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Cloud Computing in Healthcare and Biomedical research: Exchanging data at the speed of thought

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ABSTRACT

Advances in computing and networks have considerably improved the way we communicate and exchange information. The improved efficiency in communication and data exchange has contributed to globalization in true sense, with business possible around the clock without boarders. Cloud computing is a rapidly developing branch of this sector with considerable applications in healthcare and biomedical research. In this brief review an insight into the utility of cloud computing in healthcare and biomedical research is described.

Key words: Cloud computing, Biomedical research, Clinical data management.

BACKGROUND

A few years ago, I had the opportunity to deliver an IT architecture workshop for a large multi-utility hospital in Malaysia. The ideas generated through the interactions with the medical and IT staff at the hospital during the workshop were around architecting medical grade solutions and a set of software architectures aimed at improving the quality of services to its customers. It is interesting to know that, during the course of the workshop, we decided to debate the then prevalent SaaS (Software as a Service) as an approach to developing a strategic architecture for the above said purpose.[1]

The objective was to brainstorm and arrive at a consensus with regards to the right set of architectural components and solutions to take the hospital to the next phase of business transformation. Less we were aware that time about the Cloud based approach of which the SaaS has been a precursor.

Communication Logical, Operations Universal Database (Cloud) computing is an emerging solution to high scalability of infrastructures and applications, with its potential impact to healthcare and research sector.[16] Cloud computing which is now a household name, has been known at the time as a SaaS (Software As A Service) model. The idea behind SaaS was to create an IT service delivery platform where set of tools and technologies were treated as loosely coupled hardware that delivered IT and application services remotely. As an example, a bed-side solution in a hospital would enable the patient to download services to her/his hand-held device such as a mobile phone or a VoIP (Voice over IP) phone. So, the interaction between the remote computers and the patient or the interaction between the patient and the nurse were facilitated by the SaaS based architecture.

Cloud technology has been a natural transition from the SaaS model with enhanced capabilities such as security, privacy, redundancy, virtualization, low cost of operations, etc. Hospitals are now able to exploit Cloud features to deliver cost effective and reliable services to its customers. As in other industry domains, Cloud is invading Healthcare industry and making a huge impact in the patient care business, albeit, it is much slower than many other industries in adopting Cloud for obvious reasons of privacy, safety and reliability.

The philosophy behind Cloud Computing has been to deliver IT services over a network such as an internet. The end user community can be technology or device agnostic. Doctors and nursing staff can use their mobile, smart phones, tabs, desktops or any other hand-held devices to connect to the Cloud environment. Cloud (say, the internet) is the medium between the user and the computing systems.

Cloud solutions come in different flavors such as Private, Public, Hybrid, etc depending upon the user requirements and the associated architecture. For a typical healthcare provider, dedicated Private Cloud architecture is the most preferred version as this guarantees privacy, quality and reliability of services but at a higher cost. Hospitals looking to adopt Cloud for the first time, may choose to start with a low end Public Cloud solution and test run for a few months before moving to a large suitable Cloud model. A number of Cloud vendors today provide scalability mapped to the needs and demands in terms of more capacity and volume of transactions, etc.

Cloud architecture can be visualized as electricity supply model. Each of the households can use switch to turn on or off the electricity sup-

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ply depending upon the need. In exactly, the same way, a Cloud user can use his/her device (such as mobile/laptop) to connect to the Cloud provider and access software services. For example, a doctor may like to analyze patient health records stored in the Cloud provider's data center by logging into an appropriate application being delivered as a service. The medical application itself will be residing in the Cloud storage area far away from the hospital either in the same or different town/country.

The biggest advantage of adopting Cloud for the hospital is that, there is no need to invest or build its own IT infrastructure for the purpose. Normally, the user of the Cloud services uses the services as "pay-per-use" basis just like the electricity or other utility services. Further, the responsibility of maintaining the IT and network infrastructure rests with the Cloud vendors bringing down large capital commitments and hiring IT resources efforts drastically.

