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A Novel Approach to Introduce Cloud Services in Healthcare Sectors for the Medically Underserved Populations inSouth Asia

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ABSTRACT
Cloud computing is a technology and standard platform of knowledge domain that concerns about the distributed information systems to support the community even without installation and access their personal files at any computer with internet access. Distributed, virtualization and service-oriented nature along with reliable, scalable, elasticity and inexpensive on-demand computing infrastructures with good quality of service levels have given ascendancy to cloud computing to distinguish from its core descendants like grid computing, geographical information systems, and distributed system. During research we studied, and analysedthe factors directly related to the health care sectors in South Asia regions and found enormous amount of medically underserved populations who are far behind from proper medication and services they deserve. In this paper along with this case study we proposed a detailed cloud ontology, a novel cloud service structure and a record-survey service oriented cloud computing model that will help both general citizens, researchers, academicians, and cloud service providers to meet and solve the healthcare problems in that regions.

Keywords- **Cloud Computing, Distributed Systems, Healthcare, Medical Underserved Populations, South Asia Regions**

I. INTRODUCTION
The increasing rate of cloud adoption, services and implementations per year in all around the world is very rapid and remarkable. Due to this important reason the overall behaviour and functionaries of cloud computing (CC) are changing every day which influence the architecture, taxonomy of CC, and its services. Many hardware and software industries, such as IBM, Intel, Microsoft, Cisco, as well as other Internet technology industries, including Google and Amazon, Security Company, such as Semantic, knowledge groups and even several businesses, also those not technically oriented, want to explore the possibilities and benefits of CC are joining the development of cloud services [1]-[9]. Although there are huge scopes in developing, implementing, and updating CC but there is a lack of standardization of cloud computing services [3]-[4], [10], which makes interoperability when working with multiple services or migrating to new services difficult.

The NIST (National Institute of Standards and Technology) proposed the following definition of cloud computing: ”Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model promotes availability” [11].
Currently three service models are being differentiated- Software as a Service (SaaS), i.e. online applications, such as web-based email, Platform as a Service (PaaS), which allows customers to deploy their own applications, and Infrastructure as a Service (IaaS), which provides, for example, processing power or storage [12]. Service models identifies and enumerates the components of cloud computing that are providing basic knowledge underpinning management and implementation of the cloud spectrum.

In a cloud computing scenario, the beneficiary, such as hospitals, healthcare units, medical service providers, just need the medical services and do not need to undergo the challenges posed by technology, administration and implementation in computerization. Technologically challenging tasks of designing, implementing and maintaining a Data Center/Server, Databases, and Application etc are all eliminated and is left to such service providers of IT industry. With healthcare providers looking at automating processes at lower cost and higher gains CC can act as an ideal platform in the healthcare IT space. A number of hospitals could share infrastructure with large number of systems linked together. By this pooling the hospitals automatically reduce the cost and increase utilization. The resources are delivered only when they are required. This also means real-time availability of patient information for doctors, nursing staff and other support services personnel from any internet enabled device. Though some models are existed to support medical services, but still system faces many limitations like: capacity building, integration of prevailing health system, promotion of inter-operability using universal standards, cost, and E-health observatory.

In this paper we proposed a complete, extended, and granular structure of CC service model that will help CC service providers, users, and also academia, researchers, professionals, stakeholders of information technology (IT)

as well as enterprise to provide healthcare services in South Asia region. A short comparative study of different issues directly related to human health and medical services in this region is also analysed in order to address and find the proper way to solve the medication and medical service oriented problem. This paper is organized as follows: Section II related study. Section III Medically underserved population in South Asia regions: A case study. Section IV Proposed cloud ontology. Section V Proposed a novel cloud computing service structure for underserved populations. Section VI Proposed a service-survey oriented cloud model. And finally Section VII concludes the paper.

II. Related Study

Some major and recent advances in medical technology and science which have transformed the medical field and the long term implications of these transformations are apparent [13] [14]. However, millions of people across the world do not have a full measure of opportunity to obtain the optimum medical health limited by cost and accessibility. Information Technology (IT) which has revolutionized the operating model [15] presents an opportunity for universal access to medical transformation at very low cost. In 2005, Miller [4] documented expected shifts in healthcare, including: 1) The increased use of online support systems; 2) The use of electronic files (or PHRs); 3) Web pages with health promotion, medical and health-related information systems; 4) Health interventions through the use of tele-health applications for health promotion; 5) Prevention interventions, using the web for health education and awareness; 6) Providing incentives for patients. Currently, there is no system that addresses all of these projected shifts. For example, PHRs look to incorporate features such as a patient's ability to review personal health information, to comprehend, analyze and choose provider and insurance services, manage prescriptions, appointments, and medical procedures, maintain a continuous health record for themselves and family members, and communicate effectively with doctors and care providers [16]. Successful adoption of PHRs will hinge on the ability of PHR systems to allow patients to directly manage their illness and to make the system transparent enough to invoke a notion of trust [17]. PHRs will not be extensively adopted until they can prove to patients that there is some inherent health value associated with them [16] and will likely necessitate greater integration with electronic health record (EHR) systems. Additionally, the use and access to PHRs and EHRs within underserved populations faces increased barriers to adoption due to challenges pertaining to economic, education and technology access [18][19]. Therefore, a solution that addresses all shifts, coupled with the needs of underserved patients is highly sought.

