Factors affecting the adoption of cloud computing based-medical imaging by healthcare professionals

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Abstract: Cloud computing, the new paradigm, is well utilized in business and education but not in healthcare. In healthcare realm, cloud computing offers the chance to provide patient-oriented care. This study aims to investigate factors affecting the adoption of cloud computing based medical imaging solutions by health care professionals. Multiple regressions test was used in order to test the research hypothesis and come up with research result. According to multiple regressions test, the results of the study illustrates that there is a statistically significant impact of all independent variables (perceived usefulness, perceived ease of use, perceived risk, performance and availability) except for institutional trust and compatibility on the dependent variable of intention to use. Results indicate the impact and the importance of the independent variables and explain the important role of these factors on the intention of users to use cloud computing solutions in the medical sector. Additionally, these findings support findings of some previous related studies. Based on these results, research in the medical sector should pay more attention for these factors.
Key words: cloud computing, cloud computing adoption, medical imaging.

RESEARCH BACKGROUND

Demand on healthcare services has dramatically increased recently, as the world's population is growing day by day, the increase in life expectancy rate and the increase in elderly population with the resultant abundance of chronic diseases which necessitate careful treatment and monitoring; these factors together have posed an extra burden of medical data. Advancement in medical technologies and diagnostic procedures has caused an exponential rise on medical digital data; this is attributed to the increased amounts of medical imaging studies (Mirarab, Fard and Shamsi, 2014). The new imaging modalities have expanded the storage requirements especially for CT and MRI studies by 10% - 25% annually (Kagadis et al., 2013). Large-sized medical images not only constitute a storage challenge, but also the need for high performance processors has concerned healthcare services providers.

Handling medical data, of most importance, medical imaging data is becoming a concern for healthcare services providers (Silva, Costa and Oliveira, 2012). Cloud computing, the new technology paradigm, has made information sharing and data storage a smooth and dynamic process via the services it provides offering a reasonable strategy for handling medical data (Shin, 2013). In contrast with the great attention cloud computing has experienced in the

developed countries such as the United States, Canada, and Europe cloud computing in the developing countries including Jordan, yet is understudied field and most of health care professionals never heard of (Sultan, 2014).

Cloud computing would provide the chance for health care domain to lower the total IT investment costs without any violation to the health care laws and regulations and maintaining the accessibility to the most recent medical technologies (Bidgoli, 2011). It was demonstrated that when health care organizations deploy its provided services and applications to a loyal third party, the demand on purchased software, hardware and IT personnel would be reduced and thus would reduce the overall costs which is of great importance for economic growth in developing countries especially with the limited budgets and high indebtedness they suffer from (Glaser, 2011). Furthermore, the huge amounts of medical media data generated owing to improvements in imaging techniques and diagnostic procedures have posed another load on the shoulders of healthcare services providers (Silva, Costa and Oliveira, 2012). Film format and compact discs (CDs) were the mainstay for image archiving and sharing, being costly and prone to data loss necessitated exploring other alternatives. The evolution of Electronic Health Records (EHR) had, to some extent, replaced the conventional films and CDs. Nonetheless, EHRs are no longer satisfactory to the demanding needs of healthcare industry as they are expensive to establish, require IT departments establishment, require software update and maintenance and hinder sharing of medical data among healthcare institutions because they lack interoperability (AbuKhousa, Mohamed and Al-Jaroodi, 2012).

There is a limited number of studies on the acceptance or adoption of cloud computing in healthcare as evidenced by reviewing current literature. Most of which have examined the adoption of cloud computing solutions among healthcare professionals based on their basic knowledge of the cloud technology without providing an illustrative program or software. It is obvious that research in the area of adopting cloud-based technologies is lacking especially those that address factors that influence the implementation of cloud-based technologies in developing countries.

CLOUD COMPUTING OVERVIEW

Cloud computing is a prototype in Information Technology (IT) which describes the process of delivering on demand services over the internet. Cloud computing has expeditiously evolved and developed replacing the conventional computers. In the 1990s, grid computing was conceived as a novel technology that made it possible for users to access computing power on demand. Grid computing represents the outgrowth of distributed computing as the type of technology provided by the grid can assist in various research societies and enterprises in their endless demands. The table 1 below compares between cloud computing and grid computing features.

