

CLOUD COMPUTING IN HEALTHCARE

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Abstract- Information Technology (IT) has modernized healthcare sector via the newest development. Cloud computing in healthcare is budding and charming as crucial methodologies by most of the stakeholders. It has the special ability to offer infinite capacity and power of process in the e-healthcare sector. This leads computer to be used efficiently and exclusively by the sharing of resources in healthcare. This paper provide a review of some proposed cloud based e-healthcare architectures edge along with issues in both technologies and the crucial reasons of enhancing forward to a cloud based e-healthcare especially in Malaysia.

Keyword—cloud computing; e-healthcare; healthcare

I. INTRODUCTION

Healthcare is defined as the service delivered to individuals or populations by healthcare service providers to promote, maintain, monitor or restore health [1]. Internationally, the ultimatum of healthcare is well predictable as it is expected to endlessly expand in future due to tangible reasons such as projected demographic shifts among the aging population, life expectancy, and lifestyle diseases.

Malaysia has escalated enormously as preferred healthcare travel destination for the world due to the high mounting like the one of the paramount developing country especially among the ASEAN countries. This agenda is parallel with the vision and strategies of Malaysia's 12 National Key Economic Areas (NKEA) under the new Economic Transformation Program (ETP) for the economy drive next 10 years as it is aimed to develop seamless and integrated healthcare system is aspired to be preferred healthcare terminus in the constituency [2].

World class quality of healthcare services, which includes easy accessibility and patient to be competitively affordable, is the crucial attractive proposition of healthcare in Malaysia. Malaysia's healthcare system are divided into two main pathways which are a public and private sector. Total expenditure on healthcare in Malaysia is estimated 4.75 percent of gross domestic product (GDP) while the total funding of healthcare are 55 per cent and 45 per cent for Government and private sector respectively.

Correspondingly, the value of Malaysia healthcare industry is estimated at \$8.4billion with as per August 2011, 145 public

hospitals, 2880 health clinics and 165 mobile health clinics were reported and registered as per statistic while 217 private hospitals, 34 maternity nursing homes, 36 ambulatory care centres and 6442 medical clinics in private sectors[3]. The growing progress of healthcare coupled with local as well as foreign patients will definitely attain huge aggregate of patient data, variety, veracity and leads to the necessity of perfect system in order to sustain and further up the good quality status of healthcare service provider. Generally this situation creates two main problems for a healthcare system that includes complexity and upsurges the needs of the IT experts deadily.

Moving of healthcare sector to cloud computing system in order to overcome this delinquent will be definitely a virtuous idea of solution of all the problems individually [4]. Cloud computing is highly rated as the sole representative from current IT trends of efficiency, business agility, and cost reductions. Therefore, the aim of this paper is to provide a review of some proposed cloud based healthcare architectures solution edge along with issues in this technology and the fundamental reasons of enhancing healthcare forward to cloud computing in Malaysia.

II. CLOUD COMPUTING

An archetypal which enable ubiquitous with expedient demand network access to a shared pool of configurable computing resources such as storage, applications, network, servers, and services are delineate as cloud computing. Also, cloud computing has its own exclusive benchmarks in where it operate with minor management exertion or service provider interaction [5]. There are five important characteristics, three service models, and four deployment models under this masterpiece as per stated by National Institute of Standards and Technology, U.S Department Commerce. The five important characterizes as per stated:

On demand Self Service: Consumer or client of cloud computing can fascinate computing capabilities individually including server period and network storage as required spontaneously deprived of human interaction with the entire service provider.

Broad network access: Competences of this technology are obtainable over the network and are retrieved through ordinary

mechanisms assorted by thin or thick client platforms, for instance, mobile devices and workstations.

Resource pooling: Numerous consumers is serve by the providers and computing resources is pooled with a multi-tenant model that enable various physical, virtual resources dynamically assigned and reassigned rendering to consumer demand without control or knowledge over the precise location of the provided resources unless in a higher level of abstraction.