Jimison et al. [20] argue that current Health IT systems offer only a fragment of patient's needs, emphasizing the need for a complete feedback loop including monitoring of patient status, patient self-monitoring, individual treatment goals, and timely communications to the patient with tailored recommendations or advice. Jimison et al. [20] state that the inclusion of human interactions along with a more complete Health IT system will prove most effective, such as providing rapid and frequent communications from clinicians. In response to the latter described findings HealthATM seeks to address these needs by providing a comprehensive PHR that also allows for inclusion of care management practices. Underserved populations, who would otherwise have trouble navigating complex web sites and/or using computer based information systems on their own can have access to a very simple, touch-screen interface that can be used in collaboration with care givers. HealthATM hopes to increase the impact of PHRs by leveraging resources across the cloud of online services provided by 3rd parties such as Google and Microsoft for a population who would otherwise be unable to access this resource or know how to create a PHR. Integration across this cloud allows users to then have access to health promotion and education material, allowing for knowledge to better manage their health. If it is recognized that a majority of personal health information will be accessed via computer and web-based applications, HealthATM assures that underserved populations are not left behind during this major shift, allowing them to have the ability to take advantage of tailored health management tools. The consequence of these factors are that people within these communities are less likely to seek continuous or preventive health services necessary to identify yearly indicators of health problems [21]. Community based organizations (CBOs) also face challenges when coordinating care for underserved patients who do not have established primary care homes [22]. In graceful of these and similar findings that extrapolate on socio-economic issues commonly attributed to the "social divide" domain (e.g. literacy, access, adoption), there is a need to create health related self-management resources that are freely available and easily accessible to people within underserved populations, in our case in South Asia regions.

III. Medically Underserved Population In South AsiaRegions: A Case Study

South Asia, a region of strategic importance, faces public health challenges on a demographic and geographic scale unmatched in the world. India, Pakistan, Bangladesh, Nepal, Bhutan, Sri Lanka, Maldives, and Afghanistan are home to nearly one-fifth of the world's population. The sustainable provision of accessible, high-quality healthcare to such a population over such an area demands both substantial resources and efficient administration of their use.

Underserved populations struggle with poverty (basic human needs), disparity in healthcare. During research we found some potential reasons straightforwardly correlated with this underserved situation in south Asia are:populations with family incomes below of the normal poverty level, patients with medical disabilities or chronic illness, populations residing in geographically isolated or medically underserved areas, populations with limited literacy, populations confined to residential settings, and population with lack of IT knowledge.

1. Population

South Asia is the home to one-fifth of the world's population and home to half the world's poor [23] [24]. Poverty is a persistent and widespread problem in South Asia with the bulk of the poor in most countries living in rural areas. Thus the percentage of the poor living in rural areas is 82 per cent in Bangladesh, 78 per cent in India, and 73 per cent in Pakistan [25].

2. Education

Education is a key need, along with other basics, in today's world for anyone, anywhere to have a good quality of life. In developing countries particularly, such as those in the South Asia region, basic education is crucial to alleviating poverty, reducing inequality and driving economic growth. Available data indicate that, the number of out-of-school children of primary school age decreased by about 11.5 million in India, 3 million in Afghanistan, 2 million in Pakistan, and 1 million in Bangladesh. It is also very remarkable that public spending on education in South Asia currently averages about 4.1 percent of GDP – one of the lowest levels of any region [26].

3. Economic circumstances

Health of any country man depends on the analysis of financial commitment to health care as well as establishment of infrastructure, and commitment on healthcare from the government side for that country. In general, the financial commitment to health care in South Asia is low compared to other parts of the world – Maldives is an exception. Per capita health care access (in $US normalized to Purchasing Power Parity-PPP) in almost all of South Asia is less than half to what a citizen of China has access. Besides Maldives and perhaps Sri Lanka, there is little difference among the other countries. Annual health care per capita ($US PPP) in Sri-Lanka is USD 120, Pakistan-USD 80, Nepal-USD 60, Maldives-USD 270, India-USD 70, Bhutan-USD 70, and Bangladesh-USD 60. If we analyze the percentage of total GDP in South Asian countries for health care expenditure, we will see that, in public sector percentage of GDP in Sri-Lanka is 1.8, and in private sector 1.9, in Pakistan health care expenditure from public sector is 1%, and from private sector is 3%, in Nepal from public sector is 1.5%, and from private sector is 3.6%, in Maldives health care expenditure from public sector is 5.5%, and from private sector is 1.2%, in India from public sector 0.8%, and from private sector 4.2%, in Bhutan from public sector 3.6% and from private sector 0.4%, and in Bangladesh health care expenditure from public sector is 1.6% and from private sector 2%. This percentage is also varied from region to region, and the rate is very low especially in rural area.