Table 1. Cloud Computing Vs Grid Computing.

Feature	Grid computing	Cloud computing
Business model	Resources sharing between users	Resources deliver services for every users according to their demands
Performance	Low	High
Scalability	Normal	High (resources are consumed according to users' demands)
Interoperability	Open Grid Forum Standards	Web services (SOAP/ ReST)*
Availability	Low	High
User management	Decentralized	Centralized or might be outsourced

Virtualization	Not a property	Key property
Security	Minimal concerns	Great concerns due to virtualization
Failure management	Limited	Sufficient
Example	GIMPS	Amazon Web Services

*SOAP: Simple Object Access Protocol, ReST: Representational State Transfer.

As illustrated in the previous table, it is believed that cloud computing is derived from the expansion of the concept of grid computing as it constitutes the cornerstone and infrastructure support of cloud computing. A change in interest from infrastructure that convey storage and computing resources (as in grid) to more naked resources and utilities (as in cloud) has led to the development and evolvement of cloud computing (Foster et al. 2008).

CLOUD CHARACTERISTICS

Cloud computing has five essential characteristics that are described as follows:

- On-demand self-service: a consumer can unilaterally provision computing facilities as needed automatically without necessitating personal communication with providers (Mell and Grance, 2011).
- Broad network access: facilities are feasible over the network and can be approached via standard mechanisms that encourage employment by different users' platforms (Mell and Grance, 2011).
- Resource pooling: the provider's computing resources are gathered to serve numerous users by a multi-tenant model, with various physical and virtual resources assigned and reassigned according to consumers' needs (Mell and Grance, 2011).
- Rapid elasticity: facilities can be flexibly provided and delivered, in a few situations automatically to escalate speedily up and down based on demand (Mell and Grance, 2011).
- Measured service: cloud systems consequently manage and enhance resource use by leveraging a metric capability at some degree of abstraction convenient to the type of service. (Mell and Grance, 2011).

CLOUD COMPUTING BENEFITS

Cloud computing implementation offers many advantages for organizations that choose to turn into the cloud. Among these benefits are: scalability and sustainability of information, location- independent computing, huge storage capacity, 24/7 availability of services, flexibility, ubiquitous network access, pay as you go infrastructure and cost lowering (Han, 2011). Some of these benefits are explained in the following paragraphs:

- Cost effectiveness: cloud computing adoption would enable enterprises and organizations to lower the total IT costs by three to five folds compared to in-house options (Han, 2011). Cost lowering is attributed, in part, to the lowering of hardware, software and IT infrastructures costs. Additionally cloud computing would enable organizations to reduce their expenditure on licensing fees and charges on data storage and software updates. Moreover, cloud computing services are provided through "pay as you go" manner; through which customers or users pay only for the services and resources they use eliminating the need for purchasing software licenses or maintaining annual contracts; this would lower total IT expenditures (Han, 2011).
- Availability: users can access data stored in the cloud from anywhere via the internet; hence it is the cloud service providers who are responsible for the provision

of continually available resources. Providers not only ensure continuous service availability but also offer alternative locations to avoid failure (Dinh et al., 2013)

- Scalability and performance: cloud computing offers the user the advantage of unlimited storage capacity as its infrastructure enables the creation of multiple virtual machines, the storage of which can be scaled up or down according to users' demands (Buyya et al., 2009). Virtual machines are utilized based on demands and needs, thus, consumers pay only for the data and applications used (Buyya et al., 2009). The performance of cloud computing is comparable to that of local servers.
- Backup and recovery: while using cloud computing, data is stored in the cloud rather than being stored on local computers or local servers, this would guarantee, somewhat, a trusted sort of data backup. Additionally, cloud service vendors provide trustworthy options for data and applications backup and disaster recovery (Subashini and Kavitha, 2011).

