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Opportunities and Challenges of Sensor Networks in Health Care Applications

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***Abstract* - Healthcare is a promising application of the cloud computing technology. Healthcare network over the cloud has been described in this paper. The existing processes for patients' vital data collection require a great deal of labor 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 scenario restrains the clinical diagnostics and monitoring capabilities. A solution has been proposed to automate this process by installing health kiosk and integrate the devices. The information becomes available in the "cloud" from where it can be processed by expert systems and or distributed to medical staff. This design is able to make the system more user-friendly while retaining all the benefits of more complicated processes.**

Keywords: **Sensor networks, Telemedicine, Cloud computing Wireless Sensor Network (WSN)**

I. Introduction

Existing processes for patients' vital data collection require a great deal of labor work to collect, input and analyze the information. Not only that, patients must travel and wait for the doctors for their assistance in spite of their physical difficulty. I suggest that current solutions based on manual note taking are slow, time consuming, and labor resource intensive. Besides, it imposes an obstacle to real-time data access that curbs the ability of clinical diagnostics and monitoring[1]. The figure below depicts how the process works based on manual notes. The interactions are described below.

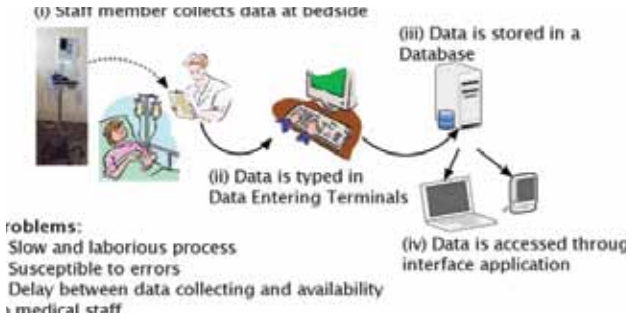

Fig.1 Present Status

Distributed Computing normally refers to managing or pooling the hundreds or thousands of computer systems which individually are more limited in their memory and processing power. On the other hand, grid computing has some extra characteristics. The idea is to be able to make the system more user-friendly whilst retaining all the benefits of more complicated processes.

Cloud services offers healthcare an attractive solution, helping hospitals scale with ease, better manage resources, and provide fluid access, viewing , and sharing of medical images across organizations, departments and providers-achieving a connectedness that supports healthcare organizations' patient care goals. Rich patient and health data created by electronic health records and other information systems promises to radically improve patient care and increase efficiencies for lower system –wide costs.

A. Explosive Growth of Medical Imaging

From a data management point of view, digital medical images represent a particular challenge. They produce large data files and the modalities used to create them are constantly evolving. At the same time health organizations

existing technology –including existing data storage capabilities and the picture archiving and communication systems(PACS) used by radiologists- are radically limiting efforts to harness the massive amount of medical imaging data.

The millions of medical images generated each year represent an enormous challenge for healthcare organizations as they struggle to manage, access and share this data while trying to reduce costs.

Some eye opening statistics:

- Medical image archives are increasing by 20-40 percent each year. It is projected that by 2014 there will be 1.5 billion medical images stored in India alone
- One individuals online medical record could equate to 12 billion novels
- It is estimated that medical imaging information storage constitutes one-third of global storage demand which in 2012 was the equivalent of 1.9 billion average hard drives.
- As of 2014, it was estimated that medical centers needed to hold 2.6 trillion filing cabinets worth of information.

With some older systems, accessing viewing and annotating digital images can be a slow process for radiologists and physicians delaying patient care and frustrating users. When older systems do not have the needed bandwidth to handle the image volume, some organizations have opted to store less data on the older system and archive older images in less costly data storage systems.

This means that images are not readily accessible for users, resulting in long wait times for image delivery. Backup tapes and other "budget "storage methods can compromise the quality of image archives. The cost and complexities of data backup and redundancy can be cumbersome for many IT departments that choose to manage this in-house, as they must deal with multiple proprietary storage solutions and systems from a variety of vendors. Health organizations are beginning to consider cloud computing as an attractive option for helping them manage medical imaging data.