Following is the simple Cloud architecture that can be adopted for Healthcare environment. (Figure 1)

Any Cloud architecture being proposed to a Healthcare application must sufficiently address the following requirements:

- Privacy of the patient's health records
- Secured access to medical documents/records
- Strict enforcement of security policies
- Dedicated computing and storage resources
- Redundancy and Reliability

Cost of operations

One of the key components of the Cloud architecture is the virtualization, a technique that enables running multiple software systems on the same hardware thus further reducing the hardware costs. Cloud architectures also support partitioning of the customer data and applications logically for better reliability and management. Most of the Cloud offerings come with SLA (Service Level Agreements) that help the customers in addressing the down time issues and liabilities arising thereafter.

Migrating to Cloud in Healthcare

Although Cloud technology brings significant benefits to the Healthcare industry in the long term, migrating to Cloud environment for the first time takes quite a bit of internal selling effort. The key stakeholders such as CEO, CIO, CFO, IT and Medical staff need to be taken into confidence before embarking upon implementation of the Cloud based systems. It is with this objective that we designed the Cloud awareness workshop for the Healthcare customer in Malaysia. Any Cloud based initiative calls for a lot of justification as this is regarded as a business transformation project within the enterprise. Simple questions such as What, Why, When and How need to be addressed through dialogues at all levels of the organization.

Some of the key messages that were employed in the workshop were as follows:

- Cloud brings huge benefits in terms of operational efficiency and agility.
- Cloud can be implemented incrementally without major shake-ups in the way the hospital operates.
- Initial capital investments are offset against strategic benefits in terms of the reduced costs of operations and improved services quality.
- Cloud can reduce risks by automating policy enforcements and compliances critical for Healthcare industry.
- Cloud can benefit in terms of scalability, speed and reliability.
- Cloud architecture provides a flexible way to manage one's compute resources depending upon the computing demands. This means the hospital can scale up or scale down its cloud usage depending upon its needs.

Any Cloud migration project starts with a discovery workshop and stakeholders brainstorming ideas and options, collecting business goals and imperatives and mapping them to Cloud architecture. Ideally, a white paper delivered at the end of the workshop highlighting the Cloud approach, solution options, benefits, investments and migration plan, schedules and effort estimates will be quite useful for the management and the operational staff as a reference document.