CLOUD COMPUTING ADOPTION

Cloud computing adoption has grown notably to an extent that no new technology has ever reached as most research studies stated. As with all technological innovations that require basis for further build up and development, so was the cloud computing paradigm as an expansion of the distributed computing and grid computing for the purpose of providing tremendous technological solutions. Despite of the unprecedented success that cloud computing has gained in the developed countries; its biggest impact seems to be among nations with growing markets and advances; more precisely among the developing countries.

The exploitation and adoption of new technologies would enhance the innovation and would finally lead to tangible achievement impacts. Many models were developed and adjusted to assess the acceptance of cloud computing.

Cloud computing should provide users with unprecedented benefits to facilitate its adoption. In addition cloud computing should be flexible and compatible with their traditional computing technology. Another thing that must be taken into account is that the adoption of any new technology occurs in steps and phases; and so is the case with cloud computing adoption.

Géczy, Izumi and Hasida (2012) have classified the benefits of adopting cloud computing for business and education sectors into three categories: deployment, financial and functional. According to Géczy, Izumi and Hasida (2012) the deployment benefits include: the fast, simple and obvious access to the cloud based services and applications.

Financial benefits comprise: pliable deployment models, holding information technology resources with lower expenditure, a reduction in the costs of performance and conservation, lower the efforts and expenses on software boost and the primary exploitation expenditure (Géczy, Izumi and Hasida, 2012). Functional benefits include: enable institutions to handle up-to-date software and hardware with lower costs, innovation resulted from the adoption of cloud computing solution would enable institutions to use on demand resources and services (Géczy, Izumi and Hasida, 2012).

Despite of the various benefits that the adoption of cloud computing offers, it provokes many risks and threats. Researchers stated that the risks of cloud computing adoption include: questioned security of shared information, concerns of data loss, a reduced immediate supervision and monitoring of shared data, network availability and connectivity, technological problems that arise when transforming current data to the cloud environment, integration of data and applications and reliability.

As a growing technology, cloud computing still suffers from challenges especially when talking about the adoption of cloud computing by public institutions. Janssen and Joha (2011)

have identified these challenges and further classified them into four groups: strategic and organizational, political and legislative, technical and economic. The adoption challenge from an organizational point of view lies in managing the delivered service in terms of planning and setting up the budget and recruiting highly qualified personnel. Technically for an organization to adopt cloud computing it should regularly control its work accomplishment in an attempt to make sure that the quality, security and speed meet the service level agreement (SLA) (Janssen and Joha,2011).

The economic challenge on the adoption of cloud computing focuses on the payment models and the contract period of either being too short or too long. The legislative aspect of cloud computing adoption challenge faces the public agencies when adopting cloud computing in choosing a model to adopt and the possibility that the chosen model might negatively affect their security, identity management and user authorization. From a political aspect, cloud computing adoption by public agencies is directly linked to cloud computing providers (Janseen & Joha, 2011).

CLOUD COMPUTING ADOPTION IN HEALTH CARE

A wide range of IT services, extending from the simple productivity software like word processing to the more complex biomedical devices like computed tomography (CT) scanners, are being utilized by healthcare industry. However, healthcare is about 10-15 years late when compared to other industries in terms of IT solutions implementation (Goldschmidt, 2005). Hospital accounting systems were the first healthcare IT implementation; it was not before the 1990s until electronic health records emerged (Goldschmidt, 2005). According to Goldschmidt (2005), electronic health record (EHR) is a term used to describe a system that combines all patient's medical information; the term electronic medical record (EMR) is used alternatively as well.

Patients' data including medical images, physicians' notes, pharmacy records and other related medical information used to be arranged in paper-based medical records. Switching to EHR was in an attempt to provide a patient oriented medical care by decreasing medical errors, providing prompt access to accurate information and enhancing safety protocols.