Number of physicians per 100000 people in South Asian countries is: Sri-Lanka 40, Pakistan 70, Nepal 5, Maldives 80, India 52, Bhutan 5, and in Bangladesh 25. It reflects the absence of commitment of the state to the health care to its people. Other health indices such as mortality rates and incidence of disease reinforces the claim the health of South Asia are also dismal. These countries are home to two-thirds of the world's population living on less than $1 a day. South Asia's low life expectancy and high rates of malnutrition, infant mortality, and incidence of TB and HIV/AIDS are second only to those of sub-Saharan Africa. The countries of south Asia on average spend less than 3.2 percent of their gross domestic products on health, compared to a global average of 8.2 percent [27].

4. Healthcare and Medicine

Due to the low GDP rate in national economic and lack of health resources contexts, the people in South Asia have been anguish a lot. The malnutrition rate in some of the countries in south Asia is: Pakistan-40%, India-47%, and Bangladesh 48% [28]. 20 to 40% of one-year olds in South Asia were found to have not been immunized against common diseases such as TB and Malaria with Pakistan and India being at the bottom of that heap. While one could argue that the low immunization rates are a sign of a culture that has not taken to western medicine. That may be one interpretation; however, it is more likely that these numbers reflect the lack of infrastructural commitment. Immunization including polio, Measles, TB rate of 1 year old babies in the countries in South Asia is: Sri Lanka-99%, Pakistan -51%, Nepal-79%, Maldives-98.50%, India-73%, Bhutan-80%, and Bangladesh-87% [27].

Perhaps the most conclusive evidence of the lack of the states' commitment to health of the people is the lack of sustainable access to improved water (defined as regular access to potable water), to sanitation facilities and to drugs. For most part, access to sustained sanitation is between 30 to 80% in South Asia with Sri Lanka, Bhutan and Pakistan heading the pack. For most part, between 40 to 70% of South Asians have access to common drugs except for Nepalese at about 30% and Sri Lankans at about 90%. Between 60 to 100% of population have access to improved water in South Asia with Bangladesh and Maldives heading the pack [27]. Of the 27 million unimmunized children in the world, however, more than 10 million live in South Asia. Diarrhea, acute respiratory infections, and diseases preventable by vaccines make childhood mortality a continuing public health challenge, particularly in Pakistan, where 90 of every 1,000 children will die by age five. The absence of basic health systems throughout the region has had disturbing ramifications for maternal health as well. In South Asia, shortfalls in health services, compounded by systemic poverty and malnutrition, result in one of the highest maternal mortality rates in the world.

Improving immunization coverage requires expanding basic health services in rural areas and ensuring a resilient and inexpensive supply of vaccines. Unattended home delivery is both a cultural tradition and a current necessity in many rural parts of Bangladesh, India, Nepal, and Pakistan. Furthermore, problems for maternal health start well in advance of birth. Although 78 percent of expectant mothers throughout the developing world receive at least one antenatal checkup, that number falls to 68 percent in South Asia. Non-communicable diseases pose an even larger health challenge. Cardiovascular disease, respiratory disease,

digestive diseases, cancer, and diabetes already account for over 50 percent of deaths in South Asian countries [29].

5. IT and Communication

Information and communication technology play an imperative role nowadays in every sector of human life. The analytical report shows that, in South Asia regions number of telephone line users is 3%, mobile users 15%, internet users 3%. Percentage of telecommunication revenue in GDP is almost 2%, secure internet server per 1 million people is only 1. The governments of South Asian countries have taken some initiatives in providing IT to their health sectors, such as, in Bangladesh- Integrated Rural Health information System (IRHIS), Bhutan- ICT 2007 vision encompasses e-health, India- Framework for Information Technology Infrastructure for Health, in Nepal- Healthnet Nepal, Pakistan- TelMedPak: Telemedicine in Pakistan, Sri Lanka- the Sri Lanka Health Telematics (SRLHT) [30][31].

Analysis and research show that the health and medical services in South Asia regions depend on the proper infrastructure and information technology supports and proper distribution of resources among all the regions. To minimize the gaps in healthcare sectors in these regions including both urban and rural areas it is very important to provide services and infrastructure in lower cost. Both government and non-government bodies can take part in developing medical sectors in such a way that underserved people in this region can get proper information, treatment, reports from anywhere anytime. Providing single services in rural areas cost more for the companies or the consumers. In case of urban areas where more consumers are present the companies can provide cost effective services. There is a need to create a platform to provide services cost effectively at rural areas. In our research paper we proposed to implement cloud computing in healthcare sector for underserved populations that will eventually help to overcome the medical gaps existing in this region.

IV. Proposed Cloud Ontology: The First Step Towards Cloud Computing In Healthcare

One of the major concerns of CC is to provide services are accessible anywhere in the world with the cloud appearing as a single point of access for all the computing needs of consumers at affordable cost, elastic scalability, high performance and security. This section details an overall ontology that illustrates various aspects of CC as shown in Figure. 1. The proposed ontology is classified into major eight classes, these are: architectural modes, major service layers, main features of cloud, economic aspects, technical aspects, area or locality, weight against, and stakeholders. According to the needs of cloud medical services all these components of cloud ontology we classified into the three major domains, such as cloud basic domain, advantages of medical cloud domain, users domain, and cloud motivation and future domain.

