

# Cloud Computing Adoption Conceptual Model of Malaysian Hospitals

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## Abstract

The emerging of cloud computing with flexibility, improve accessing data and cost saving has made this technology popular and fast-growing. As a result it has created interests among healthcare companies seeking to explore the cloud technology. Although there are many benefits of cloud computing, healthcare industries are typically slow in adopting it. The goal of this paper is to review cloud computing benefits and implementation aspects in hospitals, identify cloud computing adoption factors and to propose a conceptual model for understanding the adoption phenomenon by considering security perspective in the case of hospitals in Malaysia.

*Keywords:* Cloud Computing, Technology Adoption, Health Informatics

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## 1. Introduction

In Malaysia, Kumpulan Perubatan Johor or widely known as KPJ was the first private healthcare provider in adopting cloud computing. With more than 20 hospitals in Malaysia and two hospitals in Indonesia, they believe that cloud is able to lower their costs or enjoying savings of 30% to 40% of their IT spending in the long term. Hence, with the use of cloud they can operate efficiently and provide better services to patients [1]. Cloud computing is growing with scalable and elastic abilities to deliver as a service to cloud users [2]. Cloud computing market for healthcare has shown a steady increase recently according to Linthicum [3]. Shetty [2] added that the growth of cloud adoption is due to regulatory influences from the American Recovery and Reinvestment Act of 2009 (ARRA) in encouraging the utilization of electronic patient records to be used in hospitals. Reduction of budget also makes healthcare companies desperately looking for cost effective technologies to replace their legacy system and the growth of technology also makes healthcare application providers starting to migrate to cloud computing [4].

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The aim of this paper is to review the background of Cloud Computing adoption in hospitals and to propose the relevant factors to be considered when adopting cloud computing in hospitals in Malaysia.

## **1. Background of Cloud Computing**

The US National Institute of Standards and Technology (NIST) defines 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 release with minimal management effort or service provider interaction” [5, pp. 2].

According to Soman [6], cloud signifies fundamental changes in the manner on services are consumed by individuals and organisations. Cloud involves the variations from owning and managing the systems to accessing IT systems as a service whenever required. Cloud services satisfy the needs of (1) consumers who may neither own the hardware on which data processing and storage happens, nor own the software that performs the data processing and (2) unlimited accessibility and service at anytime and anywhere over the internet.

According to Aleem [7], cloud computing changes the way businesses are conducted by transforming the expenses from capital expenditure (Capex) to operational expenses (OPEX). This means usage is billed on pay per use basis; i.e. no hardware and software need to be purchased by the companies. Cloud computing brings several advantages such as efficient use of business resources, ability to increase data execution time, less patch management pain, less volume of computer infected by virus, maintenance of data storage and disaster recovery plan, cloud service provider are compliance with regulatory and compliance [7].

## **2. Method**

The peer reviewed articles published in English from 2010 to 2015 were searched using IEEE Explore and Science Direct. A combination of terms “cloud computing” and “adoption” was used as the keywords to search relevant papers. Only full-text articles, scholarly peer-reviewed and referential cited articles bearing potential relevancy for the review have been assessed and included in the review.

### 3. Result

#### a. Cloud Computing in Healthcare

Healthcare industry differs greatly from other industries. The uniqueness of healthcare is due to privacy and security of patients' data which makes the data itself sensitive and any misleading data will cause serious impact which sometimes can lead to life or death. In healthcare, the key differences of healthcare industry with other industry can be categorized into three segments, and these are High risk industry (1) errors occurred in healthcare are more costly than other industry, (2) highly regulated as healthcare industry is governed by law and regulations to safeguard patients and (3) multiple entities such as hospital administration staff, payers, labs and patients [5]. Hence, the sensitivity of data handling can result in slow adoption of new technologies in healthcare industry.

A collection of previous research listed in Table 1 shows the benefits and achievement of cloud adoption in healthcare area. In summary, Cloud Computing makes the deployment process for patients' data more easily accessible and managed thus promotes health delivery and high availability of patient data.

