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Exploring Cloud Computing Implementation Issues in Healthcare Industry

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Abstract: Nowadays, cloud computing—as a flexible, collaborative, cost effective and scalable computational approach—is being applied within different public and private organizations. Furthermore, the use of cloud-based applications is becoming more widespread on both the organizational and individual level than it has been in the past. Healthcare is one discipline that could benefit from cloud-based applications; however, because of various privacy and security issues, it has been adopted more slowly than in many other disciplines. The purpose of this preliminary study is to investigate the related literature in order to explore the cloud computing implementation issues in the healthcare industry. Technological, Organizational, Environmental and Human factors are considered as the most important factors in implementing cloud computing in healthcare. The early framework for implementing cloud applications in healthcare is addressed to administrators and healthcare managers at the end of this study; however, the complementary study will be needed in the future to examine our hypotheses and research questions with collected data.

INTRODUCTION

According to the study from Transparency Market Research (2011), the global cloud computing market in the healthcare industry was valued at 1.82 billion USD in 2011 and is expected to reach 6.79 billion USD by 2018. From this, it is obvious that the health informatics systems trend is towards cloud-based applications; cloud-based medical record is one of the necessary and high demand application, which users such as physicians, nurses and hospital staff should adapt. However, knowing more about the user attitudes, organizational structure, cloud characteristics and environment factors could help healthcare administrators implement cloud-based applications more smoothly and increase their effectiveness.

As a new trend of technology, cloud computing is focus more on applications, information and people and this trend could be extended to serve emerging global demands in digital health care applications (Liu & Park, 2013). There are different effective factors that have an impact on the implementation of cloud computing in the healthcare industry; however, two theories of Tornatzky et al. (1990) Technology-Organization-Environment (TOE) and Yusof et al. (2008) Human-Organization-Technology fit (HOT-fit) is applied in this study to offer the framework for implementing cloud computing technology in the healthcare industry.

Ketikidis et al. (2012) addressed the role of the user in health information technology (HIT). They explained that the reactions of people in dealing with new technologies in health informatics have a huge impact on accepting these technologies. Also, the low acceptance of health information technology (HIT) applications would result in delays in,

or failure of, successful implementation of HIT and/or achieving organizational goals such as effective patient data management and storage.

In order to offer a preliminary framework for implementation of cloud computing in healthcare, we would like to explore the following research questions:
1. Which cloud computing model (i.e. SaaS, PaaS, and IaaS) is more suitable for healthcare organizations?
2. Is security a concern for using cloud computing by healthcare organizations?
3. Is privacy a concern for using cloud computing by healthcare organizations?
4. What are the obstacles for using cloud computing by healthcare organizations?

LITERATURE REVIEW ON CLOUD COMPUTING

This section covers cloud computing definition and services, different technology implementation framework and technology, organization, environment, human aspects of cloud computing implementation in the healthcare industry.

Cloud Computing

Cloud computing is a challenging concept in that the technology is still evolving, and there is much disagreement as to how to best define it for study. While the final definition will likely continue to evolve along with the technology, there are some characteristics of cloud computing that seem to be common to most of the literature. The similarities between cloud computing and other types of high performance computing (HPC) such as Cluster computing, Grid computing, Peer-to-peer computing, Service-Oriented Computing and Market-Oriented Computing also add complications to the efforts to create a standardized cloud computing definition and methodology.

The National Institute of Standards and Technology (NIST) defined 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 (Mell & Grance, 2011). Jing et al. (2013) on the other hand addressed cloud computing as a new operation rather than a new technology. Jing et al. (2013) argued that cloud computing is actually a set of existing technologies that are operating businesses in a different way. Zissis & Lekkas (2012) discussed the convergence of grid computing, utility computing and Software as a Service (SaaS) as a new concept of cloud computing. Furthermore, Belgolazov, Abawajy &Buyya (2012) introduced the design of next generation data centers as an objective for cloud technology application. They argued that by intentionally designing data centers as networks of virtual services (hardware, database, user-interface, application logic), users could gain access to their applications from everywhere. Tebaa, El Hajji & El Ghazi (2012) defined cloud computing as an information technology model for computing and explained that Information Technology components (hardware, software, networking and services) are necessary to deliver cloud services via the Internet or a private network.

Cloud Computing Services

Based on Mell & Grance (2011), cloud computing can be viewed as a triad of service models consisting of Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). The SaaS model of cloud computing involves the cloud provider offering the application to the end user on or through a cloud infrastructure. In this case the consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or data storage. Cloud applications using the SaaS model can either be accessed through a program interface in the way that Dropbox works or directly through a client interface as is the case with web-based email like Gmail.

