Conceptual model for mobile health services using cloud computing environment: A case study of Uttarakhand a state in the central Himalayan region of India

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Abstract--- Information and communication technologies (ICT) with the continuous growth and diversified advancement, has evolved into a key facilitating quantifiable services across different sector of society while proving to be a powerful driver of enhanced living conditions and opportunities around the globe. ICT has changed the world radically and it is bound to continue to do so in the future. The next urgency of technology is to handle the vast amount of information generated by modern society. This research is to provide a platform for exploring the new ways to determine how the emerging advancements of IT like "cloud computing" can be used with its innovation to enhance the hyper-connectivity, hence helps to transform all the sectors of society. In this research we are proposing to use the advancements of cloud computing for the mobile health vans and ongoing 108 medical services in Uttarkhand state to support the medical facilities in difficult geographical areas of state. We have collected the primary data on state health status like health indexes (like maternal mortality rate (MMR)) and discussed the influences of using technical support systems as cloud computing on those indexes , hence proposed a conceptual model to use IT and communication advancements for health services .

I. INTRODUCTION

The information technologies which has evolved over many years to assist several occupational shifts by allowing people to implement the advancements of emerging technologies to aid in their work. The proliferation of technology into different aspects is an agent for emergence of new era – knowledge processing society. The thrust of innovation continues toward technological advancements focused on comfort, better service deliveries, time and money saving that enhance the quality of life.

Computer the basis for technology has briskly entered in all disciplines of science, society, politics, and economic development and even in daily life of human being. Development of internet has revolutionized communication and made information available in a quick and easy manner hence, publicly accessible and within easy reach. Entry of wireless services and communication advancement has equipped the users with mobility and coverage in negligible price.

In 1984, Sun Microsystems co-founder John Gage coined the phrase "the network is the computer" to describe his vision for the future of information technology [1]. This was a noble statement at the time that predicted a future in which data networks would be powerful enough to supersede services, platforms even desktop PCs as a primary IT resource. Cloud computing explored as practical implementation of this vision.

Cloud computing is seen as the next wave of information technology for individuals, companies organizations and governments. Cloud computing is internet based computing that involves delivering hosted services, platform or infrastructure over the internet. Cloud computing is a type of computing that relies on sharing resources on internet rather than having local access to the applications. Limitless virtualization of scalable environment, cost effective benefits, device and time independence, optimization of resources has expanded the potential of cloud computing as a well promising technology for modern society.

II. MATERIAL AND METHODS

During last 4 decades *Information technology* has passed through five major transition phases. The first period was the 1970's time of mainframes and batch transaction processing. IT was fully centralized and transactions related to accounting systems and other user application was processed in batches and offline where the end-users simply receiving the outputs. The second era was of online processing where transaction processing was online processing in 1980's. During this period, transactions were still centralized and still performed on the mainframe, with the difference that the submission interface was now online and users could interact directly with the system by performing queries and getting reports. The third and forth phases are of decentralization of technologies. Web 1.0 in fourth generations was expansion of decentralization of technology to new extents. It was the revolution of information technology to advance the mass decentralization giving opportunity to everyone for internet access providing facility to perform online task like e-mail and online shopping and the most recent period of web2.0 with cloud computing. Web 2.0 is another generation of World Wide Web providing opportunity to collaborate and share the information online. It transformed the internet access with more dynamic and open sharing of information. Cloud computing is a technology initiative for sharing information capabilities on private, community-shared, and public-shared information technology (IT) environments. Enabled with several new emerging information innovative for more efficient use of IT resources, yielding significant cost and operation capabilities , cloud computing advantages in expansion of effective and qualitative service delivery in different discipline of society.

Cloud computing extends the potential of information technology to amplify the capacity and capabilities on the fly without investing in new infrastructure, training new personnel, or licensing new software by any organization or individuals. Cloud computing encompasses any subscription-based or pay-per-use service that, in real time over the Internet, extends its existing capabilities.