Table 1: Benefits of Cloud Computing in Healthcare

Authors	Project	Benefits
Rolim et al. [8]	To automate process of collecting patient's data using network sensor which connected to legacy system and deliver the information for storage, processing and distribution in the cloud.	<ul style="list-style-type: none"> <li>• Real time data collection</li> <li>• Eliminate error and automate manual work</li> <li>• Make the deployment process easier by using wireless.</li> </ul>
Nkosi and Mekuria [9]	Cloud computing protocol management systems to provides multimedia sensor signal processing and security as a service to mobile devices.	<ul style="list-style-type: none"> <li>• Improve the utilization of ubiquitous mobile device</li> <li>• Promote health service delivery</li> </ul>
Subrahmaya et al.[10]	Promoting use of cloud computing and wireless technologies to access patient health information in rural area.	<ul style="list-style-type: none"> <li>• High availability of patient data</li> </ul>
Koufi et al. [11]	Integration of emergency system and personal health record system in cloud computing.	<ul style="list-style-type: none"> <li>• High availability of patient data</li> </ul>

#### b. Security Aspects in Cloud Adoption

Based on the study by Abuhussein et al. [12], seven categories of security need to be considered before deciding to move into cloud computing and three well known cloud service providers such as Amazon EC2, Microsoft Azure and Google Apps Engine have been evaluated with results showing uncertainty in the trust and safety of data with cloud service provider, weaknesses of unauthorised access and attacks against the company infrastructure. The list of security categories which are recommended to be used as assessment in considering factors in adopting cloud computing in the organizations are Network Security, Interface Security, Data Security, Virtualization Security, Governance Security, Compliance Security and Legal Issues Security [12].

In another study, Sengupta et al. [13] has divided the common cloud computing security issues into four main categories namely cloud infrastructure, cloud data, cloud access and cloud compliance. This study has considered common security concerns when adopting cloud computing such as listed in the following:

i. Security of Cloud Infrastructure

This is related to virtualization, storage and networking weaknesses which comprises of the security of physical data centre against security breach, the security of virtualize infrastructure against the malicious attacks, the potential of vulnerability attack that would affect the application hosted in the cloud, the security isolation in hybrid cloud and trust towards API's and interfaces provided.

ii. Security of Data in the Cloud

This concerns related to data integrity, data lock in, provenance, and data confidentiality and user privacy which comprises to guarantee on the data integrity and data loss prevention are taking care, data privacy and protection, prevention from data lock out in the case of CSP fail, ensures that data are tracked properly and valid data provide to customer once needed and maintaining data confidentiality and integrity when the multiple cloud involved.

iii. Security of Access in the Cloud

This concerns pertaining to authentication, authorization, access control, encrypted data communication and user identity management which comprises to no unauthorised access by disgruntled employee, ensure on the proper level of authentication practise and sufficient delegation of access in different domain of users with minimum common access control.

iv. Cloud Compliance

Concerns from regulatory agencies such as security audit, data location, operation traceability and compliance.

On the other hand, Ackerman et al. [14] regards security as part of the decision maker's perception of risks that affects safety and security of company when moving into cloud. Hence, for cloud computing adoption study, IT professional feedbacks and opinion are important as they are decision makers for adoption any technology for the hospital. Table 2 shows the recent collection of previous cloud computing adoption studies considering security as part of the adoption factors.

Table 2: Security Aspects of Cloud Computing in Healthcare

Authors	Title	Findings
Bernsmed et al. [15]	Healthcare Services in the Cloud – Obstacles to Adoption, and a Way Forward	In healthcare domain, stakeholders concern about data availability, transparency, compliance with data protection, legislation, access control and audit logs.
Lian et al. [16]	An exploratory study to understand the critical factors affecting the decision to adopt cloud computing in Taiwan hospital	The findings indicate that the most critical factors affecting the decisions to adopt cloud computing are data security, perceived technical competences, cost, top manager support and complexity.
AbuKhoua [17]	e-Health Cloud: Opportunities and Challenges	Several technical challenges in adopting cloud computing are availability, data service or reliability, data management, scalability, flexibility, interoperability, security, privacy and maintainability
Alkhatir et al. [18]	Factors Influencing an Organization's Intention to adopt Cloud Computing in Saudi Arabia	Finding from the study found that security, privacy, trust and compliance with regulations issues were the biggest concerns for most organizations in decision to cloud adoption.
Bamiah et al. [19]	Cloud Implementation Security Challenges	Reluctant of critical industries such as healthcare and banking towards cloud computing adoption is due to fear on losing sensitive data. The findings have addressed several security challenges such as Insecure Application Programming Interface (API), Virtualization Vulnerabilities, Insider Attack, Service Level Agreement, Identity Management, Data Governance & Regulatory Compliance, Abuse and Nefarious Use of Cloud, Multi-tenancy and Key Management.
Behl. and Behl [20]	An Analysis of Cloud Computing Security Issues	Development of standard security model is too complex and intangible due to no specific security model suit with dedicated cloud service. The study categorized cloud computing security issues into few key areas such as Multi-tenancy, Elasticity, Availability of Information or known as Service Level Agreement (SLA), Secure Information Management, Information Integrity and Privacy and Cloud Secure Federation.