PaaS model of cloud computing provides the consumer a platform to deploy applications into the wider existing cloud infrastructure. PaaS gives the end user a space to build their own application using shared languages, libraries and services that are either supplied or supported by the cloud platform provider. Examples of this model include Herkou and the Google App Engine.

The IaaS cloud technology model provides the processing, storage, networks, and other fundamental computing resources that allow consumers to deploy and run the software of their choice. This can include programs and

application and can even extend to running operating systems via the cloud infrastructure service. Amazon Web Services and Microsoft Azure are prominent examples of the IaaS providers.

Cloud Computing Deployment Model

Mell & Grance (2011) described four distinct deployment models for cloud technology applications including private cloud, community cloud, public cloud and hybrid cloud. Dillon, Wu & Chang (2010) explained that a private cloud is operated solely within a single organization and that either the organization or a third party could manage the infrastructure. Concerns about security issues are one of the main reasons for choosing a private cloud deployment model in an organization (Dillon, Wu & Chang, 2010). In an academic setting, the ability to build a private cloud to keep proprietary materials secured and to facilitate an online educational community is another advantage of a private cloud deployment.

In community cloud, several organizations jointly use the same cloud infrastructure and a third party or one of the organizations could host the infrastructure. The advantages of a shared cloud include minimizing loss or failure risks by spreading the resources and decreasing costs by utilizing shared scalable resources. At the same time, to be successful, sharing resources requires a higher degree of agreement and cooperation, which can be challenging among higher educational institutions that are each trying to best promote their own needs and may actually be viewed as competitors to one another.

A public cloud is the most common form of cloud deployment with which students, instructors or faculty have experience. In a public cloud deployment, the service provider has full ownership of the infrastructure. Many of the most popular cloud services fit into the public cloud deployment model; these services include Amazon EC2, Amazon S3, Google Drive, and Microsoft One Drive. The final deployment model, hybrid cloud, is a combination of two or more of the other cloud deployment models (private, community, or public) that aims to address the limitation of each approach by combining aspects of each model. As a general rule, hybrid cloud deployments have more flexibility and range of use than either public or private clouds.

Lian, Yen & Wang (2014) explained that healthcare industry is dealing with patient's data and it is so important for healthcare administrators to control the user access to these information and facilitate healthcare services. They addressed that in Private cloud, there are relative less security and privacy concerns than public cloud computing. Because the data will be stored in the hospital or the trusted third company and managed by the hospital staff or an authorized users.

Cloud Computing Adoption

Borgman et al. (2013) mentioned in their paper that the Tata Consultancy Services (TCS) found regional differences in cloud adoption rates. Latin America has the most adoption rate by 40% of using SaaS in the large enterprise. The adoption rate of large enterprise in Asia Pacific is 28%. Surprisingly, large firms in the United States have only shifted 19% of their applications to the cloud and the rate in Europe is near to 12%.

Kuo (2011) mentioned that cloud computing has an effect on healthcare IT implementation. Electronic Health Record (EHR) as one of the most popular IT application in healthcare is affected by cloud computing dramatically. There are some example of cloud computing adoption in different countries all around the world. For example, NEC and Fujitso working on cloud computing solution for hospitals in Japan (Japan-NEC, 2012). Microsoft Europe have been working on the quality of patients' care with cloud computing technologies. Furthermore, they found a way to reduce the costs of pediatric research and treatment center in Italy by applying cloud computing (Lisa, 2011). IBM is another tech company that invest on healthcare cloud computing in the United States to develop a new clinical information management system (Ostrovsky, 2010).

Cloud Computing Benefits

AbuKhousa, Mohamed, & Jaroodi (2012) listed some benefits of cloud-computing application in healthcare, which are giving incentives to the health administrators to adopt cloud computing in their organization. They specifically mentioned the benefits of collecting patients' data in a central collection by applying cloud computing:

- **Patient care:** the staff has access to the patient's record everywhere and at any time. There is a unified patient medical record that let the healthcare providers to view the patient's history in a centralized place.
- **Cost:** using cloud computing create a collaborative economic environment and it is the best solution for the small and medium sized healthcare providers to reduce their costs.
- **Resource scarcity:** applying cloud enables providers to use remote medical services and data in a rural places or anywhere that don't have access to health services.
- **Quality:** healthcare providers will be informed about the quality indicators such as infection rate, lengths of stay, and readiness percentages by using the central cloud services.
- **Research:** the cloud could store the huge amount of patient's data, which can be accessed uniformly and the researcher can conduct their research by using this database. Also, they can find a new research idea from this depository.
- **National security:** by storing lots of information, the news about the infection diseases will be spread very fast. The healthcare providers can monitor the news very fast by this way.