The origin of term "*cloud computing*" is vague however it became eminent in 2007-08. Among the various popular definition of cloud computing one is: "Cloud Computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the datacenters that provide those services. The services themselves have long been referred to as Software as a Service (SaaS). The datacenter hardware and software is what we will call a Cloud." Armbrust et al. [1] . A cloud can be private or public. A ***public cloud*** is one which provides services to anyone on the Internet while ***a private cloud*** is a proprietary network or a data center that supplies hosted services to a limited number of people.

III. CHARACTERSTICS OF CLOUD COMPUTING

Cloud computing provides accessibility for the information is found in the "clouds", and does not require a user to be in a specific place to gain access to it. This innovative technology can be easily exemplified by an email service like Gmail where user needs only a computer and an internet connection to access complete mail processing as reading a mail or composing it. It caters the client needs in highly scalable environment. It is differentiated by traditional computing techniques with three fundamental characteristics:

- Elasticity---- user can define the size of service they want much bigger or less at any time
- service on demand—no need for installation on personal system , on demand user can buy from cloud on minute or hrs basis
- No managerial cost for user- provider is responsible for management of service. User needs a personal computer and internet access to use any service from cloud.

The term cloud computing is a metaphor for internet computing creating a large pool of resources linked to each other in order to provide a shared and virtual IT infrastructure at low cost in very efficient way.

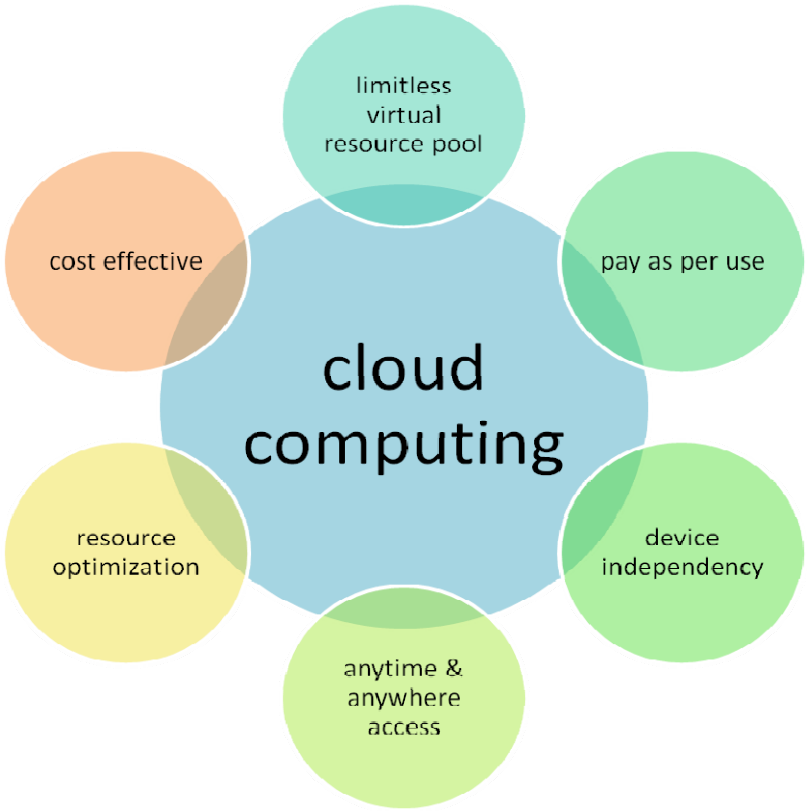

Fig. 1 Cloud Computing Model

IV. CLOUD COMPUTING MODELS

Cloud computing deploys its capabilities according to three fundamental models.

A. Software- as- a- service

Software as a Service (SaaS) is a cloud computing deployment model which provides facility to host applications by a vendor or service provider and made available to customers over a network, typically the Internet with easier administration and global accessibility with easier collaboration and compatibility.