Rapid elasticity: Cloud Computing is also able to provisioned and released elastically, scale rapidly outward including inward commensurate with demand automatically in some selected cases. Capabilities for provisioning unlimitedly and an appropriate quantity of time are one of the major vital concerns for consumer particularly.

Measured service: Cloud computing systems spontaneously control and optimize resource with metering the capability at some level of abstraction by fitting into the variety of services. Characteristically this is done on a pay as per use conceptual. Provider and consumer able to monitor, control, and report, resource usage which tortuously provide positive transparency for both side of parties.

A. Service Models

The factor of operating costs and flexibility can be highly correlated with the service models. The above mention factors are inversely proportional in where the operating cost of SaaS is the lowest followed by PaaS and IaaS, and these conditions lead to higher flexibility in IaaS followed by PaaS and SaaS. The three vital service models (Figure 1) of cloud computing are as indicated:

Software as a Service (SaaS): Service provided or available to the client is to use the applications created by host which directly available on a cloud infrastructure, and the applications are easily accessible throughout various devices such as a web browser or even through a program interface. Infrastructures including network, servers, operating systems, storage, and even individual application capabilities are not managed by the consumer or client unless with the omission of limited users specific application configuration settings.

Platform as a Service (PaaS): Consumer is competent to deploy onto the cloud infrastructure either consumer based create or acquired applications which generated using programming languages, libraries, services, and tools supported by the service provider itself. 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 configuration settings for the application hosting environment.

The common example is when a client needs an email system or data software, they can use cloud computing service as a solution wisely [6].

Infrastructure as a Service (IaaS): This service allows the establishment of processing, network, storage, and ensuring computing resource in where end users are arrayed and route arbitrary the software such as operating systems and applications. As per remaining other two services, the consumer does not oversee the cloud infrastructure but administer over frameworks, storage, and set up applications with the restricted regulator of selected components networking such as host firewalls.

B. Deployment Models

There are four types of model that are deployed under cloud computing:

Public cloud: This type of cloud infrastructure is provisioned for open use by the general public. Corporate, academic, government organization, or a combination of mentions above usually responsible to managed and operated as they are owned. The concept of payment is as per use which sanctions the range of resources to meet ongoing fluctuating stipulates either positive or negative.

Private cloud: Infrastructure of private cloud is exclusive for the use by a lone organization comprising multiple consumers. It may be possessed, managed, and operated by the organization, third party, or combination of them, and it may exist as on or off premises. Flexibility in imposing related compliance requirements of data ownership and seclusion is greater due to the reason of single organization use only.

Community Cloud: This type of model is designed specifically for the community of consumers from organizations that have communal concerns such as in mission and policies. A third party, one or more than one organization from the same community and even combination of the two mention above may hold, managed, and operate this type of cloud and it may exist as on or off premises. Sharing conceptual of this leads the organizations to typically have parallel security, privacy, performance and even compliance requirements, but conversely, the community curbs participant from similar industry or desires.

Hybrid Cloud: This hybrid cloud infrastructure is composed of two or more distinct cloud infrastructures that mention above and remain as a unique entity, but are bound together by standardized or proprietary technology which permits portability of data and application.

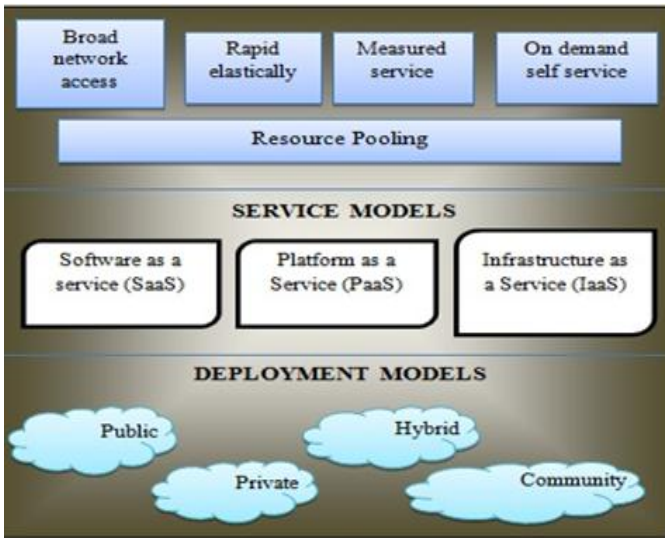


Fig 1: Definition of cloud computing. Source from Peter Mell and Timothy Grance (2015) NIST