1. Cloud Basic Domain

In order to build cloud service oriented infrastructure in medical sector, the basic cloud domain should have the ability to identify what type of cloud architecture and service oriented modes are needed for the cloud providing company.

1.1 Architectural Mode

Modes of CC can be defined by four major categories. These are: public cloud, private cloud, hybrid cloud and community cloud.

1.1.1 Public Cloud-in public cloud the cloud infrastructure and resources are made available to the general public or a large industry group via web applications and services from third party organizations who share and selling resources and services.

1.1.2 Private Cloud-the cloud infrastructure, such as data and processes are processed and operated within single organization.

1.1.3 Hybrid Cloud- the cloud infrastructure is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability.

1.1.4 Community Cloud- the cloud infrastructure and shared concerns, such as mission, security requirements, policy, or compliance considerations are shared by several organizations and supports a specific community.

1.2 Major Service Layers

1.2.1 Cloud Software as a Service (SaaS)-provides the consumer the ability to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through a thin client interface such as a web browser (e.g., web-based e-mail). The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.

1.2.2 Cloud Platform as a Service (PaaS)-provides the consumer the ability to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly application hosting environment configurations.

1.2.3 Cloud Infrastructure as a Service (IaaS)-provides the consumer the ability to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over

operating systems; storage, deployed applications, and possibly limited control of select networking components (e.g., host firewalls).

1.3 Locality

Services and data sharing and distribution among cloud users are a vital issue. Tomorrow's internet will integrate all kind of resources for the customers needed. For our research, identifying locality for distributing cloud services is important because hospitals, clinics, pharmacy, healthcare centers, etc in a community are situated in different palaces both in urban and rural areas. Types of locality are:

1.3.1 Remote-most cloud systems have focused on hosting applications and data on remote computers,employing in particular replication strategies to ensure availability and thus achieving a load balancingscalability.

1.3.2 Local-there has been a tendency of clouds to evolve from private, internal solutions (private clouds) to manage the local infrastructure and the amount of requests e.g. to ensure availability of highly requested data. This is due to the fact that data centres initiating cloud capabilities made use of these features for internal purposes before considering selling the capabilities publicly (public clouds).

1.3.3 Distributed-To attract individual user areas, due to competition, customer demand and availableexpertise it is important to provide CC including specialized functionalities, e.g. distributed document management.

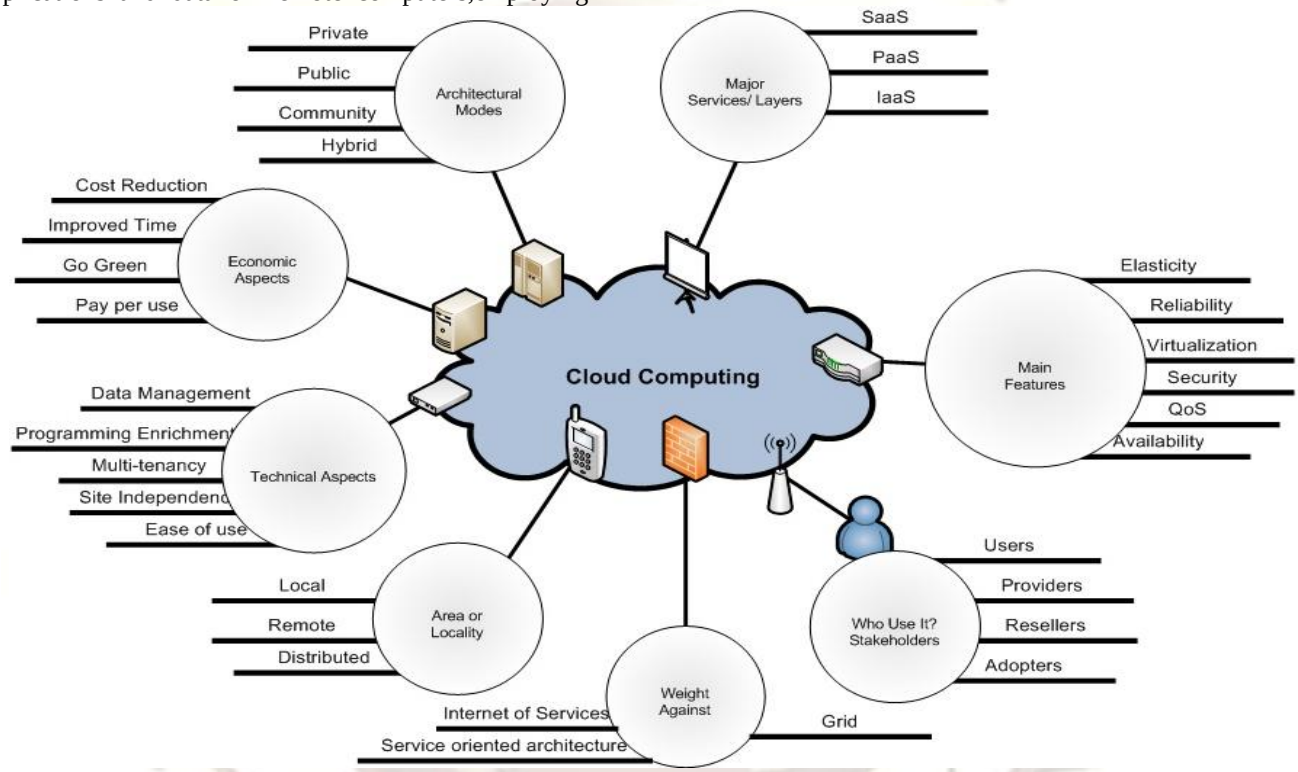

Figure 1. Proposed cloud ontology including all the properties, opportunities, and merits important for healthcare services