Cloud Computing Risks

Like any other technologies, cloud computing has some benefits and some risks and disadvantages. For having a successful implementation of cloud in the healthcare, the health providers should solve the problems related to the cloud risks. AbuKhousa, Mohamed, & Jaroodi (2012) listed some of the cloud computing risks in healthcare:

- **Data security:** patient's data is the most sensitive assets of the hospital; so accessing these data by unauthorized users is an important risk for the health administrators. According to HIPAA compliance, the unauthorized users should not access the patient's data. Still, more work is needed to enhance the data security and increase the user's trust level.
- **Loss of data:** lots of work has been done to improve the database management system, but still for reducing the risk of losing data, the healthcare providers should pay more attention to backups and disaster recovery sites.
- **System unavailability:** in the healthcare industry, system unavailability could lead to the irreversible damages. Losing an electronic health services is a major issue in an emergency situation.

RESEARCH CHALLENGES

Adopting cloud computing in industry is not a new paradigm. Cloud computing have been implemented in different organizations and companies and have been started to use from several years ago. However, cloud computing adoption and implementation in healthcare is not similar to other industries. Because of different barriers, cloud computing is not implemented in many hospitals or health institute. Therefore, there are not enough examples or literature review related to implementation of cloud computing in healthcare.

As a preliminary study, we have tried to search and categorize the implementation issues of healthcare cloud from different journal articles and scientific magazine and at the end give some recommendation to healthcare administrators, who want to implement health cloud in their hospitals. The further studies will be needed to examine the hypotheses and research questions, which we found in this study:

1. Which cloud computing model (i.e. SaaS, PaaS, and IaaS) is more suitable for healthcare organizations?
2. Is security a concern for using cloud computing by healthcare organizations?
3. Is privacy a concern for using cloud computing by healthcare organizations?
4. What are the obstacles for using cloud computing by healthcare organizations?

Based on the above research questions, we have proposed the following hypotheses:

- H1: There is no difference among three cloud computing for healthcare organizations.
- H2: There is a negative relationship between security concern and adoption of cloud computing in healthcare organizations.
- H3: There is a negative relationship between privacy concern and adoption of cloud computing in healthcare organizations.

Research Framework

For categorizing the cloud computing implementation issues in the healthcare industry, several studies such as Gangwar, Date & Ramasway (2013), Borgman et al. (2013), and Lian, Yen & Wang (2014) have suggested different frameworks for implementation and adoption of cloud computing. These framework included Tornatzky et al. (1990) Technology-Organization-Environment (TOE) and Yusof et al. (2008) Human-Organization-Technology fit (HOT-fit) and Davis (1986) Technology Acceptance Model (TAM). Lian, Yen & Wang (2014) addressed that TOE is a good framework to determine the critical factors in IT adoption in any organization. On the other hand, the main focus of HOT-fit framework is on healthcare information system adoption in hospital. Therefore, this study summarized both frameworks to explore the effective factors in implementing cloud computing in the healthcare industry. Lian, Yen & Wang (2014) mentioned that TOE framework is not designed for adoption of technology in the healthcare but it is useful to understand the IS adoption in the health industry. Furthermore, the HOT-fit framework is developed specifically for the adoption of information technology in the healthcare. So, the combination of these two frameworks could cover most of the factors that has an impact on the implementation of cloud computing in the healthcare. Based on these frameworks, the impact of technological, organizational, environmental and human factors on the adoption and implementation of cloud computing in the healthcare will be discussed in the next section.

Technological Issues

Lian, Yen & Wang (2014) explained that he technology issues have some internal and external effects on the adoption of cloud in the healthcare. Some of these issues related to the nature of cloud computing as a technology. The privacy and security issues are very important, when we are talking about cloud. Actually, the major barrier of adopting and implementing cloud in the healthcare is the privacy and security issue that still is not desirable for health providers to adopt cloud in their organization. Establishing a secure environment for sharing and integrating patient's data is challenging and needs more work to solve the problems.

Complexity and compatibility are two other elements of technology that have an impact on adopting and implementing cloud in the industry (Borgman et al. 2013). Installing cloud applications and equipment in health industry is complex when it combines with health equipment. Based on Lian, Yen & Wang (2014) study, in terms of compatibility, it should be checked that how much cloud applications and infrastructure is compatible with the existing IT systems in the hospitals.