### c. Proposed Conceptual Model

In line with this study, security itself is not sufficient without the base theory of technology adoption. Hence, technology adoption theory is considered to formulate the conceptual model which then can be used to facilitate the understanding of the feasibility of cloud computing adoption in hospitals. Referring to previous study, most of the researchers are using Technology-Organization-Environment (TOE) [21], Diffusion of Innovation (DOI) [22] as well as a combination of both TOE and DOI in addressing the technical and operational issues of cloud computing adoption [23].

TOE framework introduced by Tornatzky & Fleischer [21] addresses the process of innovation to be implemented at enterprise level. Three factors that influence the adoption are: technology, organization and environment. Technology dimension refers to internal and external technologies elements that are potential to influence the adoption of cloud computing in the organization. These include current practices, equipment in the organization and its readiness. The organization element refers to characteristic of the firm itself based on the organization structure, firm size, degree of centralization, resources and communication process among staff. On the other hand environment dimension consists of market elements, competitors and regulatory [23].

Innovation process in organizations involves staffs and adversaries, each of them is regarded as an asset and bear important during innovation decision using their new idea and this makes the innovation process more complex [22]. According to Rogers [22] innovativeness reflects individual (leader) characteristics, internal organizational structural characteristics, and external characteristics in the organizations.

TOE framework provides a strong analytical tool from the technical perspective and differentiates the essential qualities of an innovation and the motivations, capabilities, and wider environment context of the adopting organization. Hence, TOE provides detailed understanding on critical factors that influence new innovations adoption [24]. The summary of adoption factors based on TOE used by previous researchers in gaining understanding of Cloud Computing adoption is shown in Table 3.

Previous study conducted by Ismail et al. [25] considering Malaysian perspective has suggested that TOE can be applied to explain the adoption of cloud computing in hospitals. TOE categorizes the factors based on three dimensions:

- a. Technology is important to ensure successful of IT adoption as technology need support from resource infrastructure, technical skill, developer and use of time.
- b. Organizational context is important for hospital to confirm on efficiency of organizational structure which also refers to firm size, centralization, formalization, managerial structure, and human resources.
- c. Environmental is important to ensure an effectiveness of IT in the hospital which referring to firm surrounding, stakeholders, industry members, competitors, suppliers, customers, government and community.

Based on the findings and comments of Table 3, the integration of adoption factors from TOE model and security factors are proposed to be considered in facilitating the understanding of cloud computing adoption in hospital. Further, a preliminary study has been done involving five IT professionals working in Malaysian hospitals environment to help confirm the relevancy of the factors in the context of Malaysian hospitals.

Subsequently, this study proposed a model for cloud computing adoption in hospitals as illustrated in Figure 1. The proposed model derived from a consideration of integrated model of technology adoption model of TOE, DOI and security perspective. The model highlights four dimensions of cloud computing adoption bearing important aspects in the decision to adopt cloud computing. Each dimension comprises several factors reflecting the dimension. The first dimension is technology consisting technology readiness and costs. Top management support and firm size are factors in organizations dimension. The third dimension is environment which is reflected by government policy, legal environment and industrial pressure factors. The last dimension is security where it considers security of cloud infrastructure, security of data in the cloud, security access in the cloud and cloud compliance.