2. Advantages of Usage of Cloud Computing in Healthcare Sector

The advantages of the CC to the medical services, educational foundations, government and non-government agencies and societies, trusts are considered in the non-functional, economic and technological areas.

2.1 Non-functional Features

It is an important fundamental feature of clouds and defines the potential of the primary infrastructure to adapt to changes potentially non-functional requirements like application supported data size, number of simultaneous users etc.

2.1.1 Elasticity does allow the dynamic integration and extraction of physical resources to the infrastructure. Whilst from the application perspective, this is identical to scaling[32].

2.1.2 Reliability-reliability is considered one of the main features to exploit cloud capabilities.Reliability denotes the capability to ensure constant operation of the system without disruption, i.e. no loss of data, no code reset during execution etc.

2.1.3 Quality of Service-quality of service support is a relevant capability that is essential in many cases where specific requirements have to be met by the outsourced services and /or resources. With QoS controls available, cloud providers offer a range of services and price points that provide more choice to customers and back these services with service-level agreements (SLAs) that go

beyond uptime and mean time to repair specifications. The result for enterprises is lower-cost IT infrastructure, applicable to a greater range of application types, obtained by combining shared platform economics with high levels of performance assurance.

2.1.4 Agility and adaptability-are essential features of cloud systems that strongly relate to the elasticcapabilities. It includes on-time reaction to changes in the amount of requests and size of resources,but also adaptation to changes in the environmental conditions that e.g. require different types ofresources, different quality or different routes, etc. Implicitly, agility and adaptability requireresources (or at least their management) to be autonomic and have to enable them to provide self-capabilities.

2.1.5 Availability-availabilityof services and data is an essential capability of cloud systems. It lies in the ability to introduce redundancy for services and data so failures can be masked transparently. With increasing concurrent access, availability is particularly achieved through replication of data /services and distributing them across different resources to achieve load-balancing.

2.1.6 Security- usually security is the focal concern in terms of data, infrastructure and virtualization etc. Corporate information is not only a competitive asset, but it often contains information of customers, consumers and employees that, in the wrong hands, could create a civil liability and possibly criminal charges. Many discussion around cloud computing are cantered on privacy, confidentially, the isolation of data from application logic. Typically, Security as a Service involves applications such as anti-virus software delivered over the Internet but the term can also refer to security management provided in-house by an external organization.

2.1.7 Virtualization- a scalable and partitioned infrastructure is provided to the applications through virtualization. Virtual machines are created with web interfaces or APIs. The applications specify how these virtual components are to be configured and interconnected.

2.2 Economic Aspect

Cost reductionis one of the first concerns to build up a cloud system that can adapt to changingconsumer behaviour and reduce cost for infrastructure maintenance and acquisition. Scalability andPay per Use are essential aspects of this issue.

2.2.1 Pay per use-the capability to build up cost according to the actual consumption of resources is arelevant feature of cloud systems. Pay per use strongly relates to quality of service support, wherespecific requirements to be met by the system and hence to be paid for can be specified.

2.2.2 Improved time to market- itis essential in particular for small to medium enterprises that want to sell their services quickly and easily with little delays caused by acquiring and setting up the infrastructure,in particular in a scope compatible and competitive with larger industries. Medical service and stakeholders of CCcan focus on meeting their objectives instead of spending time on infrastructure which is not their core competency.

2.2.3 Return of investment (ROI)-ROI is essential for all investors and cannot always be guaranteed – in factsome cloud systems currently fail this aspect. Employing a cloud system must ensure that the costand effort vested into it is outweighed by its benefits to be commercially viable.

2.2.4 Going Green- Clouds principally allow reducing the consumption of unused resources (down-scaling). Users of cloud computing are more likely to significantly reduce the carbon footprint.Beyond software stack aspects, plenty of Green IT issues are subject to development on thehardware level.

2.3 Technical aspects

The main technological challenges that can be identified and that are commonly associated with cloud systems are:

2.3.1 Data Management-data in cloud domain is flexibly distributed across multiple resources. Data size may vary at any time, data management deal with both horizontal and vertical features of scalability. Consumers need not be bothered about thedatabases.

2.3.2 Programming Improvements- the developer takes care of the scalability and autonomiccapabilities himself, whilst a cloud environment provides the features in a fashion that allowsthe user to leave such management to the system.

2.3.3 Multi-tenancy- itis a highly essential issue in cloud systems, where the location of code and / ordata is principally unknown and the same resource may be assigned to multiple users (potentially atthe same time). Multi-tenancy implies a lot of potential issues, ranging from data protection to legislator issues.