B. Platform- as- a-service:

Platform –as-a service is as deployment technique to deliver cloud computing capabilities as a set of software and product development tools hosted on the provider's infrastructure. Developers create applications on the provider's platform over the Internet with almost zero infrastructures at lower cost. It facilitates for easy and quick development with reusable code and business logics.

C. Infrastructure- as-a-service

Infrastructure-as-a-Service model provides virtual server instances and APIs to start, stop access and configure their virtual servers and storage. In the enterprise, cloud computing allows a company to pay for only as much capacity as is needed, and bring more online as soon as required.

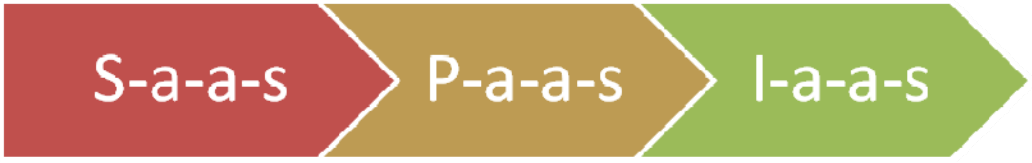

Figure 2: Infrastructure as a Service

With the capabilities of cloud computing Information technology is migrating toward is a blended computing model that will collaborate the best elements of public cloud services with private clouds of organizations which

use the same architectures as public cloud services. On this transformation, technological advancements will cross the threshold to a new era of IT flexibility that should for the first time really allow Information technology application to dynamically respond to the rapidly changing needs of the civic. The applications of cloud computing are nearly limitless. A cloud computing system could execute all the programs that a normal computer could run. Potentially, everything from common email system to customized computer programs designed for a purpose. IT initiatives contributing for sustainable development of different discipline of society education, agriculture, governance or health may be showered with potentials of cloud computing capabilities. This paper is structured to discuss the immense possibilities for using cloud computing technologies in healthcare sector. The case study discussed with public health department of Uttarkhand, a Himalayan state in India (Asia).

A report by Certification Commission for Healthcare Information Technology (CCHIT) states there are more than 300 vendors currently offer some variance of electronic medical records in available local, public and hybrid clouds each[5]. They include:

• Payer-based Health Records (PBHRs)

• Electronic Prescribing (E-prescribing)

• Financial/Billing/Administrative System

• Electronic Health Records (EHRs)

• Electronic Medical Records (EMRs)

• Personal Health Records (PHRs)

• Computerized Practitioner Order Entry (CPOE) Systems

The most imperative attribute of cloud computing is the fact that it is network based, and accessible at anytime from anywhere, from any standardized platform. This transforms availability of the right information to the right people at the right time to make use of golden hours and save lives. Facility to pool the resources online makes it favorable for providing high quality health consultation at peak hours even with low infrastructure facilities, hence supporting its candidature as strong information technology initiative to empower the health sector in developing countries.

V. TEST CASE OF UTTARAKHAND

Uttarakhand a Himalayan state in India, is spread over an area of 55,845 square km having 78 Tehsils, 95 blocks ,7227 Panchayats and 74% of its population is residing in 16,826 villages of state. Geographically state borders Himachal Pradesh in the north-west and Uttar Pradesh in the South and has an international border with Nepal and China. The current public health system was carved out of the earlier state's (Uttar Pradesh) human resources and infrastructure.

The state has 3 medical colleges, 6 nursing schools. The share of AYUSH systems of medicine is to be quite significant in the state. It has one Ayurveda college at Haridwar. State has 13 districts of which, nine have mountainous terrain. Because of tough geographical condition and high sensitivity for disaster vulnerability of this Himalayan region lack of healthcare facilities are most crucial issue for this area. Access to even primary healthcare services is nearly impossible for many people.

VI. RESEARCH DESIGN

The challenges of physical access to facilities, the quality of services is limited by a scarcity of basic amenities and an insufficient number of healthcare providers, as a large number of positions for doctors, laboratory technicians, pharmacists, nurses and mid-wives remain vacant, are major problems in health sector of state .