Enough knowledge and thorough training on the use of new technology would help users realize its benefits. For instance, implementing EMRs warrants initial users training and larger initial finance before benefits can be felt. IT solutions adoption and implementation among healthcare is slower when compared with other industries. Goldschmidt (2005) has attributed this to the failure of IT solutions to show noticeable operational costs reduction and patient care improvement. The interlinked markets within the healthcare sector were added as a contributor to the slow IT adoption, theses interlinked markets include: medical services, health insurance, the government and the labor market. It was argued that IT adoption delay in healthcare sector might enable stakeholders to get advantage of the previous research on IT solutions' acceptance and adoption in healthcare aiding in their future application.

User acceptance is another important factor as well; previous experience with failing solutions might hinder the adoption of new IT technologies. Fears that implementing new IT solutions might affect healthcare professionals' conventional workflow contribute to the slow adoption of new IT solutions. IT professionals working in healthcare industry act as both end users and service administrators, thus understanding their organizations needs and visions might help in the process of new technology adoption as they constitute part of the decision makers.

Demand on healthcare services has dramatically increased in the past few years resulting in increase in the burden of medical data and financial costs. Cloud computing, as an emerging IT technology, can benefit healthcare industry by providing a chance to control and reduce the integral costs, optimize resources and enable data access from everywhere at any

time and ultimately enhancing the quality of services delivered for patients. It was estimated that about 32% of healthcare entities are using a source of cloud-based solution, of the remaining entities 75% are planning to adopt cloud computing solutions in the upcoming 3-5 years (Ahuja, Mani, and Zambrano, 2012).

Cloud computing provides storage capacity that is scalable to organizational needs which would reduce healthcare IT expenditures. Cloud storage for health information offers the healthcare services providers the benefit of the effective administration and update of their data and the enhanced control on admission minimizing unauthorized access. Additionally, cloud storage of health data makes it possible for the stakeholders in healthcare industry to keep adherence to legal regulations as electronic format of data can be managed, analyzed and protected much easier (Ahuja, Mani, and Zambrano, 2012).

Researchers have drawn the attention toward the third party nature of the services provided via the cloud and the consequent risks; in that end users have little to no control over the security and integrity of their stored data on the cloud. However, such risks are not uncommon in the conventional IT environment while dealing with a third party, in other words these risks are not exclusive for cloud environment. In spite of that, worries of current and future users of cloud computing are said to be rationalistic as the privacy and security risks are aggravated in the cloud environment compared to that of traditional IT. In the cloud environment, end users not only encounter the external privacy and security risks which are popular among conventional IT solutions, but also have to deal with internal risks. Internal risks occur when other users who are supported by the same cloud provider get an unauthorized access to data stored in the cloud. To avoid violations to legal regulations and the resultant fees and penalties, cloud providers efforts must be directed toward resolving these risks and assuring users that their data is properly stored and confidentially secured and protected (Armbrust et al., 2010).

CLOUD COMPUTING AND MEDICAL IMAGING

Medical imaging is defined as the process of using variable technologies to view the human body in attempt to diagnose, monitor or treat medical conditions. Imaging modalities differ according to the type of technology used and information contained in the image about the body area examined. Imaging modalities include: X-ray, CT, MRI, Mammography, Ultrasound imaging and Positron Emission Tomography.

For decades, film was the format through which medical images are previewed and shared among healthcare professionals; however it was costly, bulky and ineffective as it might be lost. Later on, Compact Discs (CDs) evolved and partially replaced film. CDs are less expensive, portable and have high storage capacities. In spite of that, CDs are prone to damages and might become unreadable causing data loss as well.

The shift in focus toward providing patient-oriented care has led the foundation of Picture Achieve and Communication System (PACS) to store, process, retrieve and visualize medical images (Silva et al., 2014). PACS consists of four parts: the imaging devices, the storage archives, workstations for image visualization and a network through which PACS elements are connected.

The transfer and distribution of medical imaging data is done through Digital Imaging and Communication in Medicine (DICOM) standard. DICOM enables sharing of medical imaging data between medical devices in the same institution but not among different institutions. Shifting medical images into digital systems has highly benefited healthcare institutions in terms of costs lowering, enhancing productivity and promoted collaboration among healthcare practitioners (Silva et al., 2014).