2.3.4 Ease of Use–cloud helps hide the complexity of the infrastructural management andconfiguration etc. Cloud makes it easier for the users to build up new applications, as well asdecreases the overhead for controlling the system.

2.3.5 Site independence-services of cloud can be accessed independently without knowingthe physical position of the user and the resources.

2.3.6 Tools-toolsare generally necessary to support development, adaptation and usage of cloud services.

3. Users Domain

3.1 Users-usersmake direct use of the cloud capabilities. This involves in particular larger enterprises which outsource their in-house infrastructure to reduce cost and efforts. Future market developments will most likely enable the user to become provider and consumer at the same time**.** Medical health care service oriented users like: patients, general users, physicians, nurses, health staff, community health professionals, managements, etc.

3.2 Providers-cloud providers offer clouds to the customer – either via dedicated APIs (PaaS), virtual machines or direct access to the resources (IaaS). The hosts of cloud enhanced services (SaaS) are typically referred to as Service Providers.
3.3 Resellers-they provide a larger resource infrastructure to their customers. Important task is to match the economic benefits of global cloud infrastructures with the understanding of local customer needs.
3.4 Adopters or (Software / Services) Vendors-enhance their own services and capabilities byexploiting cloud platforms from cloud providers or cloud resellers. This enables them to provideservices that scale to dynamic demands – in particular new business entries who cannot estimatethe uptake / demand of their services as yet. The cloud enhanced services thus effectivelybecome software as a service.
3.5 Tool Providers- tools providersdo not actually provide cloud capabilities, but supporting tools such asprogramming environments, virtual machine management etc.

4. Cloud Motivation and Future Domain

Internet of Services-service based application provisioning is part of the future internet as such and therefore a similar statement applies to cloud and Internet of Services as to cloud and future internet.

Service oriented architecture and grid- There is a strong relationship between the "Grid" and Service Oriented Architectures. Service Oriented Architecture however typically focuses predominantly on ways of developing, publishing and integrating application logic and / or resources as services. Aspects related to enhancing the provisioning model, e.g. through secure communication channels, QoS guaranteed maintenance of services etc.

V. Proposed Cloud Service Structure In Healthcare Sector For Underserved

In information systems literature, technology adoption is correlated with how easy the system is to use and how useful that system actually is to the user [33]. Our proposed structure for CC for health services can be classified into two classes, such as out domain and in domain. Where out domain consists of all hospitals, medical care units, pharmacy, local community, and of course end-users, system providers, and system administrators; and in domain consists of CC core service associated model, such as IaaS, PaaS, and SaaS, as shown in Figure 2.

The total function of this proposed model is correlation, cooperation, communication, sharing, and distributing services from infrastructure level to development level, from development level to implementation level, and then finally to the stake holders. And of course all the services provided to the users should be cost effective, efficient, secured, and real time basis.

The connectivity between the central server and the hospitals is one of the major components of the CC architecture. A Virtual Private network (VPN) is established between all hospitals and the data canter using physical