III. CLOUD COMPUTING IN HEALTHCARE SECTOR

Traditionally, healthcare sector underutilized technology especially in improving the delivery of patient care. Healthcare has entered sixteen years after millennium, but hence in healthcare, the number of system operate manually, generally or relaying on paper, such as medical records to notify and make decisions in most of the conditions still significantly high. Healthcare industry differs greatly from other industries, and the key differences of the healthcare industry with other industry can be categorized into three segments. Firstly this sector are highly regulated by governed law including regulations to safeguard patients. Secondly cost of high risk errors to occur in healthcare are more costly than in other industry, and finally, this sector consists of numerous number units such as hospital administration staff, labs, and patients.

Exceptionality privacy of healthcare and security of patients' data makes the data itself sensitive and any criteria misleading will cause severe impact and may lead to life or death at times. Hence, the sensitivity of data handling can result to be unhurried by the adoption of new technologies. Universally, healthcare is reorganized, and reform causes the healthcare information technologies (HIT) to be modernized and as a pathway for this route or center of this transformation is definitely cloud computing without hesitation [7].

Adoption of cloud computing in healthcare can ominously enrich the healthcare system especially in the comfort zone of efficiency, effectiveness, and reliability. Cloud computing offers an infrastructure that permits hospitals, medical

practices, and insurance companies including research facilities which use computing resources at lesser of initial capital costs [7]. By implementing this cloud computing in healthcare, access costs which will usually be in millions of dollars each year, especially in duplication and waste, can be overcome thoroughly.

In general, it can be strongly mentioned that cloud computing in healthcare is growing by day to day and plays a major role in the field of healthcare as per stated by authors in their articles below:

Reference [4] stated that there are various suitable reasons to use cloud computing in healthcare and numerous problems can be solved such as limitation capacity of storage, high operating cost, and optimizing resource.

According to references [8] moving towards cloud computing in the healthcare system is the superlative movement due to the emergent number of the electronic file which contributes to raising of several unsolvable problems [4] [9].

Reference [9] suggested migration of healthcare sector towards cloud computing brings some risk which strongly interrelated to the privacy and security although benefits from this decision is attainable. Consequently, it is necessary to maintain, upgrade, and monitor the hardware and software which consists of healthcare data and are crucial in order to avoid negative consequences.

Complexity and facilitating can be reduced while collaboration among the information systems in healthcare sector can be increased if cloud computing is included in this sector. The architecture of cloud computing have the capability to assemble, integrate, analyze the data from various sources either in real time and permits doctors to access patient records without any barrier of place and time. One of the offers that important in healthcare that could be done by cloud computing is the capability of recovery of data in an emergency state such as disaster recovery, and backup data redundancy as it reproduces the data in numerous locations for more heftiness and accessibility [10] [8] [11].

References [12] mentioned IT cost which usually bare heavily by healthcare sector can be reduced significantly when moving towards cloud computing which can be seen immediately. Additionally, adopting to cloud model will cause migration of all the IT processes to the infrastructure of cloud computing where the processes will be stored and performed more effectively and precisely. Significantly, the latest model which known as "pay-as-you-move" allows organizations to pay only for what they use or implement. To put in other words, the associations will not have any particular explanation behind getting costly equipment infrastructure, programming warrants

or to keep in site staff for maintenance, security, and replications. This is as the cloud offers packages which take care the reasons which may be questionable from the respective organizations.

Reference [13] declared a human life is very precious, and the facilities of the medical resources are restricted. Along these lines, human services administrations embraced in cloud suppliers coordinate a practical idea where patients wellbeing associated exploit this innovation by enhancing persistent nature of administration through a circulated high incorporated stage which coordinating of medical process and additionally decreasing IT base of venture or upkeep cost which prompts a superior human services environment.

