Lappeenranta University of Technology

Faculty of Industrial Engineering and Management

Degree Program in Information Technology

Tulibako Paiti

WHAT ARE THE OPPORTUNITIES AND CHALLENGES OF CLOUD COMPUTING TECHNOLOGY IN THE HEALTHCARE INFORMATION SYSTEMS

Examiners: Professor Kari Smolander
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ABSTRACT

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This thesis discusses the opportunities and challenges of the cloud computing technology in healthcare information systems by reviewing the existing literature on cloud computing and healthcare information system and the impact of cloud computing technology to healthcare industry. The review shows that if problems related to security of data are solved then cloud computing will positively transform the healthcare institutions by giving advantage to the healthcare IT infrastructure as well as improving and giving benefit to healthcare services.

Therefore, this thesis will explore the opportunities and challenges that are associated with cloud computing in the context of Finland in order to help the healthcare organizations and stakeholders to determine its direction when it decides to adopt cloud technology on their information systems.

ACKNOWLEDGEMENTS

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LIST OF SYMBOLS AND ABBREVIATIONS

AWS	Amazon Web Services
BpaaS	Business process as a service
BPO	Business process outsourcing
Daas	Desktop as a service
DBaaS	Database as a service
DBMS	Database management system
EAI	Enterprise application integration
EC2	Elastic Compute Cloud
EHR	Electronic health record
EPR	Electronic patient record
EMR	Electronic medical record
GPS	Global Positioning System
HIPPA	Health Insurance Portability and Accountability Act
HIS	Healthcare Information System
IaaS	Infrastructure as a Service
ICT	Information and communication technology
IGOHcaps	Individuals Groups Organizational Human Controllers Acceptors Providers Supporters
IS	Information System
IT	Information Technology
NIST	National Institute of Standards and Technology
PaaS	Platform as a Service
PAC	Picture archiving and communication systems
PC	Personal computer
POE	Computerized provider order entry
S3	Simple storage service
SaaS	Software as a Service
SLA	Service level agreement
S2aaS	Sensing as a Service
StaaS	Storage as a service

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1 INTRODUCTION

1.1 Background

The interest in cloud computing technology has rapidly grown in recent years. In the most basic terms, cloud computing can be defined as delivery of computing as a service rather than a product, whereby shared resources, software, infrastructure and information are provided to computers and other devices through network or an internet. In this way, an access to information or network resources is not limited by the user's physical location. Therefore, resources and people are connected irrespective of any location around the world provided there is internet connection (Buyya, 2008; Fernández, et al., 2012). This information technological advancement in which access to information and resources is attained without geographical limitations, has attracted many sectors including banking, education, governance, and healthcare information systems (Rastogi, 2010; Kuo, 2011) with the primary objective being to satisfy customers (West, 2010).

Cloud computing can help in modernization of health services through its ability of facilitating information exchange between medical records systems and health stakeholders such as patients, doctors, pharmacist and all other medical institutions which are geographically isolated at any time (Kuo, 2011). However, security and confidentiality issue has slowed down the adoption of cloud computing to healthcare information management systems. Such slower rate of adoption could be caused by lack of knowledge on whether the data are fully secured. In cloud computing, users mostly may not know where their data is physically stored and which security mechanisms are in place. For instance, because of danger of facing societal isolation in some societies, mental health patients and patients with HIV are among the people that will want their medical information to be confidential (Kuo, 2011; Malin, et.al, 2013).

Scientists such as Braunstein (2013), Gavrilov et al. (2013), Guo et al. (2012) and Kuo (2011) have started to invest their energy to find out the ways on how cloud computing can be adopted in healthcare information systems with minimum problems of both confidentiality and security. It is therefore important to critically review the literature to see what the scientists have so far done on cloud computing and its relation to healthcare information systems. Such literature review will help in synthesizing knowledge that will

provide information about opportunities and challenges related to cloud computing in healthcare information systems, the knowledge that will help in advancement of cloud computing adoption in healthcare information systems.

The benefits associated with cloud computing technology have caused its rapid growth. Due to such growth in terms of number of consumers adopting it, scientist have also put more effort in improving quality of cloud technology to meet the demand of the consumers. For that reason, the relationship between the cloud provider and the customer is described with the Service level agreement (SLA). SLA is the contract made between customer using cloud service and cloud service provider where by the cloud service provider make agreements for service delivery to the customer by defining how the service is going to be delivered and how is the service going to be used. The typical SLA document includes the information about the parameters used to measure the quality of the agreed service level. Examples of parameters defined in SLA are, the responsibility of the provider, responsibility of consumer, service availability, security measures adopted by the cloud service provider, auditing processes to monitor the service and the rates of the services (Choo, 2010; Chauhan, et al., 2011).

1.2   Goals of the thesis

The main objective of this thesis is to identify the opportunities and challenges of cloud computing in healthcare information systems. In order to address the main objective of the thesis, the following two research questions (R1 and R2) are established, which are going to be answered in this thesis.

R1.   What are the opportunities of cloud computing technology in the healthcare information systems?

R2.   What are the challenges of cloud computing technology in healthcare information systems?

All the answers to research questions R1 and R2 are given to chapter 3 and 4 which are the results of the thesis.

1.3 Framework of the thesis

The framework of the thesis presented in Figure 1 below gives an overview of different aspects of the study and their relationship. By using literature review, benefits and risks associated with cloud computing has been explained then the application of cloud computing to healthcare information system (HIS) has been described. Furthermore, discussion of challenges and opportunities associated with the application of cloud computing to healthcare IS (the case of Finland) have been presented.
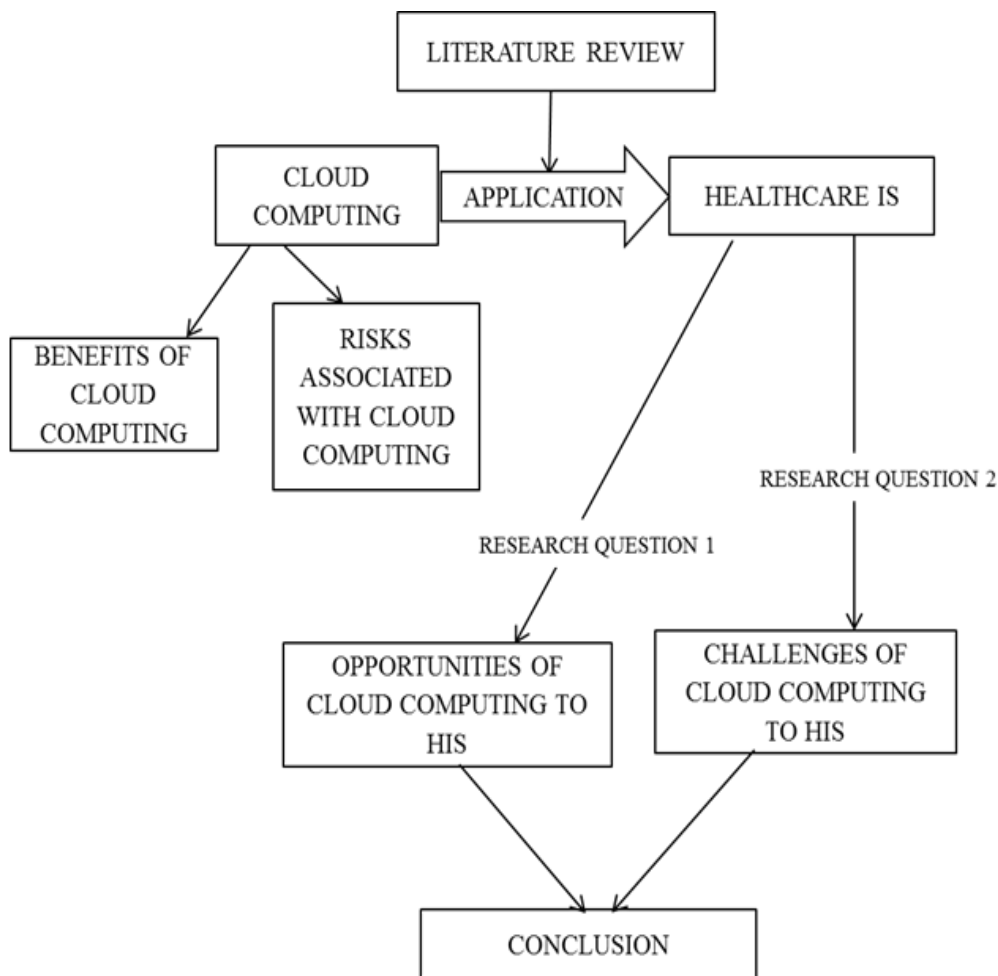
Figure 1: Framework of the Thesis.

Generally, this thesis is divided into 8 different chapters. Each chapter has been organized in a form that it gives the required information based on the objective of the thesis.

Introduction to the thesis is started in chapter 1 whereby subsection 1.1 gives a background and brief introduction to cloud computing and healthcare information systems. Subsection 1.2 defines the main objective and the research questions of the thesis. Subsection 1.3 details the framework of the thesis. Furthermore, subsection 1.4 explains the research methodology by telling how the research was conducted and how the information was collected.

Chapter 2 introduces the main concepts of the study. These main concepts are explained and the association of the main concepts in the study is explained. Generally, this chapter contains the discussion about cloud computing, healthcare, healthcare environment, healthcare actors, healthcare information systems (HIS) and cloud computing in HIS. Chapter 3 discusses in detail the benefits of cloud computing to healthcare while chapter 4 provides the risks associated to cloud computing in healthcare. In addition to that, past studies on the topic of study have also been mentioned out.

Chapters 5 and 6 answer the main research questions of the thesis, which are the opportunities and challenges of cloud computing in HIS (the case of Finland) respectively.

Finally, in chapter 7 the conclusion and responses to the study are summarized and presented in. Moreover, the future research works that could be carried out on the field of study and the limitation of the study have been mentioned in chapter 7.

The end of the thesis contains the list of references of sources of information used in the literature survey.