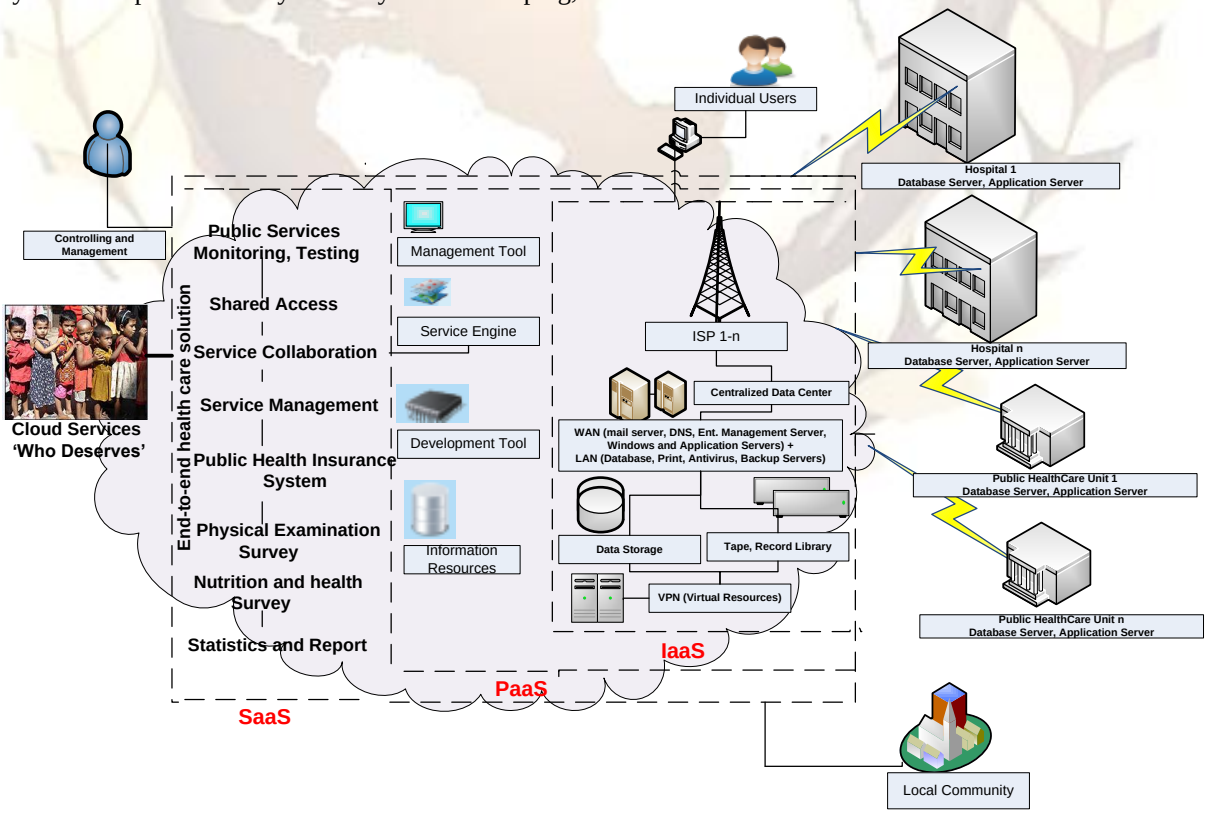

Figure 2. Proposed cloud computing service model for underserved population

network links between them. This is achieved by sourcing the services from an Internet Service Provider (ISP). For the purpose of redundancy, services from multiple ISPs could be sourced as shown in the Figure 2. When multiple data centres could be connected, they can seamlessly be integrated into this structure. Each data storage centre will become one node of the VPN. This will facilitate better redundancy and availability.

Seeing the growth of the underserved populations in South Asia regions, the scalability provided by CC is most important benefit to the stakeholders in that region. By moving from the usual capital upfront investment model to an operational expense, Cloud promises to enable medical care units to accelerate the development and adoption of innovative solutions. Hospitals, care units can take of advantage of the infrastructure provided by the CC and focus on building capabilities need to support their objectives. Our proposed CC structure can be used in SaaS level by applying several services to people in both urban and rural regions in South Asia region, such as, public services including monitoring and testing. Due to the real circumstances in South Asia regions the monitoring process should follow the hygienic process, water purification, vaccination, HIV/AIDS upsetting, etc. Some other IT-enabled healthcare services are also proposed in our CC structural model, such as shared access, service collaboration, service management, public health insurance system, public health examination survey, nutrition and health survey, physical examination survey, medical statistics and reports including personal healthcare report (PHR), EMR, EHR, tele-healthcare service report (THSR), virtual desktop office service management, etc. The consumers of these services are Medical specialist, hospitals, clinics, pharmacy, health care units, physicians, end user person, family, and community. Major care domain in this sector includes Lab testing, continuous care, Home care,community care, and wellness self-care.

The use of CC solutions in healthcare or hospital will help in standardizing the infrastructure for healthcare IT solutions in contrast with the current highly diversified scenario. It ensures availability of hardware with high end servers, huge data stores, bulk licenses and cost-effective utilizations of infrastructure for the health sector. The investment costs are distributed across hospitals and thus get reduced for each hospital. Service Provider take over the headache of patching, upgrading, fixing, scaling, software and hardware and managing data security and backup. Cloud can allow providers to focus less on managing IT and more on delivering better care. It can, for instance, be used to migrate e-mail, collaboration and other traditional applications also into the web. It can also be used to share information seamlessly and in near-real-time across devices and other organizations. Agility improves with users able to rapidly and inexpensively re-provision technological infrastructure resources. An additional benefit of cloud computing is that the Peak-load capacity increases. Reliability improves through the use of multiple redundant sites, which makes it suitable for business continuity and disaster recovery. Security is often as good as or better than traditional systems, in part because providers are able to devote resources to solving security issues that many customers cannot afford. Sustainability comes about through improved resource utilization, and more efficient systems. For smaller hospitals and physician practices, in particular, cloud-based applications can be extremely cost-effective. These organizations typically don't have the IT staff, required to support new technologies; and the cloud removes the burden of hiring internal IT staff to maintain and service in-house infrastructure for mission-critical applications, such as email. In the cloud model, providers only pay for what they use. The electronic medical report (EMR) or electronic health report (EHR) which is a crucial part of the CC in medical sector, is data storage intensive. Compared to locally-housed resources, "cloud" services typically *improves* security because SaaS providers will be able to devote resources to solving security issues that many customers cannot afford. By implementing high-level encryption across connections, as well as housing the data in a disaggregated and encrypted structure, the "cloud" implements all the security requirements. Access to medical data is tightly controlled.

A patient's EHR data might be shared between practices taking care of that patient. This can be easily achieved by having the SaaS model in place. With the cloud hosted EMR, the government and the medical fraternity will be able to have access to state wide medical information of the people, across the country. This facilitates analysis of the patterns of illness and mitigation plans. The medical fraternity can also utilize the data to improve the medical methodology. Laboratory results forms a crucial part of the patient treatment. Using cloud the patient's laboratory data can be centrally stored and shared between practitioners taking care of that patient and the patient directly.