Major and potential applications of Cloud

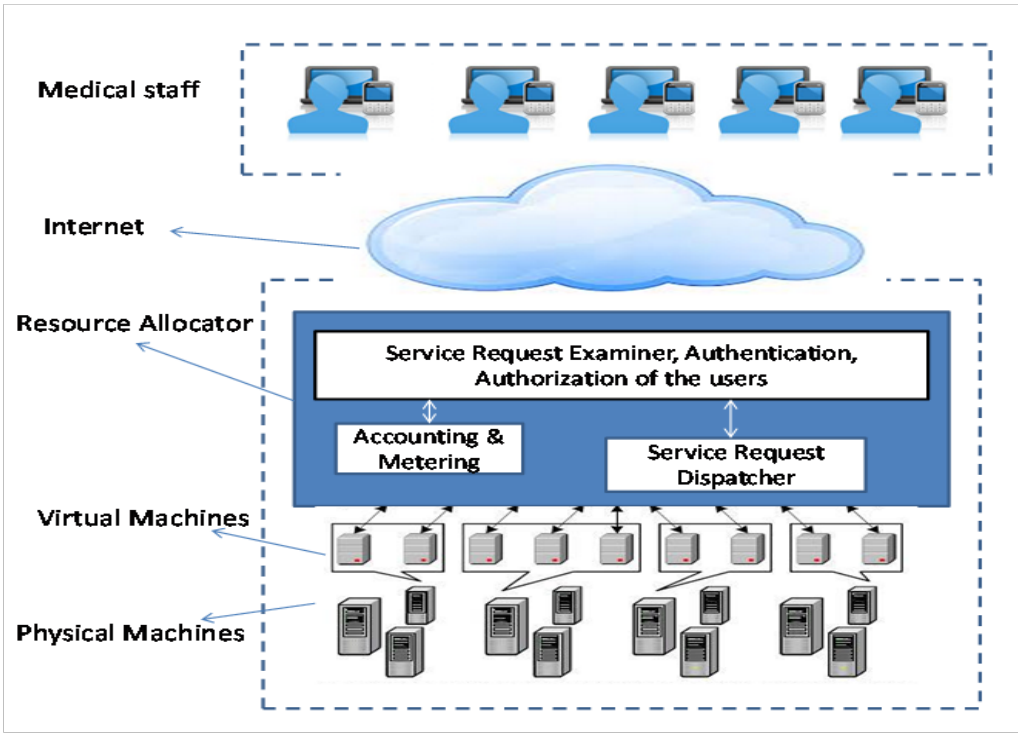

Figure 1. Cloud Architecture

computing

- Clinical image reviews[17-19]
- Clinical research database[20-22]
- Biomedical data management[20-22,24]
- Global online education [12-13]
- Archiving scientific publications in virtual space[28-30, 43-45]
- Facilitating open access and open peer reviews[29-30]
- Duplication in science
- Public health information systems[23]
- Health Electronic Reports safety.[35-42]

The concept of cloud computing eliminates the need for maintaining servers or software at local space. Moreover all usage is on demand and need based hence bringing efficiency. Specifically the efficiency in utility, scalability, flexibility, maintainability and massive data processing are major advantages of Cloud-based system.[2] Several infrastructure such as HIPAA[3], ProteoCloud[4], e-Science Central[1], Eucalyptus, Amazon AWS, Microsoft Windows Azure and Cloud Bio-Linux[25-27] to support cloud computing have recently being developed and interestingly some of them are in open source platform which is essential to promote its adoptability and wider usage.

Interestingly, The Open Group which promotes TOGAF (The Open Group Architetcure Framework) provides ADM (Architecture Development Method) that can be mapped to the healthcare related business processes for developing business, application, data and technology architectures that result into Enterprise Architecture that drives the strategic IT agenda for the healthcare enterprise.

The extensive and rapid phase of digitalization of biological data[5] available from genomic sequencing,[31-34] high-throughput proteomics/ experiments and simulation datasets on molecular structure and dynamics necessitates the need for high throughput informatics and data share in the form of cloud computing to facilitates its wider and global utility. This if further fortified with the collateral sector of clinical data and digital diagnostics wherein cloud based computing can be very valuable in benefiting from global medical expertise at a very fast phase. Nevertheless this approach of cloud-based globalization is need of the hour to achieve a much-needed international harmonization in the medical research as well as clinical sector. Although such massive scale operations will require unbiased and very open commitment from several nations, but when achieved will provide opportunities to access data, avoid duplication, and improve efficiency at a pandemic scale.[5] Another important and much needed utility of Cloud based computing would be in addressing the issue of duplications in science, and achieving ubiquitous healthcare services,[6] Could this be achieved remains an open question? A closely related area to this is the statistical analysis of multi center major clinical databases on cloud resources, which may offer substantial benefits by shifting computer cluster to cloud computing.[7]

Such massive digital data revolution will need breaking the current barriers to achieve high computational power but with collateral high memory bandwidth, can this be achieved?[8] But if achieved, such environments will have the potential to benefit both physicians and patients at a pandemic scale.[9-13] Although some aspects of this is partly achieved in the form of Central Proteomics Facilities Pipeline (CPFP) which allow use of remote cloud and high performance computing (HPC) resources for shotgun proteomics data processing[14, 15] more needs to be done.

Additionally, a proof-of-concept project lasting for a short period of 1 month can be proposed that demonstrates in clear terms the benefits discussed during the workshop. Choosing a right Cloud architecture is important to the overall success of the migration project. Typically, this consists of developing a Business Architecture that captures the existing business processes and workflows being followed in the hospitals along with the future state architecture and processes that will be implemented post the Cloud solution. The business architecture will translate into IT and Software/Hardware infrastructure architecture leading up to selection of suitable tools for developing Cloud solutions.

CONCLUSION

Safety, efficiency, timely treatment, cost and privacy are amongst the top concerns for any healthcare organization today. Cloud computing has evolved and matured in the past five years to address these concerns effectively. Future trends in medical computing such as Wireless Implantable Medical Devices, Internet of Things (IoT), Wearbale Devices, and Nano technology related research will complement the acceleration of the Cloud technology. Universities and Research centers the world over are engaged in developing and testing Cloud solutions for the healthcare industry to benefit society at large.

The key to a successful Cloud adoption for any Healthcare organization, small or big is to assess the current limitations of the existing business services model and build a future state IT architecture with well defined roadmap and milestones for migrating toward a more profitable and agile Cloud computing environment.

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