1.4 Research methodology

1.4.1 Related literature and research process

The literature review of relevant studies, such as opportunities and challenges of cloud computing in healthcare information systems has been identified and analyzed. After that, the findings and concepts from the review have been compiled and used to develop a thesis. Literature review identifies a topic for the study and then searching and studying the existing literatures that relates to the topic of study have been started (Creswell, 2009). The purpose of literature review is to provide results of other studies that are closely related to the topic of study and it relates the study to the ongoing topic of study as well as to fill in research gaps and extend prior studies on the topic (Creswell, 2009).

The primary information collected was mostly from peer reviewed journals, articles, conference proceedings, books, articles in the books, and one thesis. Initially, I started the literature survey by locating the information that relates to this study from Google search engine by defining the keywords which are based on my thesis's research questions.

Moreover, because the Google search engine gave a lot of sources which some of them are not practical for scientific studies, Nelli database portal for Lappeenranta University of technology (LUT) was then used to get access to the commercial scientific databases. These databases that were accessed to get the information for this thesis are, Association for Computing Machinery (ACM) digital library, Institute of Electrical and Electronics Engineers (IEEE), Emerald Journal, Elsevier, Directory of open access Journal (DOAJ) database and Doria which is a multi-institutional repository maintained by the National Library of Finland.

Additionally, internet sources were used to find the information that was not directly available from published papers, articles and journals. The examples of different cloud computing products that are offered by different providers were taken from the providers' websites. Also, the references or bibliographies that were cited in the searched literature were also accessed and used to get information for the study.

1.4.2 Includion and exclusion criteria

The following keywords were used to find the information about the study topic: *"Cloud computing", "Cloud computing and healthcare", "Cloud computing in healthcare IS", "Challenges of cloud computing in healthcare", "Opportunities of cloud computing in healthcare", "Application of cloud computing in healthcare."*

Furthermore, the choice of the article to be used or not used as the reference to this thesis (inclusion and exclusion criteria) was determined by reading of the abstract, conclusion and/or introduction of each of the articles to see if the information is of relevant and can be used to answer the research questions. No literature sources published before the year 2002 has been used as the reference in this study because the topic is quite new.

2 CLOUD COMPUTING IN HEALTHCARE

2.1 Key concepts of cloud computing

Cloud computing is the web or software based technology where by shared resources including information, infrastructure and software are provided to computers and other devices through network or internet. In cloud computing, the existing known technologies such as virtual computing cluster computing, utility computing, distributed computing, Infrastructure as a service (IaaS), Platform as a service (PaaS) and Software as a Service (SaaS) are integrated to come out with technology that is using less space and infrastructures (Kuo, 2011; Gavrilov, 2012; Srivastava, et al., 2011; Fernández, et al., 2012). In general, cloud computing system's architecture comprises of frond end part and back end part, which connect each other through network (typically the internet). The front end consists of client's computer and the application required to access the cloud service and the back end consists of the cloud computing services such as computers, data storage and servers (Jadeja et al., 2012). Figure 2 shows the layers of cloud computing architecture. The *Client layer* consists of hardware and/or software designed for delivery of cloud service. The next three layers on the architecture are related to cloud computing services which are SaaS, PaaS and IaaS respectively, which will be explained more on the following section 2.1.1. The server layer consists of computer hardware and/or computer software products that are designed for the delivery of cloud services (Jadeja et al., 2012).
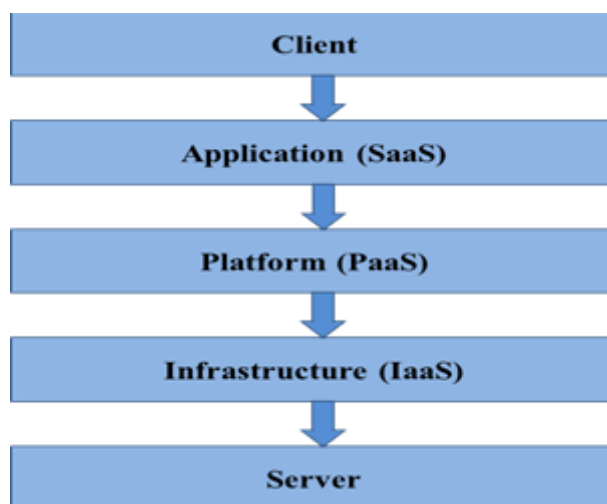
Figure 2: The layers of the cloud computing architecture.

Mell et al. (2011) from the National Institute of Standards and Technology (NIST) of U.S department of commerce define cloud computing as: "*a model for enabling ubiquitous, 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 is composed of five essential characteristics, three service models, and four deployment models.*"

Figure 3 gives an overview of the NIST's definition of cloud computing. The layers in figure 3 show the NIST definitions' components which are five important characteristics of cloud computing, four cloud computing deployment models and three main cloud computing service models respectively. These characteristics, service models and deployment models will be explained in detail on the following section 2.1.1, 2.1.2 and 2.1.3.
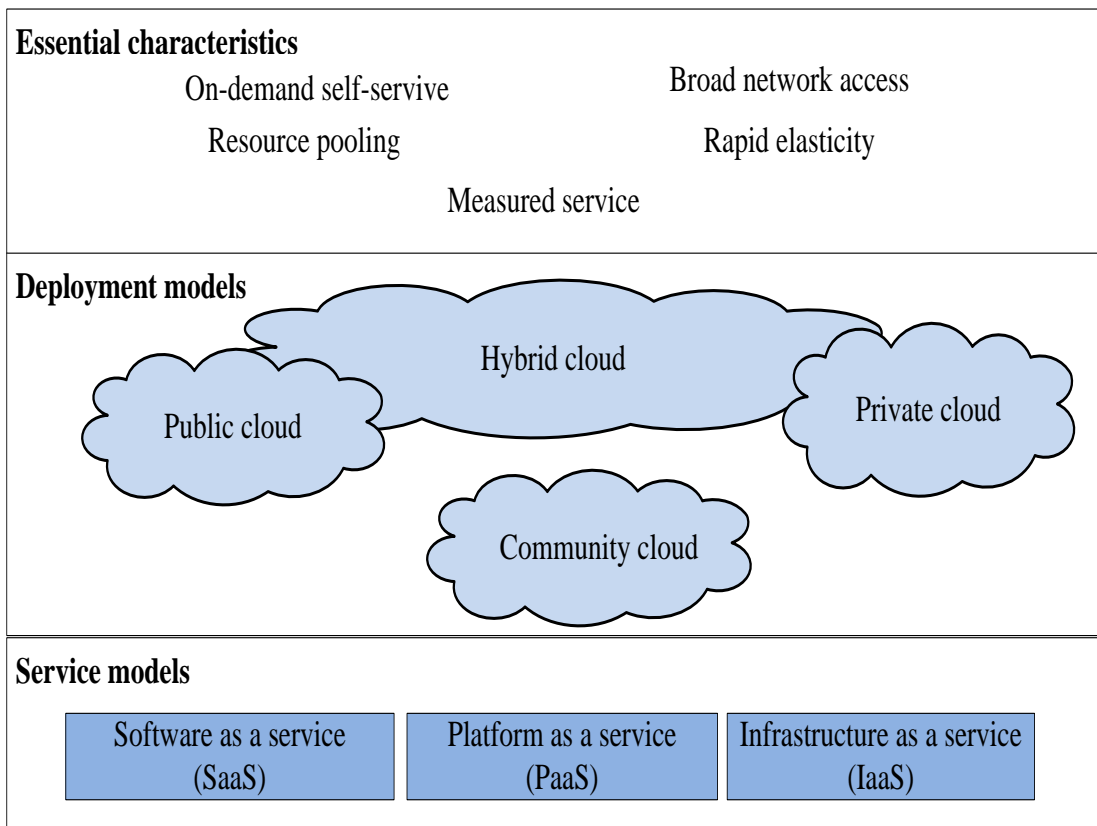
Figure 3: Representation of the contents of cloud computing definition by NIST (Mell, et al., 2011).

2.1.1 Characteristics of cloud computing

The characteristics of cloud computing by National Institute of Standards and Technology (NIST) describe the definition of cloud computing technology as follows:

On-demand self-service means that the provision of computing capabilities such as server, storage, application and network to cloud's user do not require human interaction from service provider. The provision of computing service is independent and according to the needs of the user (Mell, et al., 2011).

Broad network access means that the network access is ubiquitous. The cloud computing services are available over the network in real-time through standard mechanisms using a great variety of different platforms such as workstations, laptops, smart phones and tablets (Mell, et al., 2011).

Resource pooling means that the computing resources such as storage, processing and network bandwidth are pooled according to each user's demand to enable parallel service provision to multiple users by using multi-tenant model. Generally, customer does not have control or does not know where the provided resources are hosted but may have the knowledge of the location at a higher level of abstraction e.g. at country level (Mell, et al., 2011).

Rapid elasticity means that computing resources are rapidly and elastically provisioned in various, fine-grained quantities so that the systems can be scaled as required, and in some cases automatically. It means that the computing resources are unlimited the customer can purchase any quantity of capabilities at any time (Mell, et al., 2011).

Measured quality of service means that the resources used are automatically controlled and optimized by leveraging a metering capability depending on the type of service provided so that it is possible for the provider and consumer of the utilized service to do monitoring, usage-based billing, and validation of the service quality (Mell, et al., 2011).