II. Methodology

Cloud for medical imaging;

Cloud services refer to a network of servers connected by the internet or other network that enables users to combine and use computing power on an as needed basis. Each user does not have to purchase and maintain individual computing power. The cloud provides virtual centralization of applications, storage, etc. which can be accessed by any web friendly device (computer, laptop, Smartphone, tablet etc) virtually anywhere. Centralization gives the cloud service provider system wide control over, for example, security and application upgrades, negating the need for installation of upgrades on individual devices. Customers pay for the amount of computing power they use (Comparable to how we pay for electricity or other utilities)

The cloud enables hospitals to:

- Efficiently handle large bandwidth images.
- Use non-proprietary, standard-based, vendor- neutral architecture.
- Expand or contract storage capacity easily as needed
- Manage authentication, encryption and security protocols
- Conduct efficient system-wide application upgrades
- Extend the life of existing infrastructure/investments.

Cloud services may be the solution that enables healthcare organizations to harness their data to create a more patient - centric system and improve patient care, become more cost-efficient, and increase organizational efficiency and productivity.

Data Migration: A key benefit of cloud technology is that data needs only to be migrated one time- and can be accessed and utilized with any system.

It is important for any organization to work with a vendor that can migrate data efficiently and correctly as this is a time and resource intensive investment.

AT&T Medical Imaging and Information Management

AT & T has introduced a solution that helps hospitals achieve the benefits of cloud services to address their medical imaging needs while heading off many of the traditional challenges. AT & T Medical imaging and information management is a highly secure cloud based medical imaging solution that:

- Allows access, sharing exchange and viewing of medical images from virtually anywhere, with full image redundancy for clinical continuity
- Provides a truly managed , end-to-end service in the market- from network to mobility to security and everything in between – at a scale unmatched in the industry
- Extends the value of customers existing network investment and helps them meet ongoing and growing medical imaging needs (operationally, clinically, financially)

AT& T Medical Imaging and Information Management delivers enterprise cloud services that create more efficient healthcare while vigilantly protecting patient information with the industry - leading security of the AT& T global network. The service provides your hospital with a high degree of customization and flexibility in how you manage your data and deliver it to your end users- the providers who will use it for more insightful patient care.

A. Consolidated Access, Viewing, Sharing and Storing of Medical Images

AT& T offers a Food and Drug Administration (FDA) cleared mobile diagnostic viewer with AT & T Medical Imaging and Information Management. This mobile diagnostic viewer is a highly secure cloud based application that extends medical image diagnosis from the confines of a desktop to a providers' tablet or Smartphone. With this enhancement physicians can quickly access, view and interact with patient images and reports stored within the healthcare facility and render a clinical diagnosis from virtually anywhere. The two coupled solutions harmonize patient records, images and reports to make vital patient information accessible virtually anytime- in remote locations and 24 hours a day – helping to speed patient diagnoses. Finally, since no data is sent , stored or downloaded to the devices, there is no additional cost for data sends. More important, by keeping data off the device and behind a highly-secure firewall, you promote the security of personal health information as well.

Table 1 AT & T Medical Imaging and Information Management is A Solution For All Key Industry Challenges

Current Challenges	AT & T Medical Imaging and Information Management and Benefits
As image size increases , aging storage archives and space capacity are causing concerns for health systems	Scalable capacity as needs change Updated storage technology No need for additional hardware/server purchases
Medical images are stored in siloed PACS archives in separate physical locations	Consolidated , cloud –based storage and archive
Proprietary datasets for each PACS system require migrations if department wants to change PACS	Software conversion to standard neutral format No longer tied to PACS vendor's storage Freedom of medical image storage choice
Siloed PACS prevent sharing PACS images with other organizations	Medical images ingested from any authorized regardless of PACS
Limited access to capital funding requires a move toward operational funding	Pay-as-you-go model(per medical image study and per consumption on storage)
Organization needs to ensure business continuity to remain in compliance and protect medical records	Two copies of each image stored as well as two copies of the associated database Data stored in two different , geographically dispersed data centers
Inability for providers to collaborate across the enterprise and care continuum in a secure manner on mobile devices	Viewing from virtually any location through common internet web browsers Accessible from laptops, tablets, smartphones and other smart devices No data leaves the cloud and is viewable on the mobile devices highly secure