According to health department reports the current number of health facilities in the state are as under

TABLE I. Medical facilities in Uttarkhand state(Source: health department report)

Figure 1. **Particulars**	Figure 2. **In Position**
Figure 3. Sub Center	Figure 4. 1847
Figure 5. Primary Health center	Figure 6. 254
Figure 7. Community health center	Figure 8. 55
Figure 9. District Hospital	Figure 10. 18
Figure 11. Sub District Hospital	Figure 12. 20
Figure 13. Medical colleges	Figure 14. 03
Figure 15. ANM training center	Figure 16. 06
Figure 17. Ayurvedic colleges	Figure 18. 01

There is a significant shortfall of Medical Officers (59% vacant posts), paramedical staff (41% vacant posts).

Table2: (Source: RHS Bulletin, March 2010, M/O Health & F.W., GOI)

Figure 19. **Category**	Figure 20. **Sanctioned**	Figure 21. **Working**	Figure 22. **Vacant**	Figure 23. **% of Vacant**
Figure 24. Medical officer	Figure 25. 2308	Figure 26. 972	Figure 27. 1346	Figure 28. 59%
Figure 29. Staff Nurse	Figure 30. 1203	Figure 31. 952	Figure 32. 251	Figure 33. 20%
Figure 34. Paramedical staff	Figure 35. 804	Figure 36. 471	Figure 37. 323	Figure 38. 41%
Figure 39. Pharmacist	Figure 40. 1497	Figure 41. 1453	Figure 42. 54	Figure 43. 3%
Figure 44. Drug Inspector	Figure 45. 19	Figure 46. 15	Figure 47. 4	Figure 48. 21%
Figure 49. Food Inspector	Figure 50. 163	Figure 51. 47	Figure 52. 116	Figure 53. 71%
Figure 54. Forth class	Figure 55. 3368	Figure 56. 3009	Figure 57. 759	Figure 58. 23%
Figure 59. Total	Figure 60. 9672	Figure 61. 6911	Figure 62. 2753	Figure 63. 29%

In such conditions, the worst case is that the maternal mortality rate for state is higher than country. The Maternal Mortality Ratio (440/10,000) in the state is higher than the national average of 254/10000 and has a poor ANC (15.7%) and Immunization (79%) as compared to national average of 18.8% and 100.62% respectively.

TABLE 3: Health indicator in State

Figure 64. **Indicators**	Figure 65. **Uttarakhand**	Figure 66. **India**
Figure 67. Infant mortality rate	Figure 68. 44	Figure 69. 53
Figure 70. Maternal mortality rate	Figure 71. 440	Figure 72. 254
Figure 73. Total fertility rate	Figure 74. N/A	Figure 75. 2.6
Figure 76. Full immunization(lakhs)	Figure 77. 79	Figure 78. 100.2
Figure 79. At least 1 ANC(DLHS-3)	Figure 80. 55.4%	Figure 81. 75.2%
Figure 82. Full ANC (DLHC-3)	Figure 83. 15.5%	Figure 84. 18.3%

The research model is proposed to provide the health consultation services to the communities residing in the far-flung areas, where health services are mostly inadequate however 108 emergency health services has efficiently added its services in those areas. MHV (Mobile health van) is also scaled in entire state since 2005 under NRHM program.

VII.RESULTS AND DISCUSSIONS

The proposed conceptual model is to reveal the interrelationship between existing facilities of health sector in state and information technology initiatives should be taken to improve the health conditions of rural areas specially in case of maternal mortality ratio in state. We propose to develop a fully fledged cloud ecosystem hosting a health information system easily accessible to medical person in every 108 emergency ambulance and MHV in state as well as to health consultant in state through their mobile phone applications.

While developing a cloud it is necessary to understand all the components that are necessary to maintain and develop a cloud like server virtualization, network security, and high performance network infrastructure and storage virtualization. Although the model is proposed with wireless communication for mobile vans and rural areas, however there may be lack of connectivity for some far flanged areas in such we suggest for offline assist also available based of patient history information.