2.1.2 Cloud Computing Service Models

According to NIST of U.S department of commerce's definition of cloud computing (Mell, et al., 2011), the three main models through which cloud computing service can be offered are as follows.

i. Infrastructure as a Service (IaaS) is a model where by the cloud user outsources the equipment used to support operations. Instead for the user to buy servers, hardware or investing on data centers and network components, the user rents the equipment as an outsourced service and pays on per use mode. With IaaS the cloud user does not have control over the underlying physical infrastructure but the user can control the operating system and applications (Mell, et al., 2011; Edtech, 2013). Examples of IaaS are Amazon EC2, HP cloud and Rackspace.

ii. Software as a Service (SaaS) is the model where by cloud users access the software and data via their web browser. Under SaaS the software is not hosted on the users' individual computers but the providers install the software on the cloud, and also a cloud provider becomes responsible for the creation, updating, and maintenance of software. SaaS customers buy a license to access the software. Nowadays, hospitals access accounting software and customer relationship management software through SaaS model (Mell, et al., 2011). Examples of SaaS are salesforce.com and Google Apps.

iii. Platform as a Service (PaaS) is a model where by cloud service provider delivers the complete platform for application, interface, database development and storage as services. In this type of model a cloud service provider provides support for development, deployment, hosting and maintenance of applications. Using PaaS the development tools are hosted in the cloud and accessed through browser. The consumer does not have control over the underlying cloud infrastructure such as network, servers, operating systems, storage (Mell, et al., 2011). Examples of PaaS are Microsoft azures, Force.com and Google App engine.

In additional to these three main cloud computing service models as described by NIST, cloud computing also provides other models that are based on the service that it is offering to its users (Mohiuddin, et al., 2012). The following are some of the other special forms of cloud computing.

Business process as a service (BpaaS) is a delivery of business process outsourcing (BPO) over the cloud. Through BPaaS one business process can be used by many customers, where by the cloud provider customizes the service (business process) according to individual customer's preferences in order to suit each customer's need (Bentounsi, et al., 2012). Here the cloud customer (e.g organization) runs its business processes over the cloud.

Database as a service (DBaaS) is a model in which cloud users can have their database run through the cloud. DBaaS allow users to subscribe for data definition, data storage and data retrieval over the internet. According to Mateljan (2010), developers have three (3) options of databases when deciding to use DBaaS cloud. These database possibilities are, cloud native relational database management systems (DBMS) that will give full featured relational database, and also cloud native non-relational database which gives simple index and queries capabilities without administration, as well as cloud capable relational or non-relational databases using virtual machines and with various OS. Examples of DbaaS are Microsoft SQL azure database, FathomDB and Google AppEngine database.

*Storage as a service (StaaS)*is a cloud computing model which makes possible for the customers to manage, maintain and back up their data remotely and to access the data anytime from any place over the network or internet (Wang, et al., 2012; Kulkarni, et al., 2012). Example of cloud storage model is amazon simple storage service (S3).

Desktop as a service (Daas) is a cloud computing model in which customers host virtual desktops in the cloud and the service provider is responsible for data storage, backup and security. These virtual desktops can be shared between multiple users. In this type of cloud computing model, cloud customer obtains the desktop environment on demand irrespective of the location. This means, in case there is a disaster on the local area, the users are still

able to work from another location, using any computer. In addition, during logon or logoff is when the customer's personal data is copied to and from the virtual desktop (Kibe, et al., 2012).

Sensing as a Service (S2aaS) is the cloud as a service model where by sensing applications or services are provided to the cloud users via the cloud system. According to Sheng (2012), there are two ways in which mobile phones can be used to provide the sensing service to the users. That is, through mobile phones, users can request sensing service from the cloud or sensing activities are fully automated from the phone without the involvement of mobile users. Sensors on a mobile phone can be used automate several healthcare processes and make possible to exchange and connect data from the device where it is processed to other hospital staff quickly and effectively. For example, diabetes patients who are provided with sensors will be seen in a hospital. The physician or nurse will obtain information about a patient's blood pressure and temperature on line.

2.1.3   Cloud computing Deployment Models

The main concerns of cloud computing are confidentiality, security and privacy of data. How organizations maintain confidentiality, security and privacy of data and applications depends much on the cloud computing deployment model that the organization is using. Therefore, in the following paragraphs, I will explain how cloud computing technology is deployed and managed by describing four major types of cloud computing deployment models i.e. Public cloud, Private cloud, Hybrid cloud and Community cloud.

Public cloud is also called external cloud. In this deployment model resources are provided over the network that is for public use, such as internet. Security and privacy of data is the major concern that this form of cloud computing have, because with this model of cloud computing, IT infrastructure is owned by the organization selling cloud service and the IT infrastructure services are Multi-tenant environment, this means that, the same service can be shared with several customers of the same service provider (Fernández, et al., 2012; Savu, 2011). Examples of Public clouds are Google App Engine and Amazon Elastic compute cloud (EC2).

Private cloud is also called internal cloud. It is the type of cloud computing where by the entire service is owned by the organization (Savu, 2011). This model is considered to be safe but expensive because with private cloud, services are hosted in private data centers and the IT infrastructure services are single-tenant environment, there is no shared tenancy setting (Choo, 2010). Examples of private clouds platforms are Eucalyptus, Openstack, Cloudstack and Ganeti.

Hybrid cloud is the type of cloud which is either composed of at least one public cloud and one private cloud, or it may contain more than two clouds such as private, community or public (Savu, 2011). In hybrid cloud deployment model a provider with a private cloud makes a partnership with a provider with public cloud and then they bound their clouds together by standardized or proprietary technology that enables data and application portability (Mell, at al., 2011).

Community cloud allows the cloud infrastructure to be shared by several organizations from specific group. According to NIST, the community that is sharing the cloud infrastructure should have a common computing concern such as mission, policy, security requirements, compliance considerations and jurisdiction (Mell, at al., 2011). In addition to that, Community cloud can either be on single or shared tenancy setting, and also the IT infrastructure is either managed by the organization or a third-party cloud service provider.

The following Figure 4 provides the overview of the three cloud service model in relation to cloud computing deployment model. In order to deploy a cloud computing solution, all the three main cloud service models (IaaS, PaaS and SaaS) can be combined with one another or can be used individually.
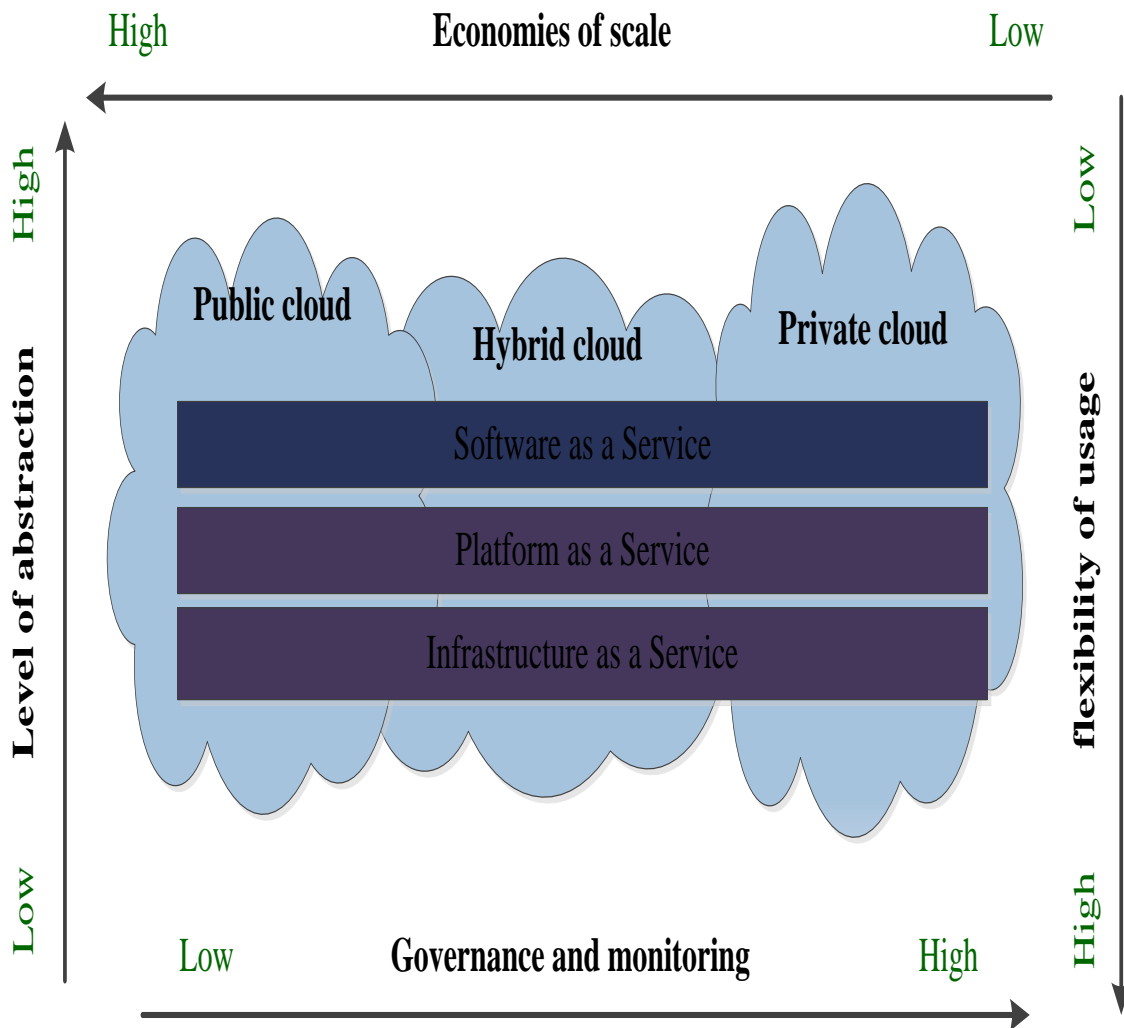
Figure 4: Relationship between Cloud computing service models and deployment model.

On figure 4 above, level of abstraction refers to the degree of complexity on usability of the delivered service. The higher the level of abstraction, the easier it gets to use the services and less flexible the service gets with respect to customization. The lower the level of abstraction, the complex it gets to use the service and the service gets very flexible to customize. The level of abstraction and the flexibility of usage features are the factors used to differentiate the three cloud service models (SaaS, PaaS and IaaS). Therefore, among the three clouds service models, SaaS has higher level of abstraction whereby its end users are having ready to use application frameworks, as well as low level of flexibility on customization of components for individual needs.

