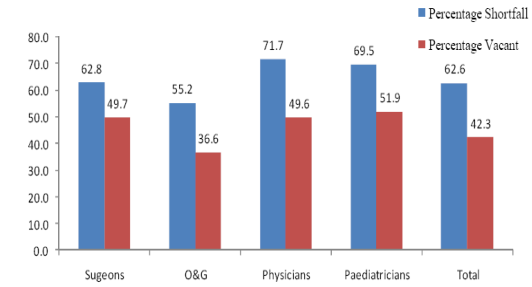


Fig. 6: Specialist Shortage at CHC

As per the SRS bulletin dated jan 2011 of Registrar General of India,Ministry of Home Affairs,GOI the IMR total is 50(Rural IMR=55,Urban IMR=34) due to high IMR in the states of Assam, Chattishgarh, Haryana, MP,Rajasthan ,Meghalaya and UP. From the above statistics we can depict the picture of Healthcare services demand vs. HealthCare supply in India as follows[19].

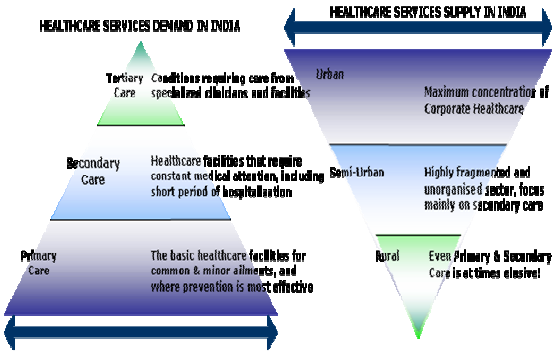


Fig. 7: Supply and Demand of Health services in India

e) Proposed Indian HealthGrid Framework

We propose a HealthGrid Framework for the State of AP. Inspite of shortages at SC/PHC/CHC in infrastructure and manpower the following are the encouraging factors to move towards a proposed HealthGrid Framework . Apart from the SWAN IT backbone structure , as per the facility survey report 2008[20] of Indian Institute of Health and Family Welfare,AP, about the SC/PHC/CHC of AP so as to make it possible to formulate the proposed HealthGrid Framework. About 95% of total 1458 PHCs surveyed in 22 districts have electricity and about 72% of the have Generator/Inverter, 68% of total PHC have telephone facility and 78% of total PHCs have a computer facility.

We have SDC at the SHQ consisting of Application server, Authentication server connected to UID Aadhaar Database server consisting of recently collected citizens personal details. We propose a State Health database Server be placed at the SDC connected to the Application server. The State Health Database server will store the consolidated EHR of rural population falling under different mandals of different districts of the state. This storage of Health data will help us in analyzing the data using the Data Mining algorithms for predictive purposes.

To SHQ Hyderbad SNS 1 PoP core router we need to connect the DHS Server System by means of Horizontal Connectivity.The different hospitals at the SHQ must be brought into this grid framework as shown in the fig10 above. These are State Health Department Hospital, and the various SHQ Participating Hospitals (The Multi-Specialty Hospitals).All the DHQs DNS MRO office core Routers of APSWAN are connected to SHQ Core Router in the Secretariat SNS using 8Mbps Leases Line. Our proposal at the district level will be : To each DHQ DNS MRO office core router we need to connect a DMO /District Hospital Server system using the APSWAN Horizontal Connectivity.

The different hospitals at the DHQ must be brought into this grid framework as shown in the fig10 above. These are District taluk Hospital, Special Hospital, and the various DHQ Participating Hospitals (The Multi-Specialty Hospitals).Each DHQ DNS core router is connected by 2Mbps Leased Line to different MHQ MRO offices core router to which Block PHC/CHC are connected.At the Mandal we have participating hospitals and PHCs with a Rural Doctor treating a patient and need to be brought into the grid. We propose a Database server to be placed at each DHQ at DMO PoP for storing the EHR of all the patients falling under the District/Mandal/Villages forming a Data Grid. These EHR data at each of the DHQ will be consolidated at the SDC in the State Health Database Server.We have now

all the hospitals put up on to the HealthGrid. A simplified model of the framework is presented in the fig7 below.

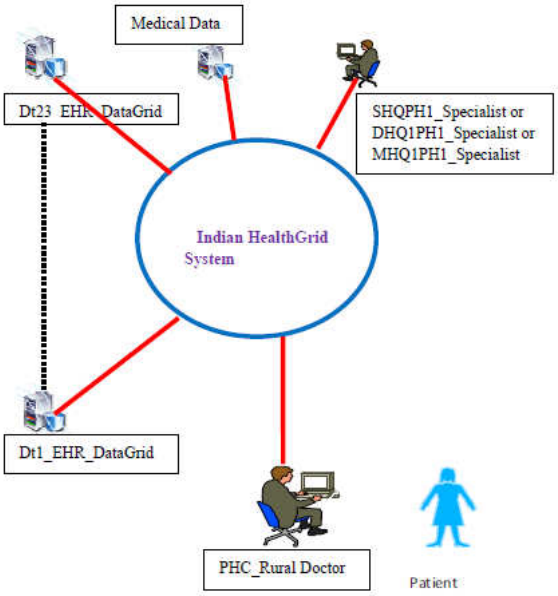


Fig. 8 : A simplified diagram of the proposed HealthGrid Framework

How this framework will help to contain high MMR and IMR thereby meeting the MDGs:

A new study by Amalia Miller of the University of Virginia and the RAND Corporation and Catherine Tucker of the MIT Sloan School of Management published in the Journal of Political Economy,may 2011 say an expanded use of electronic medical records would substantially reduce infant mortality in the U.S. A 10 percent increase in hospital use of basic electronic records would save 16 babies for every 100,000 live births, the study found. A complete national transition to electronic records would save an estimated 6,400 infants each year in the U.S. For obstetricians, electronic records might make it easier to identify high risk pregnancies and coordinate care.

Each year 18,000 babies die in the U.S. within 28 days of birth. That places the U.S. 43rd worldwide in infant mortality rate—on par with nations like Slovakia and Montenegro and behind most of the European Union. Electronic Medical Records facilitate fast and accurate access to patient's records, which could improve diagnosis and patient monitoring. A pediatric EMR helps in initiating a person's digital health records from the beginning of their medical life. Combined with the evidence that pediatric EMR reduce the incidence of missing medical information from 16 percent to 2 percent as the study has found.

Based on the above evidence we propose

A PHC Doctor must prepare an EHR for the Patient first. For this we propose to pull the personal details from the UID Aadhaar Database server and make an individual EHR record with the UID and save it in the DHQ_EHR Database server. Later on this data will be uploaded into the state Health database Server at the SDC.

When a rural doctor requests a specialist advice and treatment from the different participating hospitals at the SHQ/DHQ/MHQ in the healthgrid,the specialist can view the EHR record of that particular patient and suggest a treatment plan in turn providing remote specialist services to the rural poor thereby containing the high IMR and MMR and will be able to the MDG by 2015.

V. CONCLUSIONS AND FUTURE WORK

In this paper, we have shown how the existing SWAN to be a backbone structure for integrating different specialized hospitals with that of rural Healthcare delivery system. This in turn resulting in high performance storage and computing environment as an underlying backbone to form an Indian HealthGrid so as to meet the MDGs. We are working out how a nation-wide EHR system can be designed to get stored in the Data Grid in the above HealthGrid Framework and also how a Distributed Data Mining algorithm could be used for predictive analysis of Health data so as to give a treatment plan for most of the preventive diseases of Mother and Child in turn helping us to reach the MDGs by 2015.

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