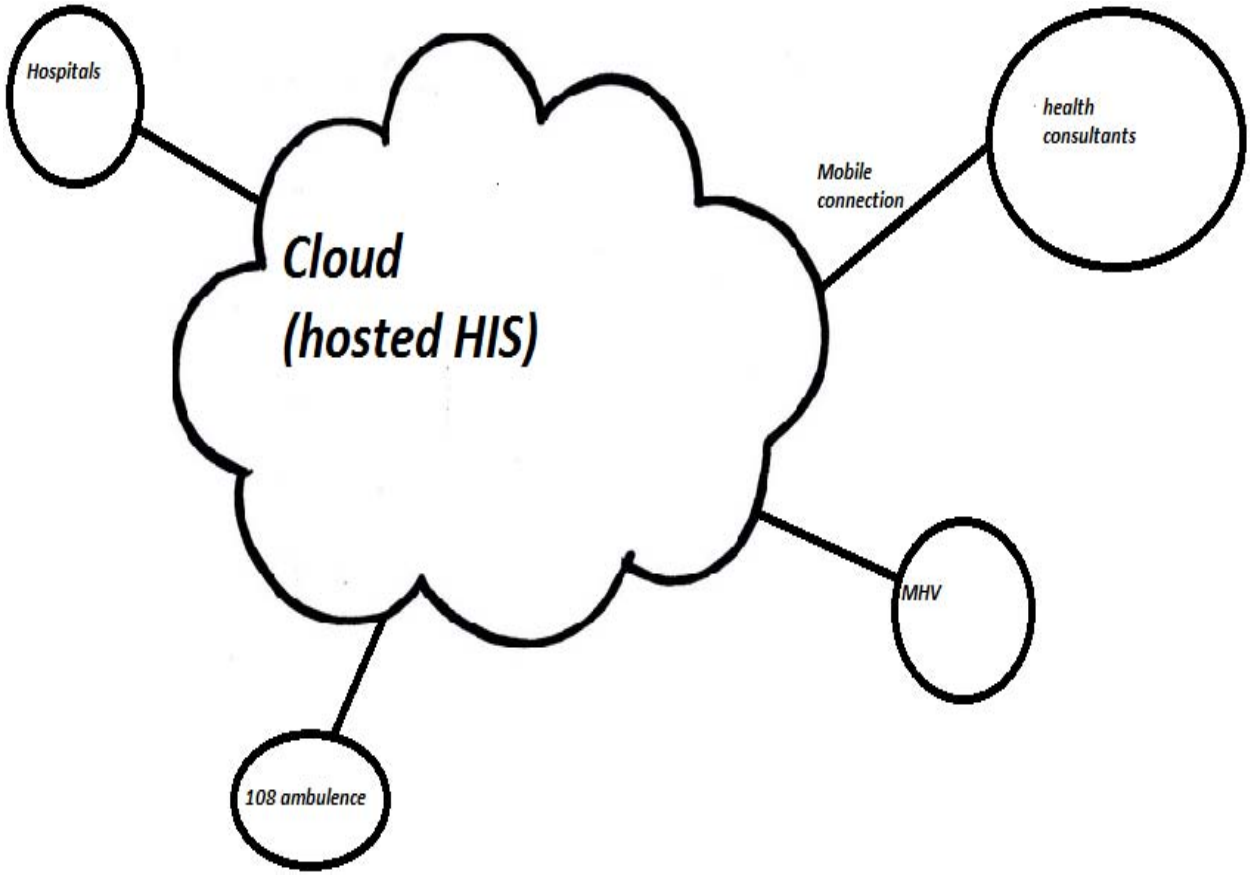

Figure 3: Conceptual model for proposed cloud based healthcare system.

VIII. CONCLUSION

The proposed model is a field service application of health sector in cloud computing environment. There are incredible potentials of cloud computing to facilitate high quality health services at low cost. Cloud computer can provide an opportunity to optimally use the resources in health sector for larger section of society.

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