Moreover, the previous figure 4 shows the economic implication of cloud computing deployment models according to the report for Microsoft (Pavel, 2010). The report for Microsoft reveals that, public cloud has large economies of scale and high IT resource flexibility as well as low governance and monitoring possibilities of internal data. In contrast, Private cloud offers fully governance and monitoring possibilities of internal data, its IT resources are fixed and it has small economies of scale (Pavel, 2010).

2.2   Healthcare and healthcare information systems

The definition of healthcare information system is ambiguous. However, it is mostly referred to the systems of information and communication technology (ICT) infrastructures that are used in provision of medical care. Hospitals, healthcare industry, pharmaceuticals, healthcare organizations and healthcare provider are among the important entities linked to the ICT infrastructures of healthcare information systems (Srivastav, et al., 2011; Mantzana, et al., 2007; Gans, 1997). According to Tähkäpää (2007), healthcare information systems relates the role of patients, medical healthcare professional and non-medical healthcare professionals in healthcare information handling

Nevertheless, literature defines healthcare by relating patients and health workers such as medical physicians, dentists, nurses and pharmacists. For example, medical online dictionary (2012), defines healthcare as the medical service offered by health professionals to a patient in order to prevent, treat and manage the disease. Moreover, Mantzana, et al. (2007) mentioned patients and clinicians to be among the entities involved in the exchange of healthcare information. Therefore in general terms, healthcare can be defined as an act that health professionals are doing so as to diagnose, treat, and prevent diseases to human beings.

Quality healthcare is necessary for economic and social stability of citizens. Therefore, healthcare sector has always been striving for quality, efficiency and cost effective service. The question of cost effective should not be underestimated because freeing the society from diseases is complicated. Presence of people in the society that cannot afford access to healthcare may complicate eradication of contagious diseases. Thus, in order to achieve this, the choice of relevant, cost effective information technology (IT) platform and setup

is necessary (Kuo, 2011). In the case of healthcare sector, the use of information technology in its daily activities is believed to simplify and improve healthcare provision and quality. According to European Union study on dynamic health systems and new technologies (2011), the ICT applications in healthcare systems can be classified into four groups as follows.

i. Applications for services addressing and disease management i.e. disease prevention, diagnosis, rehabilitation, therapy and telemedicine.

ii. Applications to support activities for management, administration, logistics and supply of health related goods and services. Examples are Electronic patient record (EPR), Electronic Health record (EHR), and Picture archiving and communication systems (PACS).

iii. Applications used for delivery of health knowledge infrastructure, medical education, medical research and clinical trials.

iv. Applications for IT infrastructure, systems operations, and framework related to security and confidentiality issues.

Healthcare has already adopted cloud computing in different places as IT industries offers various applications that can also be used by healthcare. For example, Microsoft healthVaults is the web based platform for information sharing among medical participants such as patients, physicians and caretakers (Microsoft, 2013). Similarly, Oracle offers an integrated healthcare solution suite to support performance management, best practices, and better resource utilization (Oracle, 2013), and Amazon offers Amazon web service (AWS) solutions which can be integrated to medical care (Amazon, 2013).

2.2.1 Healthcare environment and actors

Koskinen (2010) explains the purpose of healthcare as to improve the physical, mental, and social well-being of people. Also, Wager, et al. (2005) claim that "*healthcare organization is any settings where healthcare related services are provided*". As a result, in this paper,

healthcare environment is understood as the setting in which healthcare activities, such as diagnosis, treatments, drug discovery and preventions of diseases are performed. Therefore, hospitals, dispensaries, medical laboratories and pharmacies are among of the instances of the healthcare environments. Furthermore, better understanding of healthcare environments involves the knowledge about the primary healthcare participants. These are also known as stakeholders in the healthcare systems.

The main participants or stakeholders of the healthcare environment are patients and employees of healthcare. Further categorization of the employee of the healthcare gives us two groups of employee, which are medical professionals and administrative professionals. According to Mantizana et al. (2007), healthcare actors comprise of individual or organization that either affects or is affected with healthcare information systems. Here individuals are considered as to be human beings that interact with healthcare information systems, for example patients, patients' next of kin, clinicians, clinical students, technologists and administrators. These individuals may be working in different organizations including healthcare facilities and healthcare industries such as pharmacy, insurance companies, hospitals and dispensaries.

Furthermore, categorization of healthcare actors can be based on the Individuals Groups Organizational Human Controllers Acceptors Providers Supporters (IGOHcaps) (Mantizana, et al., 2007). When identification of categories of healthcare actors is based on IGOHcaps, four groups of healthcare actors namely, Acceptors, Providers, Supporters and Controllers are obtained. Furthermore, Mantizana et al. (2007) suggest combination of organization and human factors when defining the healthcare actors rather than defining and categorizing the healthcare actors separately. Likewise, Siau (2003) mentioned patients, physicians, specialists, insurance provider, pharmacies and medical suppliers as the entities involved in a healthcare industry supply chain. Siau (2003) classified the actors into three categories as: suppliers (insurance providers, pharmacy and medical suppliers), patients and physicians. Therefore, by combining the definitions from two authors, Mantizana et al. (2007) and Siau (2003), a healthcare actor can be defined as human or organization that participates on accepting, providing, supporting or/and controlling the healthcare service (Table 1).

Patients are the one that originate the information in healthcare industry but the participation of patients in the process of information exchange in health care is low. Most of the systems that are used by the healthcare industry to transfer patients' information between healthcare actors involve healthcare providers and overlook to engage patients in the process (Koskinen, 2010). Therefore, it is very important to consider all the key healthcare actors in the process of exchange of healthcare information. Whenever it is necessary, the patients should also be involved in using the healthcare information systems.

Table 1: Categorisation of healthcare actors.

	Acceptor	**Provider**	**Supporter**	**Controller**
Individual (Human)	Patients' Next of kin	-Clinicians -Non-clinicians -Clinical students	-Administrators -Legal professionals -Researchers -Suppliers -Technologists	-Managers
Organisation		-Hospitals -Medical departments	Insurance companies	-Government -Health authorities -NGOs

Provision of quality healthcare services needs better communication with all the healthcare actors mentioned in Table 1 above. Moreover, knowledge of the relationship between actors is very essential in adoption of information system (IS). For example, Mantizana et al. (2008) claim that "*healthcare actors have an important role during the IS adoption process because it is important to identify how the Enterprise Application Integration (EAI) adoption in healthcare organizations affects and is affected by the relationship between human and organizational processes*". In the absence of cloud computing, such interactions between human and healthcare organizational processes are simply illustrated in the Figure 5 below.
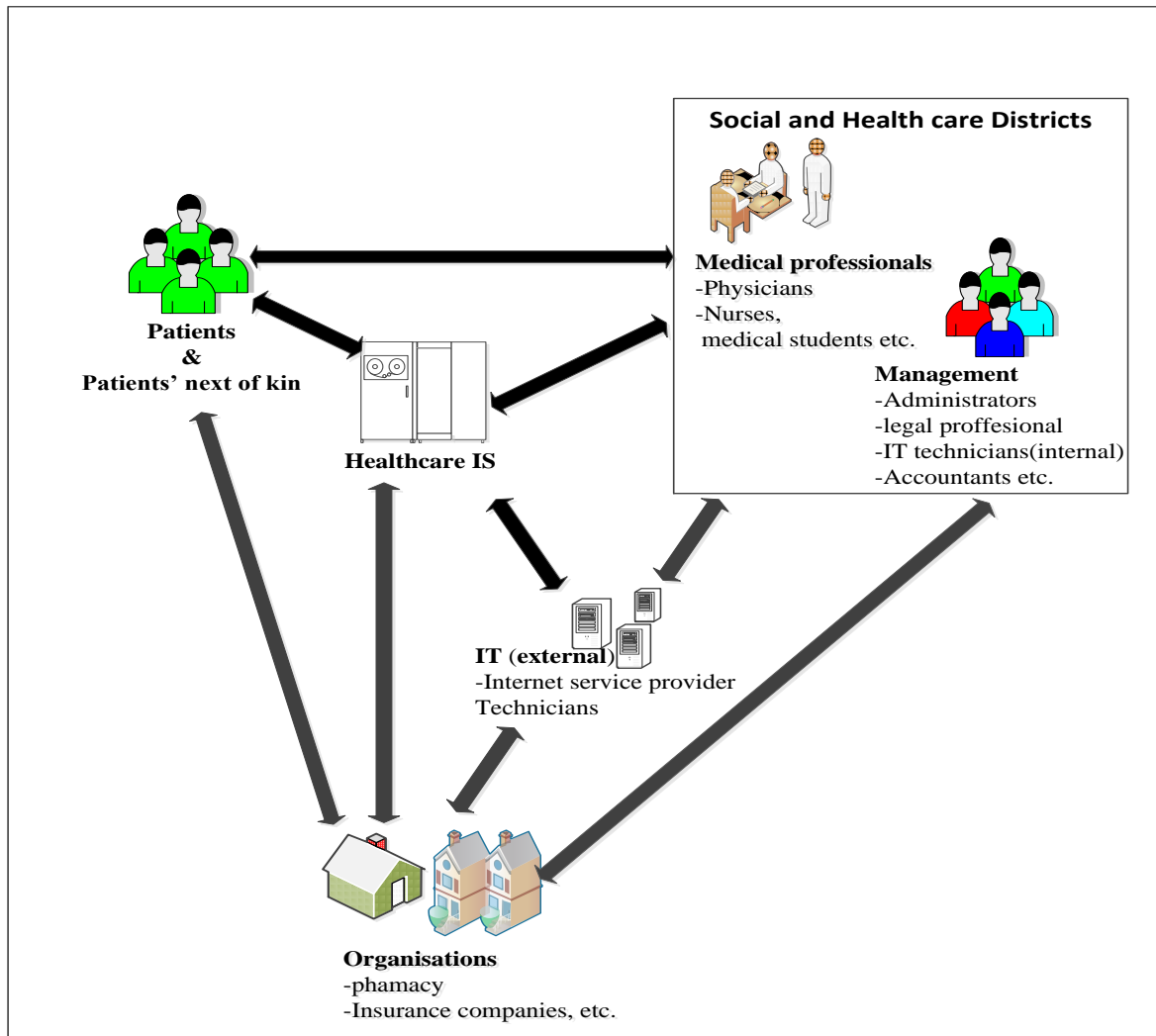
Figure 5: Illustration of interactions that exist among the healthcare actors in the absence of cloud.