Cloud computing allows radiologists to access a reconstruction software which is operating via the cloud through logging in to their local workstation. As radiologists process images only commands ordering occur at the workstation level while the computational process occurs at the cloud servers, processed images are previewed on users' devices.

Furthermore, cloud enables accessing information from anywhere as long as sufficient internet connection is present reducing the need for software and hardware establishment and maintenance aiding in lowering IT expenditure. It was estimated that cloud computing would help in IT cost reduction by 20% annually (Gupta and Mann, 2014).

STUDY HYPOTHESIS

H1: There is a significant impact of independents variables (perceived usefulness, perceived ease of use, institutional trust, perceived risk, compatibility, performance and availability) on the intention to use cloud computing solutions by health care professionals working in public hospitals among Jordan.

DATA ANALYSIS

In order to test the study hypothesis, multiple regressions was used. Multiple regressions used to investigate direct impact for independent variables and its affect on dependent variable. Table 2 shows multiple regressions results.

Table 2. Regression Result Of Main Hypothesis H1.

Dependent variable	R	R2	Adj.R 2	F	Sig F	Regression Coefficients				
						Independent variable	B	Std. error	T	Sig t
Intention to use (IU)	0.756	0.571	0.563	66.778	0.000	(Constant)	-0.563	0.220	-2.554	0.011
						PU	0.283	0.059	4.829	0.000
						PE	0.175	0.051	3.392	0.001
						IT	0.078	0.052	1.504	0.134
						PR	0.161	0.045	3.606	0.000
						Comp	0.082	0.059	1.400	0.162
						Perf	0.206	0.056	3.674	0.000
						Av	0.205	0.054	3.784	0.000

The model summary shown in Table 5.22 reports that R Square, the coefficient of determination about (0.571%) of the variation in IU is explained by the model. While ANOVA (F-test) is used to statistically validate the proposed model. In addition, ANOVA is considered a useful tool to test the model's ability to explain any variation in the dependent variable IU. The significance value of the F statistic (F=66.778) is (Sig F = 0.000) less than 0.05, which means that the effect of independent variables aggregated is significant.

Moreover, the coefficients of the regression line states that the (PU) has a significant effect on IU, where coefficient equals (0.283) is significant with (t= 4.829) and (Sig t =0.000) less than 0.05, (PE) has a significant effect, where coefficient equals (0.175) is significant with (t= 3.392) and (Sig t =0.001). (ITrust) has no significant effect, where coefficient equals (0.078) is not significant with (t= 1.504) and (Sig t =0.134). Also, (PR) has a significant effect, where coefficient equals (0.161) is significant with (t= 3.606) and (Sig t =0.000). Moreover, (Comp) has not significant effect, where coefficient equals (0.082) is not significant with (t= 1.400) and (Sig t =0.162). (Perf) has a significant effect, where coefficient equals (0.206) is significant with (t= 3.674) and (Sig t =0.000). Finally, (Av) has a significant effect, where coefficient equals (0.205) is significant with (t= 3.784) and (Sig t =0.000).

Furthermore, the difference between $R^2$and adjusted R^2(0.563) is (0.007); as shown in Table 5.22. This means that if the model is derived from the population, it would account for 0.7% less variance in IU.

CONCLUSION

According to multiple regressions results provided in this study, there is a statistically significant impact of all independent variables on the dependent variable (perceived usefulness, perceived ease of use, perceived risk, compatibility, performance and availability) except for institutional trust and compatibility. Thus, the alternative hypothesis is accepted which states that there is a significant impact for these factors on dependent variable at significant level equal (0.01).

According to these results, users' perceptions toward using cloud-based medical imaging solutions are described through the proposed relationships and hypotheses between independent variables and the dependant variable. The researcher has stated that perceived risk, perceived ease of use and performance of cloud computing solutions had a key role and significant effect on the adoption process.

These results indicate the impact and the importance of the study independent variables and explain the important roles of these factors on the intention of users to use cloud computing solutions in the medical sector. Additionally, these findings come to support some of previous study results as well as it differed from some others. Based on these results, research in the medical sector should pay more attention for these factors.

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