A. *Current State Of Cloud Computing In Healthcare*

Over the last few years, cloud computing technology has gradually gained attention in research and numbers of implementations have increased in public and private sectors as well. According to Economics Commerce and Management of United Kingdom, major businesses was expected to invest over \$150 billion on cloud computing by 2014 but however the final results shows the final amount is far more higher than predicted earlier. Besides, studies on global healthcare IT trends, expected worldwide healthcare cloud computing sector's revenue in 2017 will unquestionably boost up to \$5.4 billion due to toupwelling of this sector. Furthermore the prime contributor, North America prophesied to impact the market share of this sector up to \$6.5 billion in 2018 from 1.7 billion in 2013.

Most of the countries that have been developed and establishing healthcare data clearing houses that can aid data as more portable than earlier. For instance, Canada is the country that recognised diagnostic imaging repositories across the country in order to aid in patients care and as well as cost saving. All the countries endure to invest in cloud computing mechanism will definitely improve patient care. Based on study, statistic shows that 37% of healthcare service providers have strategic plans with adoption of cloud, 22% are in the planning stages while 25% are in the midst of executing in which this can definitely drive the respective industry. Besides, the 5% that have already embraced cloud computing have recognized an average of 20% savings on implemented applications which is a successful news that will bring this sector into a higher level.

Exchange of patient data among clinicians, departments and even patients is rare and definitely a complex agenda. An organization dependence on vendors to knit together their various technologies which indicate too expensive with unverified data experiments. This issue have approached by various countries in different ways such as from the central

national clearinghouse at UK to regional health centres which located at Canada into more granular health information exchanges where all realized numerous degree achievements. Furthermore, countries that have hopped over paper records and move towards diagnostic image believe to additional triumph in a restricted manner but however yet to attain victory in patient record due to its larger gear [14].

Previously, majority of IT departments providers are habituated to traditional technologies in where the necessity of licensed software platforms, and heavy hardware infrastructures and followed by a large group staff. As innovated technologies presented, IT infrastructure demands forces the bounds of the assured more efficient. While groundbreaking in theory, government enticements do not shield overhauling legacy equipment cost and modernizing facilities. As electronic health records, advanced clinical systems are evolving and becoming more well-known which causes current storage resources to be extended.

Implementation of digital time pathology ensure the backend technologies are accurately designed and working often taking focus away from the clinical criteria applications and user's attention. Reduction of implementation time is perilous in order to facilitate aptitude adapt hurriedly based on needs of changing and the introduction of novel applications.

Patients of this era are advocates better in rate for their healthcare. One of the reasons is because most of the patients are well educated, or concern to their diseases and raises demand of accessing to up to date technologies. This leads to the seeking of supreme care at the finest cost and is even enthusiastically to investigate the options available. Additionally, patients are demanding for access to their personal records and organizations have to keep up.

B. *Strength and Weakness*

Implementations of cloud computing in healthcare have its own range of strength and weakness (Figure 2).

The main or core strength of using cloud computing in healthcare is the cost dynamic. The cost of operating can be reduced extremely due to the absence of start-up expenditures in these plans which abide by the host initially. This situation is classified as a plus point for healthcare sector as they are not affordable to the intense expenses due to lack of resources if compare to information technology sector. Additionally, access to the patient's records anytime and anywhere can be done very smoothly and easily which indirectly hints to rise alliance between doctors and patients as well as theintensification of quality services to patients. [4] [9]

Realizing cloud computing in thehealthcare sector is aweakness of this whole idea as it is not a tranquil chore as

there they are numerous negative factors involved in adopting and implementing. Moreover, an adaptation of cloud computing increases the percentage of dependable of client or healthcare sector in this scenario to the service provider where it can indicate to the problem in future. Other than that, even in advance country, many hospitals do not have even internet connection especially in the urban area in order to connect to the cloud, thus implementing and practicing cloud computing is definitely will be tough. Therefore, it can be stated clearly fundamental and essential requirement for connecting to the cloud is the internet connection and moving forward towards it is simply impossible with the absence of requirement [15].