In this figure 5, the arrows show the flow of relevant interaction between the actors of healthcare as well as interaction of actors with the healthcare information system (HIS). HIS is used in all exchange of information between healthcare actors. The exchange of information is done in two ways, either with the patients and/or patients' next of kin are physically visiting healthcare service providers (i.e. social and healthcare districts, pharmacy and insurance) or they go online to search data, book appointment or access information to get medical guidance. Moreover, the external IT service providers and technicians makes sure that the ICT for healthcare service providers is working properly during the process of exchanging information between healthcare actors.

2.2.2   Healthcare information system

Hung et al. (2010) states that information system (IS) is a set of hardware, software, infrastructure and skilled people that are involved in coordination and decision making processes that take place in the organizations. Use of information system in decision making processes has become increasingly important in recent years. This is due to the fact that information system facilitates data exchange between users. Organizations and people use information system to process, organize, collect and distribute data so that they get quality information that they need to make rational decisions so as to meet their customer needs. In service provision sector, information technologies help the user to manage well the amounts of customer information so as to improve the quality of customer services (Hung, et al., 2010).

Like in any other sector that involves provision of services to the community, rational decision making in healthcare is a crucial process. In addition, healthcare is characterized by rapid increase in medical data from drug discovery, evolution and spread of diseases, treatment histories, environmental exposure of patients, etc. Such rapid increase in metadata needs better management so as to improve quality of health service delivery. In fact, such increase in medical data has already posed challenges to hospitals in utilizing medical information systems in order to improve quality of health service provision (Hung, et al., 2010). Thus, a well-organized information system is required in healthcare to efficiently utilize all medical data for rational decision making process to be achieved.

Healthcare Information System (HIS) is the system designed to manage the daily operations and processes of the healthcare organizations such as clinical activities, administration activities, patient registration, patient medical records, communications and financial aspects (Wager, et al., 2005). HIS is made up of a number of sub-systems which are integrated together so as to achieve the best possible support of patient care and hospital administration. In HIS, collection, storage and analysis of health information is done systematically. Data sources that HIS collects can be classified into three categories as: clinical information created during patients visit to hospital, administrative information and external information. Generally, it includes health facility data, administrative data, household surveys, civil registrations; national health accounts (NHA) and health researches (World health organization, 2004, 2008; Wager, et al., 2005). Such data can be

used to describe the health situations and trends and also assess health system performance. These descriptions are later organized in a better ways so as they can be used in facilitating planning, coordination and decision making in healthcare (Srivastava, et al., 2011).

There are two main categories of Healthcare Information System (HIS), which can be distinguished based on purpose and the type of data they contain. Table 2 contains examples of systems on each category of HIS. The categories include administrative HIS and clinical HIS. On one hand administrative HIS is the one that is used to support management and general operations of healthcare organization. It contains information such as human resource, supplies and finances. Patients' administrative systems and financial management systems are under administrative HIS category. On the other hand, clinical HIS is the one used to support patients' disease diagnosis and treatment. It contains patients' health related information. Ancillary information systems and all other clinical information systems are under clinical HIS category (Wager et al., 2005).

Table 2: Healthcare information systems classification (adapted from Wager et al., 2005)

Administrative HIS	Clinical HIS
Patient administration systems - Admission, discharge, transfer (ADT) - Registration - Scheduling - Patient billing or accounts receivable - Utilization management	**Ancillary information systems** - Laboratory information - Radiology information - Pharmacy information
Financial management systems - Accounts payable - General ledger - Personnel management - Materials management - Payroll - Staff scheduling - Staff time and attendance	**Other clinical information systems** - Nursing documentation - Electronic medical record (EMR) - Computerized provider order entry (POE) - Telemedicine and tele-health - Rehabilitation Medication administration

2.2.3 Cloud computing in healthcare information systems

Cloud computing is an important change in how Information Technology (IT) is delivered and used. In cloud computing technology, the user is not limited by physical location to access the information or network resources, but people connects to resources from any location, and also the users only use the service being requested without being concerned with how the application is working.

Like any other services, nowadays healthcare service can also be accessed by getting the service online through a website and telemedicine consultations. However, physical visit to the healthcare facility remain important. Healthcare stakeholders including pharmacies, insurance companies, patients and hospitals exchange information daily (Wu, et al., 2012). For example, on one hand, insurance companies will need to provide services to more customers and therefore will seek more opportunities from the society to get more customers. On the other hand, pharmacies may like to inform hospitals about the discovery of new drugs that can replace the drugs that have shown failures to eradicate certain diseases or which have many side effects. Efficiency and speedy information exchange is necessary for quality patient care. Information about the discovery of drugs that can easily eradicate a fatal disease needs to be communicated rapidly before more deaths can be registered. Fortunately, with cloud computing, information can be shared without geographical barriers interference. Health institutions can be run in a way that the healthcare stakeholders are able to access important information from anywhere with devices that have internet capability such as personal laptops and mobile phones. In this way, healthcare institutions can adopt cloud computing to facilitate well organized healthcare Information systems which will provide efficient medical data management and sharing process. Such an adoption will minimize costs that healthcare stakeholders would incur when accessing information and services remotely (Wu, et al., 2012).

Moreover, regarding healthcare institutions, adoption of cloud computing is believed to provide a perfect platform in IT spacing because many hospitals can share infrastructure having many systems linked together hence cost reduction and increase of utilization (Srivastav, et al., 2011). According to Wu et al. (2012), cloud computing helps to simplify the management and access of patients' data. For example, with cloud computing, it is

possible to access from one location at any time all the data relating to one patient who have different healthcare providers and different types of medical insurances.

There are different ways in which the three main cloud computing models (i.e IaaS, SaaS and PaaS) are being applied in healthcare information management system. Today, the generation of medical data is growing. Therefore, hospitals outsource the storage service in the form of cloud storage and pay only for the used gigabytes. For instance, a healthcare IT provider called Netgain is offering IaaS cloud solution for healthcare organizations who wish to have on site solutions of their IT infrastructure. This service declares control and security to its customers. Netgain's IaaS, provide solutions to infrastucture's complexities to hospitals that wish to implement electronic medical record (EMR) and also solve the headcount problems to hospitals that are lacking internal IT staff (Netgain, 2013).

Moreover, with Microsoft HealthVaults, which is SaaS cloud based health application, patients can store, use and share health information with healthcare providers and their family members, as well as keep track of their health conditions (Microsoft, 2013). Likewise, Windows Azure offers PaaS cloud platform to run quality control algorithms to process patients' images for cancer (Microsoft, 2011).

Several cloud based, medical solution systems and applications have been developed globally, in order to improve healthcare. Some of cloud based applications used in healthcare industries is as follows: emergency medical system (EMS), health cloud exchange (HCX), Health ATM kiosks, digital imaging and communication in medicine (DICOM), @healthcloud and PACs (Matlan,et al., 2013).

3 BENEFITS OF CLOUD COMPUTING IN HEALTHCARE

There are different ways in which cloud computing may positively shape the healthcare information system (HIS) and make healthcare industry more advance and efficient. The following are the benefits of cloud computing in healthcare.

Usability without taking into account time and place: In many cases *Usability* is associated with the functionality of the product, system or application. It is the extent to which the product is easy to use and learn. The main advantage of cloud computing is that user can access cloud service at anytime from anywhere using their personal computers, laptops or mobile devices. Therefore, the adoption of cloud computing in HIS facilitates the information exchange between healthcare actors (i.e patients, hospitals, insurance companies and pharmacies). Healthcare actors can get the access to important information from anywhere using any device that is capable of getting internet (i.e. mobile phones, personal laptops and desktop). In this way electronic health records (EHR) and electronic medical records (EMR) will be shared with various healthcare providers over the cloud as well as the patient's healthcare data will be available to stakeholders' information systems from anywhere at any time, and thus it will increase efficiency of medical data sharing process (Wu, et al., 2012; Bastiao, 2012). For instance, after patients have paid for their medical insurance to the insurer, the status of their payments will be viewed and accessed immediately through all other stakeholders' information systems. Furthermore, patients who need special monitoring such as those who are suffering from diabetes and hypertension, it is possible that their health status can be recorded and monitored from their home and physicians can see the records from anywhere at any time.

No need for equipment procurement: Cloud computing allows users to get the service or solution that they have requested from the cloud service provider without purchasing the hardware, technology or infrastructure that have been used to deliver the service. Also cloud computing customers can share the application or hardware that their host is providing. With cloud computing technology, it is possible for hospitals to share their machines and equipment that they use for diseases diagnosis and checkup. Therefore, smaller hospitals and dispensaries that do not have equipment for disease diagnosis and analysis can send the tests through cloud computing technology to the other hospitals

which have the equipment. In this arrangement, financially unable hospitals can perform the medical test without owning equipment but share facility with other cloud customers who use the same service and pay per the use basis (Kuo, 2011; Srivastava , 2011). For example, healthcare form developing countries will be able to access advanced healthcare application without system development, which is low cost to them (Kshetri, 2010).

Saving money: Collecting and processing patient data manually is labor intensive, costly and time consuming but if hospitals will consider the use of cloud computing, the data collection process will be simple, efficient and cheap. According to Rolim, et al. (2010), the attachment of sensors to the hospital's equipment and then applying cloud computing technology will automate the process and make it possible to exchange and connect data from the device where it is processed to other hospital staff quickly and effectively. This also will cause the reduction of staff, because only few people will be required by the hospitals to support the manual processes when it is necessarily needed. Therefore, healthcare industry will save the hiring cost because only few workers will be needed to do the manual processing and collection of patients' data.