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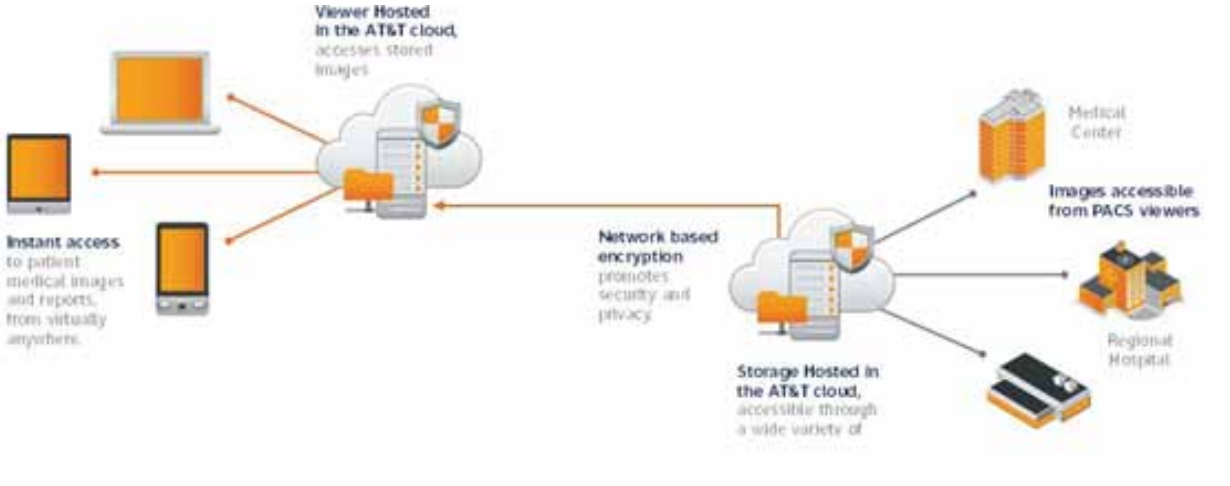

Fig.2 Consolidated sharing and storing of Medical images

B. Wireless Sensor Cloud and Innovation Capabilities

The limitations of WSNs in terms of memory, energy, computation, communication, and scalability, efficient management of the large number of WSNs data in these areas is an important issue to deal with. There is a need for a powerful and scalable high-performance computing and massive storage infrastructure for real-time processing and storing of the WSN data as well as analysis (online and offline) of the processed information under context using inherently complex models to extract events of interest. In this scenario, cloud computing is becoming a promising technology to provide a flexible stack of massive computing, storage, and software services in a scalable and virtualized manner at low cost. Therefore, in recent years, Sensor-Cloud infrastructure is becoming popular that can provide an open, flexible, and reconfigurable platform for several monitoring and controlling applications.

A typical sensor network may consist of a number of sensor nodes acting upon together to monitor a region and fetch data about the surroundings. A Wireless Sensor Network (WSN) contains spatially distributed self-regulated sensors that can cooperatively monitor the environmental conditions, like sound, temperature, pressure, motion, vibration, pollution, and so forth. Each node in a sensor network is loaded with a radio transceiver or some other wireless communication device, a small microcontroller, and an energy source most often cells/battery. The nodes of sensor network have cooperative capabilities, which are usually deployed in a random manner. These sensor nodes basically consist of three parts: sensing, processing, and communicating [23]. Some of the most common sensor devices deployed in sensor network as sensor nodes are camera sensor, accelerometer sensor, thermal sensor, microphone sensor, and so forth. Currently, WSNs are being utilized in several areas like healthcare, defense

such as military target tracking and surveillance [24, 25], government and environmental services like natural disaster relief, hazardous environment exploration, and seismic sensing , and so forth. These sensors may provide various useful data when they are closely attached to each of their respective applications and services directly.