Like any other investment, technology cost is another issue that should be addressed in terms of having a successful implementation of healthcare cloud. Cloud implementation needs different investment in hardware, software, and system integration (Lian, Yen & Wang, 2014). Therefore, the health administrator should think about it before starting to migrate to cloud.

Organizational Issues

The organizational factors have a huge impact on the successful implementation of healthcare cloud. Based on Borgman et al. (2013), the size of organization is one of the challenging issues that could facilitate the adoption of cloud. Large organization should invest more and take a bigger risk of failure for implementing healthcare cloud. The small and med-size firms are more dynamic and could adjust with cloud configuration faster and easier. Also, they don't need to spend a lot on the implementation.

Borgman et al. (2013) referred to the top management support as one of the important element in the organization aspect of cloud implementation. Without top management support, the success rate of cloud implementation in healthcare would be very low. Cloud computing will effect on budgets, processes, and responsibilities, so the administrator support will be needed for this transformation. Top managers are responsible for allocating adequate resources to support cloud implementation.

Borgman et al. (2013) addressed that cloud/IT skills of non-IT employees have an impact on adopting cloud. If the organization has enough IT/cloud skill employees, it has a better chance to implement cloud more successfully. The employee with IT knowledge could help in migrating to healthcare cloud more easily.

Environmental Issues

The environmental issues are related to "in which a firm conducts its business - its industry, competitors, access to resources supplied by others and dealing with government" (Tornatzky et al., 1990). Based on Borgman et al. (2013), competition intensity and regulatory constraints are the two important factors in the environmental aspect. There is a competition between hospitals now. Some smaller hospitals are migrating to information technology services and systems and this will force other hospitals to adopt new information systems more quickly.

Abukhousa, Mohamed, & Al-Jaroodi (2012), addressed that the regulatory constraints mostly related to the privacy and security of the patient's data. It is essential for organizations to verify that the underlying cloud infrastructure is secure. Proving that the physical and virtual infrastructure of the cloud can be trusted and becomes even more difficult when those infrastructure components are wholly owned and managed by external service providers. The Health Insurance Portability and Accountability Act (HIPAA) requires the health data be processed in certain prescribed means. HIPAA asked health provider to ensure that the privileged user access is controlled and monitored. However, it is difficult to demonstrate that the cloud infrastructures are secure and tested for HIPAA compliance.

Human Issues

Focusing on the human aspects of cloud implementation in the healthcare is very important, because at the end the users such as patients, healthcare professionals, administrators and insurance personnel should accept and be able to work with cloud applications. Different users have different behaviors and attitudes. However, most of them have a resistance against the new technology. The professional training session is a necessity before cloud implementation in the healthcare. The users should be evaluated based on their information technology literacy. Some users have a narrow knowledge of technology and others have a better IT skill, so the administrators should pay attention to this issue.

FUTURE STUDY

After reviewing around fifty articles, we could say that there is a gap in the literature review of cloud computing implementation in healthcare. There are different types of literatures, which are close to this topic. Some of them are related to the adoption of cloud computing in various industries and some others are about the implementation of Information Technology in healthcare. Although these two area are very close to our research but still there are some differences in the implementation of IT versus cloud in healthcare, because of the nature of cloud computing technology. The privacy and security issue is one of the most important barriers for implementing cloud applications in the healthcare industry, which was not that serious in implementing other technologies. As a result, we could not find any large-size hospitals around the nation that implemented cloud computing in their hospitals. We interviewed with three hospital staff in the state of Michigan and found that by the federal law (regulation like HIPAA) and their own policy, they are not allowed to use any kind of cloud applications for storing patients' data. The HIPAA compliance in the United of States enacts strict regulations for accessing the patient's data and the cloud providers are reluctant to sign a contract with healthcare provider, because the law and regulations are so rigid. As a future study, we want to benchmark the cloud computing implementation and adoption in the healthcare industry in different countries in Europe and Asia versus United State. It seems that US among other progressed countries has a much more strict law and regulations in this field. There are 241 healthcare facilities in the state of Michigan based on the statistics of Health Resources and Services Administration. For the further investigation, we want to select 40 of them randomly and explore if they are using any kind of cloud computing technologies in their work.

RECOMMENDATION

Based on this study the top management support is a necessity for implementing healthcare cloud. Top managers should allocate appropriate resources and support the process transformation in the organization. Training the staff is an important task that the managers should consider. Without the professional training the users could not be able to work with cloud applications and during the time, this could be frustrating for them and they may give up using it. Users per se have resistance against the new technology; however if they have been trained well, it has a good impact

on their perceptions and it may reduce their resistance. Users should learn that the new technology will help them to do their task easier, faster and with less energy consuming.

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