VI. A TYPICAL RECORD-SURVEY SERVICE ORIENTED CLOUD MODEL FOR MEDICAL SYSTEM

Cloud computing infrastructure provides excellent elasticity, and scalability so it can provide expanded services to the users as much as they need. Such scalability can be applicable to both cloud developers and users. A record-survey oriented cloud system must have computing domain that processes data surveyed in different areas. The storage connected with VPN can be expanded or released according to users' need. The services of CC for web-enabled medical system can be summarized according to the core service layers of CC, as shown in Figure 3.

Through IaaS layer, cloud server and storage are provided. Users can manage web documents made in HTML, XML, DHTML, SHTML, etc. Hospitals or any healthcare unit can utilize these services, when necessary, and expand system resources as needed.

In PaaS layer, programmers develop applications that manage medical data. With such tools, it is possible to provide services related to SaaS layer.

In SaaS layer, users can use web-enable application developed in PaaS using the user interface of applications or web browser.

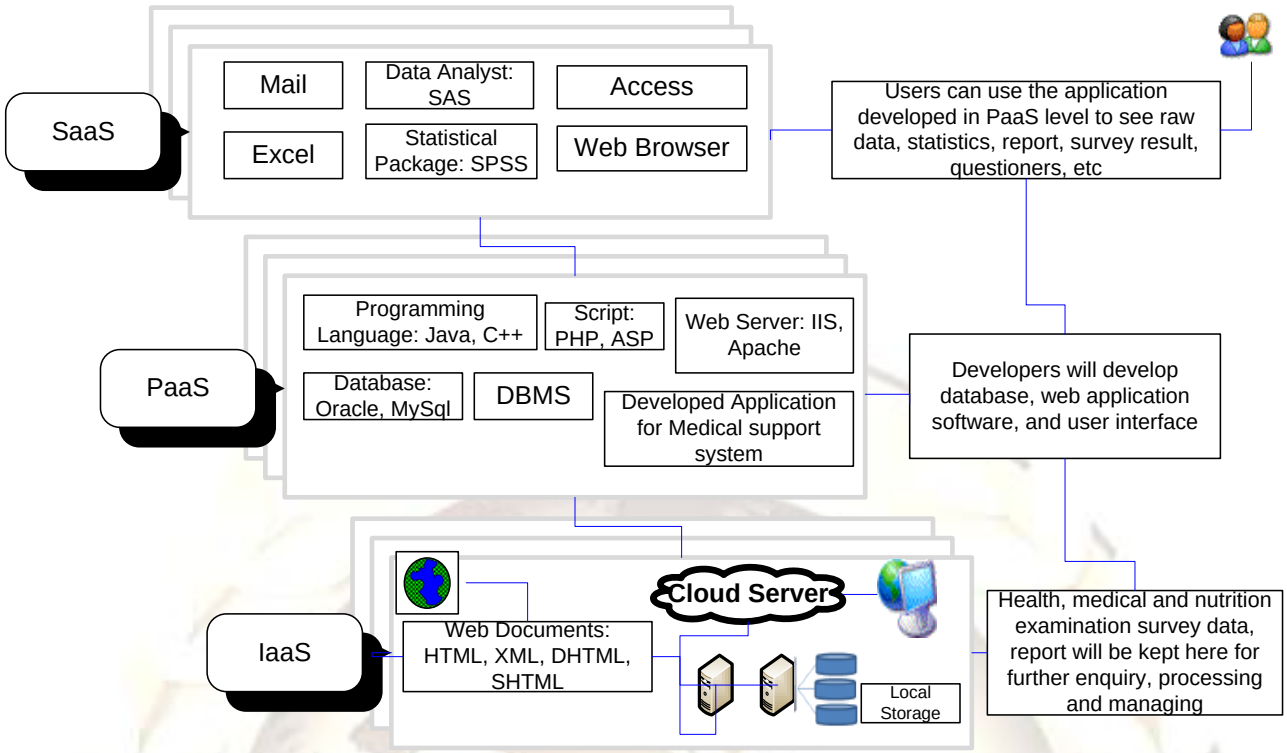

Figure 3. Proposed record-survey service oriented cloud model

VII. CONCLUSION

Cloud computing is the profitable technology in the economic respect. Moreover, users can be served by cloud services even without any professional knowledge about infrastructure of cloud computing. In this paper we proposed a detailed ontology and a well structured cloud computing system for those regions where more than 70% of the total population live in rural area without having proper education, financial support, sanitation, healthcare, etc. Applying cloud medical system in healthcare units, hospitals, clinics publicly and privately it is possible to changing their lives to better everyone future. The elasticity, scalability, virtualization, and distributed characteristics of cloud computing could help clinicians and hospitals to coordinate and exchange information more efficiently. It also would help hospitals to achieve more efficient use of their hardware and software investments and to increase profitability by improving the utilization of resources to the maximum. By pooling the various healthcare IT resources into large clouds, hospitals can reduce the cost and increase utilization as the resources are delivered only, when they are required. We hope finally it will reduce the healthcare problems in South Asia regions.

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