Moreover, with the implementation of cloud computing, users only pay on the service that they have used. In this case healthcare institutions do not need to spend money to hire IT staffs for control and maintenance of their servers, spending money on buying hardware or buying software for upgrades, but instead the cloud computing provider is the one who takes care of all maintenance, software upgrades and hardware infrastructure (Fernández , et al., 2012; Srivastav, et al., 2011; Alagöz, 2010).

No installation effort, cheaper than the local installation: IaaS Cloud computing allows its users to hold resources without having any IT infrastructure. Therefore, instead for the user to buy servers, hardware or network components, they rent the equipment as an outsourced service and pay on per use mode. At some point, users do not need to know to install the key application that they want to use, and the installation and maintenance is up to the vendor of the cloud service.

Scalability depending of the needs: Cloud computing gives room for its users to increase the service they have rented. For example, if healthcare organization started to use cloud

computing technology in the beginning while it had few customers, then after some time if the number of customers increases, the organization will just need to communicate with the service provider so as to increase the service capabilities in order to manage more customers (Fernández, 2012).

Rapid deployment: For small healthcare centers that do not have enough money for hiring, cloud computing technology take away the challenge of hiring IT supporting staff by either giving opportunity of using the applications as cloud service without being concerned of IT staff to support and maintain the applications or systems. These small healthcare centers will only pay for the service they have used (Srivastava, 2011).

No maintenance, and maintenance minimizing: The use of cloud computing helps to minimize or even get rid of maintenance at all because the goal of cloud computing is that service will be available to users on demand and the service provider will take care of technologically challenging tasks, such as implementation and maintenance of infrastructure and applications (Srivastava, 2011).

Quickly to take in use: In order for an organization to use cloud computing it just needs to have internet connections and security measures in place. Cloud computing allows healthcare staff that have credentials, to access the healthcare information systems from anywhere as long as they have an internet connection (Fernández, 2012).

Disaster recovery: The use of cloud computing provides users with the ability to replicate and back up data of site as well as to fail over server very quickly. Therefore, cloud computing is the best choice for healthcare organizations' backup plan because healthcare organisations can store data offsite and recover data faster than other back up method of using Tapes.

4 RISKS ASSOCIATED WITH CLOUD COMPUTING IN HEALTHCARE

As described in section 2.3 above, cloud computing technology seems to have the ability to improve healthcare delivery. However, like other technologies, there are also several risks associated with the use of cloud computing to healthcare. These risks are discussed in this section.

Privacy and Security issues: There is a high chance of security and privacy risks such as hacker attacks, poor encryption key management and privilege abuse when organization is using cloud computing technology (Kuo, 2011). The process of sharing information to multiple users who use different information systems or technologies to access the data is complex process that needs proper security and access control mechanisms. Also, it is possible that, various healthcare providers might be using different information systems to access and keep patient's health care records so the integration of the information from different system can become complex. Therefore, sharing of medical information to various health providers over the cloud will need a good access control mechanism. This is due to the fact that EHR may contain sensitive patient's data that needs privacy (Wu et al., 2012). For example, HIV and mental challenged patients may not like to share their status with others.

Probability of data breaches due to the multi-tenancy and decoupling between application and resources is very high in cloud computing (King, et al., 2012). This is due to the fact that cloud service provider works with numbers of other third parties. Therefore, in order to tackle this problem the cloud customers (i.e. IT administrators of the hospitals) will have to make sure that they know how their passwords are protected and changed and also to understand and know the security status of the other third part that is using the same cloud service provider. This may need very faithful individuals to work as IT administrators which may not be leak the security information and system access credentials to unintended places.

Compliance issues: Another risk related to cloud computing technology is compliance. Location of data is also one of the compliance issues that face many cloud customers.

Healthcare regulators may require patient's data to be confidential. In fact some compliance regulations restrict on cross boarder patients data storage and transfer (Guo, et al., 2012). According to Gray (2013), in most cases cloud computing users are not aware of data location. This situation makes it difficult to discover whether legal and regulatory compliance requirements are being met and whether there are enough protection for the data. Therefore, there is a need for the users to know exactly where their data reside in the cloud.

Legal issues: It is known that with cloud computing technology, the physical storage of data can be distributed across several locations and data can be accessed from any location (Kuo, 2011). Different countries or authorities have different laws and regulations regarding data usage, privacy and security. Thus, in case there are issues related to data usage, privacy or security, it will be difficult to settle the issues legally given the fact that the rules and regulations of contract differs among countries. For example, some data are considered sensitive in some countries and authorities and they require the user's consent before disclosing to the third party, while in other countries and authorities that same data may not need user's consent and they are even declared not sensitive (Gray, 2012; King, et al., 2012).

Contract breach is another legal concern in cloud computing. According to Gray (2012), many contracts have been made to favor the service provider by allowing them to use customer's data. In most cases the service provider is the one who writes the contract, and therefore it is most likely that the service provider will choose the laws and regulations that are friendly to them. Assume for example that there is a breach of contract by the service provider and the customer did not carefully look over the contract from the beginning of the business. In order for the customer to legally file the complaint, it will depend on which agreements were written in the contract. This can bring problems that can cause tensions to customers that have been affected.

Vendor lock-in issues: Another major threats in adopting cloud computing is vendor lock-in. It is known that vendor locking is unavoidable when using any IT solution. Vendor lock-in is considered a risk when a customer is dependent on the technology and/or interface of the service provider. For example, a particular cloud service provider becomes

the dominant vendor so that it prevents its customers from leaving, as the change of the service can be complex and expensive to customer. As Kuo (2011) said, "*Sometimes users will want to move to another provider just because the provider stops business but most cloud computing infrastructure does not provide capabilities on service and application interoperability*". Thus, there is a need for cloud service providers to deploy services and data across multiple cloud computing providers so that the failure of one company would not take all copies of client's data with it (Guo, 2012).

5 OPPORTUNITIES OF CLOUD COMPUTING IN HEALTHCARE: THE CASE OF FINLAND

Different countries may have different opportunities for development of cloud computing in Healthcare Information Systems (HISs). For example, the developing world needs more cloud computing because of poor infrastructures. In developing countries, more people are far from health institutions and therefore, cloud computing would simplify accessibility to healthcare. Unlike in developing countries, all municipalities in Finland have a health centre which offers primary health service and each social and healthcare district has its central hospital, five of which are university-level teaching hospitals (Doupi, et al., 2010). Likewise, the ratio between number of people that are to be saved by one medical physician is too high in developing country when compared with the ratio in developed world, like Finland. Therefore, could computing would have more customers in developing countries than in developed world. However, due to time and financial constrains, opportunities of incorporating cloud computing in Finland' healthcare information systems are discussed in this chapter.

5.1 Availability and high use of mobile phones

In order for cloud computing to be incorporated in certain sector, ICT infrastructures such as software, networking, internet and communication are needed. Previously, mobile phones were for dialling and receiving calls only. However, with current technological advancement, mobile phones have been incorporated with functions that have increased their functionalities such that they have now become as a personal computer (Allen, et al., 2010). Amongst the most important use that has been incorporated in the mobile phones is the internet ability. Incorporation of internet ability in mobile phones has enabled them to be used for web browsing, emailing, multimedia messaging, application downloads and so forth. Due to such incorporations, the mobile phones become one of the most important entry points and interfaces to the growing number of cloud computing services and online infrastructures. In some countries including developing countries such as Kenya, by using the famous mobile phone enabled with cloud computing, it has been possible to use financial transactions that enable payments to ticket purchase, school fees etc. Indeed, mobile phones have become a vital point of ubiquitous information processing (Caroll, et

al., 2010). Moreover, with more research done all over the world, increase in functionality of mobile phones is expected to continue (Carroll, et al., 2010).

According to Qi and Gani (2012) in order to provide personalized network services through numerous network terminals and modes of accessing, one should consider ubiquity and mobility features. Such features can be obtained in technological advanced current mobile phones commonly called smartphones. In fact, most smartphones have higher internet capabilities which can even allow 3G and 4G, with the fastest internet connections. Thus, the availability of such mobile phones in a country can easily allow the incorporation of cloud computing in service provision sector including healthcare. In this way, communication between healthcare actors including patients, physicians and healthcare providers can be easier as it will become easier to connect to data, information and computing resources from any location at any time.

In Finland, nearly one half of the population aged 16 to 74 owns a mobile phone with smart phone capabilities (Official Statistics of Finland, 2012). Most of these smartphones are built with health monitoring applications that can detect some basic information about health status of the bearer. A recent analysis done by Mosa et al. (2012) about 83 smartphone-based healthcare applications have already been developed (Table 3). Out of the 83 smartphone-based healthcare applications, 57 applications were designed for healthcare professionals (Table 3). For example, I-phone operating system (iOS) has several health applications such as myPlate which can calculate the amount of calories consumed by the owner (Mosa et al., 2012). And also, there exist healthcare applications such as HMS Mobile for android operating system which were designed to help physicians and nurses to obtain the patients' medical records, prescriptions clinical reports and medical images on their mobile phones (Somasundaram, et al., 2011).

Likewise, Alagöz et al. (2010) predict that in near future (few decades to come) mobile phones will have built in microchips that will be able to communicate with health care devices linked over the cloud in such a way that the devices will be available at anytime from anywhere. Taking example of Finland where almost 50% of the population owns a smartphone ((Official Statistics of Finland, 2012), this will give the opportunity to improve the Finnish healthcare sector in terms of ubiquitous communication and access to

healthcare information systems because it will make possible for the patients to feed their health status from their phones to the cloud, so that physicians can be able to view the health status of their patients from any location and give medical assistance online hence reduction of the number of patients who visits to hospital (Alagöz, et al.,2010; Mosa, et al., 2012).

Table 3: Categories of smartphones' healthcare based applications (adapted from Mosa et al., 2012).