Table 3: Recent Cloud Computing Adoption Factors

Title	Model	Dimensions			Comments
		Technology	Organization	Environment	
An exploratory study to understand the critical factors affecting the decision to adopt cloud computing in Taiwan hospital [16].	TOE and Hot-fit	Data Security Complexity Compatibility Costs	Relative Advantage Top Manager's support Adequate resource benefits	Government policy Perceived industry pressure	<ul style="list-style-type: none"> <li>Some factors of Hot-fit in regard to Human dimension is duplicating the organization dimension in TOE.</li> <li>Data security, complexity and compatibility are part of security factors in previous study by Ackermann [14] and Paquet [26].</li> </ul>
Assessing the Determinants of Cloud Computing Adoption: An Analysis of the Manufacturing and Services Sectors [23].	TOE + DOI	Technology readiness	Top management support, Firm size	Competitive pressure, Regulatory support	<ul style="list-style-type: none"> <li>DOI model taken out due to duplication with technology dimension in TOE.</li> <li>We argue the finding shown that security and privacy concern has negatively influence the relative</li> </ul>
The determinant of adoption in cloud computing in Vietnam [27].	TOE + DOI	Technology complexity Relative advantage	Formalization Infrastructure availability Organizational size	Competitive pressure Trading partner pressure	<ul style="list-style-type: none"> <li>Top management support as sub of individual factor shall group under organization dimension. Thus, this sub factor will group under organization dimension.</li> </ul>
Examining cloud computing adoption intention, pricing mechanism and deployment model [28].	TOE	Perceived benefits Business concerns	IT capability	External pressure	<p>Results from descriptive statistics finding have revealed that the top concerns are related to:</p> <ul style="list-style-type: none"> <li>Cloud provider cannot deliver quick response (93%)</li> <li>Unexpected service outages (92.5%)</li> <li>Confidentiality (92%)</li> </ul>
Factors affecting the adoption of integrated cloud-based e-health record in healthcare organizations: a case study of Jordon [24].	TOE	Privacy Security Reliability	Top management support Technology readiness	Government policy Legal environment Competition	Findings have shown top management support, privacy, security and reliability are the most factors in concerning cloud computing adoption.

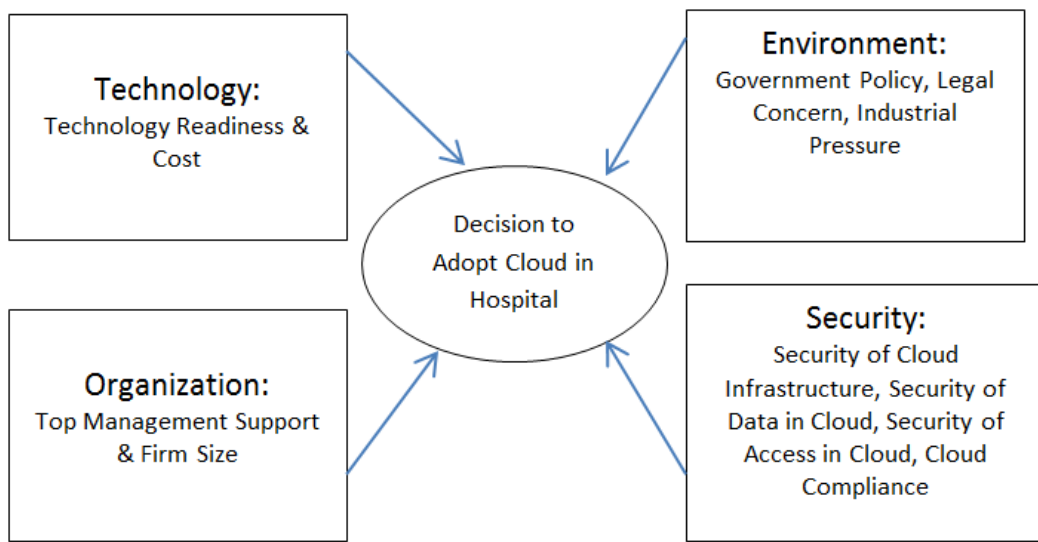


Figure 1: Proposed Conceptual Model of Cloud Computing Adoption in Malaysian Hospitals

#### 4. Conclusion

A review of cloud computing adoption issues in hospital is presented in this paper. Apart from that, issues related to Cloud Computing as well as security issues in healthcare sector are also presented. Several factors deduced from this review are used in formulating a conceptual model which then can be used to facilitate the understanding of cloud computing adoption in hospitals in Malaysia. Apart from using the original TOE, this paper highlights the importance of considering security issues when adopting cloud computing in hospital. Considering appropriate security aspects in either the formulation of conceptual model for interpretive research or validation of research model for explanatory study is essential in cloud computing adoption in healthcare context. The proposed conceptual model of Cloud Computing adoption presented in this paper will be further empirically evaluated in the next phase of research. This in-progress-study will use both quantitative and qualitative methodology in revealing insightful understanding regarding the determinants that influence cloud computing adoption in Malaysian hospitals. It is expected that the findings will benefit the hospitals IT team in planning a more secure cloud computing implementation in near future.

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