However, sensor networks have to face many issues and challenges regarding their communications (like short communication range, security and privacy, reliability, mobility, etc.) and resources (like power considerations, storage capacity, processing capabilities, bandwidth availability, etc.). Besides, WSN has its own resource and design constraints. Design constraints are application specific and dependent on monitored environment. Based on the monitored environment, network size in WSN varies. For monitoring a small area, fewer nodes are required to form a network whereas the coverage of a very large area requires a huge number of sensor nodes. For monitoring large environment, there is limited communication between nodes due to obstructions into the environment, which in turn affects the overall network topology (or connectivity) [9]. All these limitations on sensor networks would probably impede the service performance and quality. In the midst of these issues, the emergence of cloud computing is seen as a remedy.

The scalable computing capability for data processing, agile application development tools and a virtually infinite

Capacity for data storage make cloud computing technically compelling. Let's imagine, if wireless sensor nodes are sensing the micro-scale physical world individually, they can eventually function as the macro-probe to our world with a powerful brain when they work together in an intelligent and collaborative way using the Cloud as the backend infrastructure for data storage and processing. The Cloud also acts as a central library with expandable

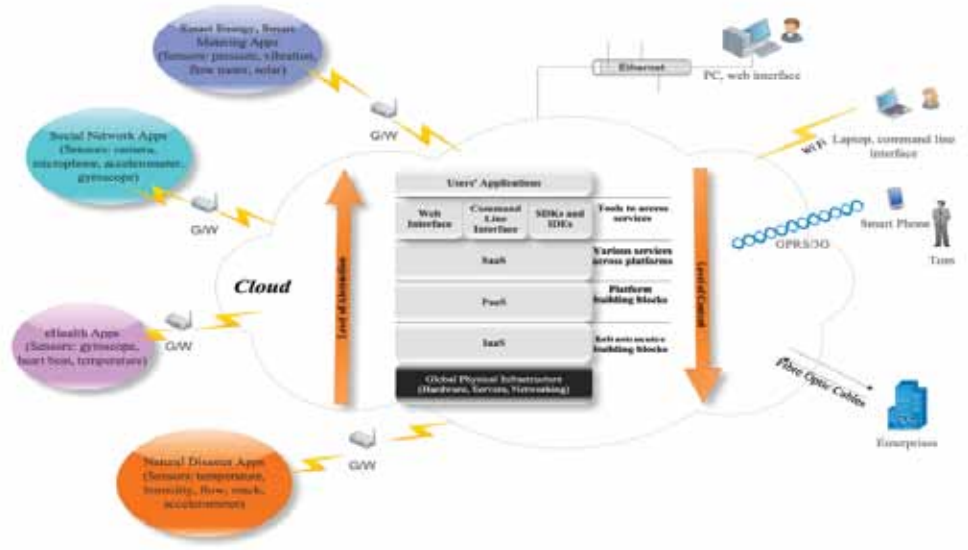

Fig.3 Wireless sensor cloud using Cloud Computing

capacity in which developers and users only need to spend their efforts in developing the application features while other components such as security, scalability and shared data models have already been developed and tested with millions of users. Further-more, geographically distributed data centres assure us of data safety by scheduling regular data backup to a different data centre. An overview of opportunities in the applications of WSNs using Cloud is shown in Figure 3.

III. Conclusion

The solution delivers an integrated telemedicine service that automates the process from data collecting to information deliver as a computing utility. There are several practical advantages in this implementation, such as: it provides always-on, real-time data collecting; it eliminates manual collecting work and possibility of typing errors, and; it eases the deployment process, as wireless

networking means no need for cabling or other physical setup. From the software engineering perspective, the proposed design promotes re-usability through the use of a standard services implemented and deployed by using a Platform as a Service (PaaS). In addition, it leverages others health-care institutions to use services through a Software as a Service(SaaS) model without investments on hardware or software licenses.

On the scientific field, the project 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 and the developments from this project will address some of the outstanding questions. 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 (QoS).

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 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 the project results in a cost-effective solution to address the requirements for modernization of health-care system in developing countries.

As future works, it is intended to validate the proposal in a real world setup to assess the benefits of the solution in large scale scenarios. In addition, it is intended to implement several services enhancements of security and management with interaction of thirty-party infrastructure service provider.

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