Application for health professionals	**Disease diagnosis apps:** Johns Hopkins Antibiotic Guide, 5MCC, 5-Minute Infectious Diseases Consult, Sanford Guide to Antimicrobial, Therapy, ePocrates Infectious Diseases Notes, UpToDate, Pocket Medicine Infectious Diseases, therapyPalmLabD, Normal Lab Values, Lab Unit Converter, Labs 360, Davis's laboratory and diagnosis test, Pocket Guide to diagnostic test, IDdx, eRoentgen Radiology Dx, iSeismomete, Video LaserLevel, EyeChart, eyePhone, DizzyFIX
	Drug reference apps: Skyscape's RxDrugs, Epocrates, Medscape, SafeMed Pocket, FDA Drugs, DrugDoses.net
	Medical calculators apps: Epocrates MedMath MedCalc, Medical Calculator, Calculate, Archimedes, uBurn Lite, Softforce's Antobiotic Dosage alculator, Paeds ED
	Literature search apps: PubSearch, PubMed on Tap, MD on Tap, askMEDLINE, PICO, Disease Associations
	Clinical communication apps: Voalté One, Amcom Mobile Connect, mVisum
	HIS clients, and medical training apps: OsiriX Mobile, MEDITECH, PatientKeeper Mobile Clinical Results, AirStrip OB iCPR, iResus
	OsiriX Mobile, MEDITECH, PatientKeeper Mobile Clinical Results, AirStrip OB iCPR, iResus

Applications for medical students	I-Surgery Notebook, Eponyms, Netter's Atlas of Human Anatomy, Netter's Anatomy Flash Cards, Blausen Ear, Atlas, Oxford Handbook of Clinical Specialties, Dissection, Cranial Nerves, iSilo, Mobipocket Reader, Instant ECG
Applications for patients	Diabeo, Cardiomobile, Pulmonary Rehabilitation, PAL Calculator, Asthma Peak Flow Monitoring, eCAALYX, Hearing Check, uHear, iTinnitus, Sleep Aid, Fall Detector, iFall, Purdue Momentary Assessment Tool, Mayo Clinic Meditation

Unlike in developing countries, in developed world like Finland, the use of mobile living assistance is common. Mobile living assistance are mobile devices programs which can monitor health status of individuals who need special monitoring because of their diseases. For example, people who suffer from diseases, such as diabetes and heart disabilities in developed world in Finland, have been using mobile living assistances because they have access to them. Mobile living assistants that are developed for mobile phones can be incorporated in cloud computing so as to provide more data to enable successful monitoring of patients who use them (Alagöz, et al., 2010).

Since users are using different mobile phones platforms that each has its own operating system and security mechanism, the use of cloud computing can provide a common infrastructure. Such a common infrastructure can facilitate an access to the shared resource as well as giving the better security solutions to mobile phone users who wish to access the healthcare information systems through the mobile phones (Doukas, 2010). Thus, high use of smartphones in Finland, which means potential for enough customers, can allow incorporation of cloud computing in healthcare information systems so as to harmonize the infrastructures.

Most smartphones have Global Positioning System (GPS) which enables the location identification capabilities of mobile phones users. Therefore, in case there is a medical emergency, patients can use their mobile phones to call for help by just pressing a certain button that will make possible for the emergence alert reach the medical center and also record the location details to the centralized database for medical officers to see. Hence, hospitals will be able to know the location of the patient and quickly respond to the

emergency (Doukas, 2010). With increased frequency of provision of patients data by using smartphones incorporated with cloud computing, monitoring of patients health status and drug discovery, especially to patients of diseases such as blood pressure, can be easy. This is possible because mobile phone can record and store the conditions information to the cloud for the physicians and nurses to see (Varshney, 2007). In this way, physicians and nurses can monitor the patient at anytime from anywhere, as long the patients have smartphones. As a result, the incorporation of cloud computing to mobile phones will enable the location based medical service and it facilitates good management of medical emergency to hospitals (Doukas, 2010).

5.2 The use of ICT infrastructure

In order for the cloud computing to be incorporated, the internet is prerequisite. According to e-Health strategies report of Finland of 2010 (Doupi, et al., 2010), each medical physician in Finland has an access to the internet connection and he/she is equipped with at least one personal computer (PC). In Finland, in terms of information and communication technology infrastructure, the entire medical patient data for Finland is stored electronically, and each healthcare division use electronic patient record (EPR) (Doupi, et al., 2010). Moreover, in order to have the national communication structure between healthcare providers and patients, the Finnish government established the internet services such as *Palveluvaaka* which is used to provide details about health and social service in Finland. Likewise, there is internet service called *Terveyskirjasto* which has been established for online health library that provides information on health and diseases in Finland (Teperi et al., 2009). All these are patient portals established with the aim of improving the access to healthcare information to all healthcare actors in Finland. According to Higgins, et al. (2011), the majority of health information seekers use health websites and portals to look for medical or health information related to medical problem, medical treatment and medical procedures. Cloud computing technology makes it possible for the patients to upload their clinical data, making appointments and viewing test results through these patient portals (Braunstein, 2013). Therefore, cloud computing is an ideal technology in the Finnish healthcare because by incorporating cloud computing technology to the Finnish's healthcare ICT, the process of sharing patient data between the healthcare professionals and healthcare actors will be simple. Patients can access and update their important information such as contact details and personal information directly from their

device; hence, there is also a fast and up-to-date availability of patients' information for hospital workers and other healthcare entities.

Additionally, the implementation of the national e-Prescription system gives the physicians an ability to issue prescriptions online and store them in the national database that stores the e-Prescriptions (Doupi, et al., 2010). Therefore, the use of cloud computing will make it possible for the availability of prescription information from anywhere at any time. By doing so, it is possible for physicians to review the patients' medication history at any time from any location, and to monitor proper drug allocation. Also it will reduce the incidence of drug abuse to the patients. Moreover, the availability of prescription data on the cloud will simplify the data collection of drug related research.

The delivery of healthcare service through telemedicine application is also another innovation made to Finnish healthcare sector. Teleconsultation, telediagnosis, telemonitoring, telelaboratory services, teleophtalmology and telepsychiatry are the examples of telemedicine services that Finland's healthcare offers (Doupi, et al, 2010). However, the telemedicine service needs special hardware capabilities which are expensive for a normal citizen to buy. Unlike hardware needed in telemedicine, cloud computing has a benefit of standardizing the infrastructure and ensuring the availability of the hardware with high end servers and huge data store. Likewise, the incorporation of cloud computing technology to the telemedicine leads to improvement of the healthcare standards of the places that are far from the main hospital. This is due to the fact that the use of cloud computing technology to telemedicine service gives the patients an opportunity to have an access to healthcare service from distant at any time using their personal devices. Therefore, incoparation of cloud computing into health information systems is expected to reduce the number of patients who will visit the hospitals and also reduce the cost that the patient will incur in-order to reach the hospitals or buy hardware to facilitate the telemedicine service (Doupi, et al, 2010; Matlani, 2013).

5.3   High literacy level of the citizens

Successful adoption of any technology must consider its main stakeholder. Thus, incorporation of cloud computing in healthcare information systems should consider its main stakeholder who in this case is the patient or/and the community. Unlike in some

developing countries where illiteracy level, measured in terms of number of people who cannot write either read, reaches 30%, in Finland almost everybody is literate. Due to the fact that most patients would like their health status remain confidential between their physicians and themselves, there is a need for them to have password to access their accounts in cloud computing. Having access will give them an opportunity to store their health status and read the feedback from the physicians. Likewise, the patients should be able to read the medical terms that physicians normally use to describe their conditions. According to World Bank, most developing countries like Tanzania and India etc. had adult literacy rate (people who are above 15 years and cannot read and write) below 80% in 2010, while Finland had 100% literacy rate (The World Bank, 2010). Therefore, Finland remains in a better position than other countries to use the high literacy level in their citizens to incorporate technologies including cloud computing to improve their medicare sector.

5.4   Financial capability

The finish healthcare finance is coming through general tax revenue. The Finnish healthcare is decentralized and each municipality out of 342 municipals in Finland is responsible for the financing of healthcare under its municipal and has rights to collect taxes for its healthcare (Doupi, et al., 2010). For that reason, Finland healthcare sectors can plan and overcome the cost related to adoption and implementation of cloud computing. As it was discussed in chapter two, cloud computing may have risks such as data security concerns and other related risks therefore for Finland the decision of spending money in the implementation of the best security mechanism to its healthcare IT infrastructures and IS will be depend on the in-country stakeholders. Unlike other countries which are financially incapable (e.g Tanzania and Ethiopia), their finance related healthcare plans and decisions depend on the donor funds. In additional to that, Finland can fund research and can be able to come up with the best solutions for security and confidentiality risks related to cloud computing.

Cloud computing adoptions may also accompanied by cost for possible regulatory compliance issues that might arise due to sensitive data being moved or stored outside the jurisdiction. Not all countries may be able to meet such cost and therefore decide to remain with traditional ways of healthcare service delivery. However, healthcare in Finland can

decide to allocate its healthcare financial expenditures for implementing regulatory compliance mechanisms to avoid all risks that are accompanied by cloud computing.

Moreover, the advancement in information technology caused the increase of the number of healthcare information systems (Sheng, 2012). The integration of cloud computing to this Healthcare Information Systems (HISs) is expensive because there are too many applications to integrate within hospitals or with the outside entities. However, the financial capabilities of the country puts Finland in a good position because the cost related to integration of HISs to cloud computing will no longer be a problem to Finland.