Fig 2: Strength, Prospects, Weakness and Threats of cloud computing in healthcare [16]

IV. CLOUD COMPUTING OF HEALTHCARE IN MALAYSIA

The market of cloud computing in healthcare has shown a steady increase from time to time [17]. Regulatory impacts from the American Recovery and Reinvestment Act of 2009 (ARRA) which encourage the exploitation of electronic patient records to be used in hospitals is the reason behind the evolution of cloud adoption [18]. Currently, installing cloud based ICT solution in Malaysia has turned out to be one of the greatest imperative trends and anticipated to nurture up to \$900 million in 2020 from \$43 million in 2012. Based on a comparative view, the interest of Malaysia on cloud computing and countries from worldwide are quite similar particularly after the middle of year 2010.

This statement is more strongly supported by the decrease of trend in Google search results after the middle of 2011 which strikingly indicate ubiquitous permeation of human life by

cloud computing in various aspects. The government of Malaysia, cloud stakeholders as well as private and public organizations have lately instigated determinations to uphold acceptance and implementation of cloud services in their respective association [19].

In an analogous move, IBM particularly in Malaysia recently broadcast the nationwide development of Kumpulan Perubatan Johor which widely known as KPJ Healthcare Berhad in the cloud healthcare infrastructure. KPJ Healthcare Berhad can be honored as the first ever private healthcare organization in adopting cloud computing. Moreover, KPJ Healthcare Berhad is prominent private healthcare provider which provides seamless healthcare services to more than 2.8 million patients per year across more than 25 hospitals in Malaysia and 4 overseas hospitals [20].

Management of KPJ believes 30% to 40% of their IT cost and expenses can be reduced in the long term with this initiation. Furthermore, collaboration among KPJ hospitals throughout cloud computing especially in the network is further secured intermediately due to support integration which will pursue better, faster and effective services to patients and families when they need at earliest time duration. In general, shifting towards cloud infrastructure relieves KPJ Healthcare to operate at a bridged cost with maintains the efficiency, reliability, and flexibility [21].

iMeus Sdn Bhd under the MSC company provides a SaaS cloud-based healthcare system, called eKlinik service which objectively to provide real time healthcare information principally to patients, doctors, and hospitals in Malaysia nationwide. Basically eKlinik offers cloud based Electronic Medical Records system which allows the hospitals to access the system via internet by avoiding installing any software. Sharing of medical history across hospitals around the world is also was one of the initial commencement of adopting cloud computing in healthcare.

Cloud adopted system allows hospitals from different places to access patient's medical records and even insurance particulars in case of medical emergency and vice versa [22]. Thus, integration of medical services using futuristic cloud adopted healthcare platform in Malaysia can improve competence, excellence, approachability, and equality of healthcare delivery regardless of geographical boundaries.

V. CONCLUSION

As a nutshell, cloud computing has its own region of benefits for healthcare information system, which not only focusing on solving problems such as storage, bandwidth and leads to reduce costing with optimizing resources. Moreover, by implementing cloud computing in healthcare settings able to

create great communication of patient. This implementation directly helps to reach an improved outcome or milestones in their treatment and boost the eminence of services to patients. Thus, the introduction of cloud computing as a solution in healthcare sectors enable the management to manage their respective patients' information and health in a more precise way which will comply their general policies.

Besides, it is imperative to identify the necessary of a healthcare organization in necessary adopting cloud computing confront with the obstacles such as security issues which establish as top barriers. Based on above statement, cloud computing vendors particularly healthcare needs to implement numerous studies in this area to gain adequate evidence about the security concerns. Cloud provider can design suitable security strategy in where healthcare sector will have a higher faith and willing to adopt cloud computing completely as a solution of those inadequacies.

In Malaysia, the government needs to emphasis more on this valuable cloud computing asset through the Ministry of Health in collaboration with the remaining ministry bodies which indirectly will lead to the triumph of this notion. In order to achieve this, the government should increase the funding or investment in Health Sector which will help them to utilize wisely in improving cloud computing to a superior level.

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