6 CHALLENGES OF CLOUD COMPUTING IN HEALTHCARE SYSTEMS: CASE OF FINLAND

6.1 Privacy and security of data

In many countries, the confidentiality and privacy of healthcare data is given a special attention because healthcare data involves the storage and processing of sensitive data about the health status of patients (Kshetri, 2010). Most security and confidentiality issues which arise in Cloud Computing are the result of user's lack of control on the physical infrastructure. Users mostly do not know where their data is physically stored and which security mechanisms are in place. Other security issues are related to web services (Jensen et al., 2009). In most cases, web related security issues, such as account or service hijacking usually occur through stolen credentials which are common to other technologies as well. Account hijacking through credential stealing is done by people who are computer literate. It is uncommon for people who do not know basics of computer to steal computer accounts credential. Sometimes credential stealing is done for scientific reasons, but sometimes it is done by people who wants to important data that may be helpful to them. Security and confidentiality issue may become a challenge in Finland because most people are computer literate and there is a high usage of internet. Unlike in developing countries where most people do not have access to computers and smartphone, most people in Finland can use both the computer and smartphones. According to Official statistics Finland online report (2012), 90% of the Finnish population aged 16-74 years use internet and 49% of population aged 16-74 own smartphones. In addition, e-Health strategies report for Finland (Doupi, et al., 2010) tells that the entire of healthcare providers in Finland uses internet to exchange the electronic patient data. For that reason, if the security mechanism of the healthcare information systems is not well implemented, there is a high possibility that unauthorized users may get access to patients' data through the internet. Vulnerabilities such as code injection and e-mail injection could compromise the confidentiality of sensitive healthcare data.

6.2   Data jurisdiction and legal issues

Like in any other country, Finland's is also involving itself for in country and multi country healthcare projects such as EuroHOPE which is the European healthcare outcomes, performance and efficiency project and European best information through regional outcomes in diabetes (EUBIROD) project (OECD health policy brief, 2013). Therefore, the healthcare data of Finland is used by many entities within and outside the country for the purpose of medical researches and academic researches. According to OECD's health policy belief of 2013 (OECD health policy brief, 2013), there are different processes to take into consideration when a certain country is involving itself into linkage of personal healthcare data. This means that, the decision to approve the user of data differs among countries, some countries the decision is made at data custodian level and in others the decision is at national authority. In Finland the decision is made at data custodian level which is national data protection authority (OECD health policy brief, 2013). For that reason, data jurisdiction and legal issues is another challenge that Finnish healthcare will face when incorporating cloud computing technology to its healthcare IS. This is due to the fact that cloud computing allows the physical storage of data to be distributed across multiple countries or authorities, where by each of the countries and jurisdiction may have different laws regarding usage, security, privacy of data.

Moreover, users of the cloud computing service does not have control of the infrastructure that make the service available instead they use the service they have requested without any knowledge of the remote application that made the service possible. In this situation the healthcare industry of Finland will need to choose the service provider with more sophisticated security systems or host all the key and sensitive data internally.

6.3   Technical challenges

Healthcare sector is one of the sensitive sectors because it deals with human life. Therefore, the reliability and constant availability of healthcare system is very important. According to Armbrust et al. (2009), the availability of the internet service is another obstacle to the adoption of cloud computing service by many companies. Since internet availability is very important when using cloud computing service, Finnish healthcare need

to maintain a country wise reliable internet service that they currently have or use multiple internet service provider so that the failure of internet should not take the healthcare IS off the service. Also, because of the well know complexities of healthcare IT infrastructure, the incompatibility of cloud computing technology to the IT infrastructure of the Finnish healthcare might be challenge that will cause a problem into operation because the implementation and adoption of cloud technology might involve upgrading of some components of the IT infrastructure to fit the new technology.

According to Kuo (2011), the limitation of physical networking bandwidth can cause data transfer bottleneck when cloud users download or upload large amounts of data to the cloud. Since medical laboratory research involves data which are in large amount such as x-rays pictures and laboratory results. Therefore, after shifting the entire Finnish's healthcare operation to cloud computing technology, it is very possible that users will experience a data transfer bottleneck. The data transfer traffic jam might cause delay to some of the hospitals activities that does not need delays (e.g. surgical procedures)

Moreover, the adoption of cloud service might involve new technical skills to IT staff, therefore the organization need to provide training on IT staffs or hire new staffs that already have the cloud services skills. Both training and hiring processes need money.

Lock in and proprietary technologies are also another challenge that Finnish healthcare industry might face. In case the service provider stops the business, then there will be a challenge of moving data and service to another cloud service provider. When an organisation wants to change the service provider the disallocation of data might arise or even healthcare could be at risk of loosing some of its data. In additional to that, healthcare organisation must expect to incur switching cost if it will be moving out to the expensive service provider compared to the one they had before.

6.4   Cultural resistance

To change the traditional way of working will be difficult especially when it comes to data sharing. It is very common for users to have lack of trust in data security and privacy. Therefore, the awareness of the service's importance and risks must be well communicated

to all actors of the healthcare information system. While setting their objectives and budgets, the management of the Finnish healthcare sector will need to plan on how they are going to raise cloud computing awareness to the citizens as well as allocate tools and resources (e.g. trainers and media) that will be used to raise awareness to all healthcare actors.

6.5   Data ownership

Data is important in healthcare industry because doctors use data in patients' diagnosis and treatments. The national data protection authority of Finland is responsible for approving the user of healthcare data for the country (OECD health policy brief, 2013). Though cloud computing gives healthcare organizations possibilities of sharing healthcare data at any time irrespective of geographic location yet data ownership and limitation of how the cloud service provider is going to use the data is another challenge that will face Finnish healthcare organizations. According to Jensen et al (2009), users of cloud computing might lack the control on the physical infrastructure and in most cases they do not know where their data is physically stored. Therefore, the national data protection authority of Finland should make sure that Finnish healthcare sector makes an agreement with the cloud service provider about the ownership and usage of data before starting using the service. Also, the Finnish healthcare sector should have key knowledge about the location of the data they own.

7 DISCUSSION AND CONCLUSION

The IT of healthcare industry is progressively changing with time. Nowadays, most companies and organisations including healthcare industries have started to use new IT systems and moving away from the use of legacy system. Cloud computing technology as a new technology provides cheaper, flexible and efficient IT services to organisations. Moreover, the emerging service models and the deployment models in cloud technology facilitate the dynamic management of the infrastructure and provide easier and faster access to data. As organisations moves their activities to cloud computing they tend to have less concern about ICT infrastructures and focus more on their objectives.

Cloud computing is the suitable technology for healthcare institutions. It facilitates the good management of e-health as well as improves the healthcare services by making possible for quick diagnosis and treatment of diseases because it is reducing the waiting time associated with exchange of information. It has been noticeable that, the manual process of exchanging medical records and medical documents such as x-ray images from one hospital to another cause the delay of medical care and treatment to patients. The use of cloud computing to healthcare IS will make possible for these medical records and documents to be available electronically from anywhere at any time via web browser. Moreover, cloud computing helps to improve healthcare researches.

In this thesis, I have mentioned several benefits, risks, advantages and opportunities of cloud computing to healthcare. However, the adoption of this technology to healthcare information system is slow. Security and privacy issues are the main concerns that cause slow adoption of cloud computing to healthcare environment because healthcare organisations handle sensitive patients' data.

Therefore in order to address these concerns, the cloud service provider must develop sufficient controls to provide the same or a greater level of security than the organization would have without using cloud computing. Healthcare institutions must ensure that data privacy is maintained and the computing environment is protected and is in compliance with all organizational policies. Also healthcare institutions must understand the public

cloud computing environment offered by the cloud service provider and make sure that a cloud computing solution satisfies organizational security and privacy requirements.

Based on the review findings, healthcare organizations need to evaluate the benefits and risks of the new cloud service before adoption. They must assess if the innovation will be in line with their objectives. Before the adopting of cloud computing the healthcare organisation should decide which cloud service model and deployment model is better for the organisation by doing a thorough analysis of the benefits and risks that the organisation will incur after adopting the new cloud service.

Additionally, the organisation should consider comparing several cloud service providers by evaluating the type of offers they deliver. The service level agreement (SLA) should be understood clearly. The organisation needs to be sure that they will get quality service from the selected cloud provider. Examples of things that can be checked are: the reputation of the cloud service provider, legal practices, pricing arrangements, availability, compliance issues, security of data and privacy policies, data recovery and backup mechanism, data portability in case the organisation will need to move the data to another provider in the future.

7.1   Contribution of the Thesis

This thesis provides a preliminary knowledge about implementation of cloud computing to healthcare information systems. The study prepares healthcare organizations to take caution when they want to adopt cloud computing in their information systems by providing them with the knowledge about opportunity and challenges of cloud computing in healthcare information systems as well as benefit and risk associated with cloud computing in healthcare.

7.2   Pros and Cons of cloud computing

Cloud computing services are easy to use because cloud computing technology hides the technological complexities as well as it makes possible for the service to be available

anywhere at any time but it has disadvantage of privacy and security problems plus interoperability and compatibility issues.

Cloud computing saves cost because it offers its services on pay per use mode as well as reduce the cost of employment through resource outsourcing and process automation. But this can be disadvantage to employees because it might leads to redundancy and deployment.

7.3   Limitation of the study

Most information relating to cloud computing and healthcare that were found on literature were mainly focused on the advantages, benefits, risks, challenges and opportunities of cloud computing as a whole. Few literatures have mentioned the impact of cloud computing on healthcare IS in terms of its opportunities and challenges.

Additionally, the author could not find enough scientific articles and technical sources that could tell what could be done by healthcare before or after adoption of cloud computing so as to overcome the challenges associated with the adoption of cloud computing. Also, no scientific article and technical sources were found that write about the application of cloud computing to the Finnish healthcare as a case study.

For that reason, the results of this study showed that despite the benefits that cloud computing has to healthcare information systems there are also risks and challenges associated to it than need to be addressed so as to acquire the opportunities that cloud computing offers to healthcare.

7.4   Recommendation for future studies

Since cloud computing in healthcare industry is in its infancy stage, more research is needed to come with solutions that will minimize the problems which is associated with it. This review could be extended to include the empirical survey where by opportunities and challenges of cloud computing to healthcare IS could be collected and compared from different selected cases in healthcare industries.

Moreover, the results from this thesis can be used as a start point to conduct the study about ways that healthcare organization can do to tackle the challenges associated with implementation of cloud computing in healthcare.

Finally, the findings from this thesis can be incorporated with other cloud computing paradigms so as to assist healthcare organizations in determining whether to change from traditional healthcare information systems to cloud based healthcare information systems.

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