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Challenges of Deploying Cloud Computing in eHealth

Nermeen Mekawie^{a*}, Kesmat Yehia^b

^aHead of BS department, Assistant Professor, Arab Academy for Science Technology and Maritime Transport, El horia, Cairo 2033, Egypt

^bAssistant Lecturer, BIS department, Arab Academy for Science Technology and Maritime Transport, El horia 2033, Cairo, Egypt

Abstract

New technologies emerge almost every day and they change how organizations and even governments operate. One of the technologies which had a great impact on business models is the cloud computing technology. Cloud computing impacts how resources and capabilities can be used to function effectively and efficiently. It allows organizations to operate in a competitive environment without focusing on scaling, maintenance, and failure. It became a key factor in IT vendors' strategies and governments like US Apps, and The Kasumigaseki Cloud in Japan. This study will investigate the challenges for deploying cloud computing in the eHealth Context within developing countries. It will examine the doctors' and managers' evaluation of cost, security, infrastructure, management support and the importance of other challenges in deploying cloud computing in eHealth.

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Keywords: Adoption; cloud computing; eHealth; Developing countries; challenges; risks; constraints.

* Corresponding author. Tel.: +0-000-000-0000 ; fax: +0-000-000-0000 .
E-mail address: nermeen.magdi@gmail.com

1. Introduction

Although technology has been a powerful tool for poverty reduction and improved standards of living in developing countries, the benefits have not been evenly distributed across the globe. Therefore, a great potential lies in the transfer of technologies to those areas that are still yet to benefit from such innovations and technological progress [1]. Thus, studying the cloud computing implementation in Egypt as a developing country can be of great help to the modernization of eHealth sector in the developing countries. Besides, they can cope with the west and enhance the availability of health care services with lower costs.

Developing countries lack resources, infrastructure and different elements of successful implementation of new technologies. Kshetri (2010) and Greenberg (2008) attested that Cloud computing allows access to advanced IT infrastructure, data centers [2], and application program that most development land do not have. Although, productivity can be enhanced through technology, developing countries, haven't yet realized the potency and welfare of technology unlike the developed countries. Access to timely and appropriate technology pose a serious problem for the developing countries [1]. Cloud computing presents a great benefit for developing countries for modernization through advanced technology with low initial investing that meet the capabilities and resources of developing countries. If the developing countries didn't take advantage of such new technologies like the cloud, they would be excluded from world markets [1]. Cloud computing can be used to modernize the eHealth sector in Egypt as a developing country and hence enhance the healthcare service delivery. Hospitals will be able to use the cloud as a public utility through pay per use model. Arguably, organizations seeking cloud adoption may be worried about different aspects of the cloud implementation. These aspects include security, toll, legal compliance as well as change and jeopardy management. The paper is organized as follows; it begins by reviewing the literature of cloud computing. A qualitative approach is adopted to investigate the challenges of cloud implementation in eHealth from different perspectives; IT experts and doctors. Themes were identified using the critical instance technique. Finally, results are discussed and future work is recommended.

2. Literature Review

The need to combine and coordinate different electronic wellbeing information from different spaces, for example, medicinal research laboratories, clinic, health care coverage firms has prompted the evolvement of an idea called electronic wellbeing (e-Health) [3]. It is anyway noticed that various areas being included in sharing of therapeutic information have made the application very difficult to oversee thus the requirement for cloud-based condition which allows community sharing of data over different administrative spaces [4]. Cloud computing has such a large number of advantages among which is constant exchange and sharing of medicinal information in a suitable way. It has additionally eased healthcare providers the strictness required to oversee foundation and furthermore provide them plentiful chance to familiarize with IT administration providers [5]. It has been built up in various scholastic papers that cloud computing offers various advantages going from adaptability, cost effectiveness, agility improvement of community oriented sharing of resources [6]

2.1. What is cloud computing?

The term cloud computing itself began appearing commonly in the literature around 2006 [7]. The closest definition for Cloud computing is defined by NIST (NIST, special publication 800-145) as follows,

"Cloud computing is 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. "

Cloud computing deployment models:

Cloud computing has different deployment models illustrated by NIST (National Institute of Standards and Technology).

- The public cloud is available to the public through a service provider like Amazon, IBM, Dell, while users have no control over the infrastructure and in this model rises the issue of security and privacy.

- The private cloud is dedicated to a particular entity or organization where the organization can host their applications and data and isn't shared whether hosted on premise or externally.
- The hybrid cloud as the name suggests is a combination or a composition of both augmenting a private cloud with the resources of a public cloud requiring on premise and external resources.
- Community cloud where the cloud infrastructure is shared by several organizations in a specific community with shared needs or concerns.

Cloud computing service models:

cloud computing has basic three service models where each offers a wide variety of services for the users based on their needs and demands; Infrastructure as a service (IAAS), Platform as a service (PAAS) and software as a service (SAAS).

Infrastructure as a service delivers infrastructure as servers, operating systems on demand based on the users' needs rather than investing in the infrastructure. At the same time, IAAS allows scaling the capabilities of the infrastructure and sharing its resources. For example:

- Amazon
- VMware: Vblocks to build clouds using VMware infrastructure
- IBM cloudburst
- Juniper.
- 3 Tera
- Rackspace

Platform as a service allows the users to create applications over the internet without licensing any software; being able to do that, PAAS maintains the applications developed through the web interface, scalability, database integration, team collaboration and handling billing and subscription. For example

- Oracle
- IBM: blue cloud computing platform
- Google: enables developing application on data centers
- AT&T
- Microsoft: windows azure
- 3Tera: cloud ware for offering applications
- NetSuite: suit cloud for on demand services

Software as a service is software delivered and deployed over the internet using pay per use model without having to handle any upgrades or patches and offers integration between different pieces of software. For example

- SAP
- Oracle
- salesforce.com: CRM solutions on the cloud
- Google: google applications like google calendar and google docs

2.2. Cloud computing challenges for eHealth

Different challenges should be considered as well when implementing cloud computing for the health.

- Security risk: since he has posts sensitive data usually in the multi sentence environment, information should be monitored as well as the communication between the host company and the end-user. Security concerns may include loss of Control over certain sensitive data and the stored kernels lack of security.
- Integration and transition, it is very hard to integrate the Netflix with a reliable and scalable infrastructure. This also includes the challenges of latency, data transfer and encryption problems. This challenge is especially for developing countries since it needs budget and capabilities to be able to cope with the security needs which as well represent a financial issue for the migration costs.

There are different types of health applications that can be moved to the cloud; Clinical applications consist of EHRs, physician order entry and software for imaging and pharmacy use. Nonclinical applications include revenue cycle management, automatic patient billing, cost accounting, payroll management, and claims management.

Healthcare organizations should consider which applications to move to the cloud or which one to start with. The cloud deployment models (Public, private or hybrid) used could be dictated by the type of applications on the cloud. However, in cases of healthcare private or hybrid clouds are more suitable for the sake of privacy and security of confidential data.

3. Methodology

The study followed a qualitative method in collecting data. Qualitative research provides in depth information and openness with people to explore areas which may not be previously considered. However, it limits the number of people reached and can't be easily generalized. The qualitative interview is a powerful research tool. It is an excellent means of gathering data, and has been used extensively in IS (information systems) research [8].

Table 1. Respondents profiles

Respondents	Informant Position
Res1	lecturer and information systems consultant.
Res 2	Clouduyedia director Egypt and NA (North Africa)
Res3	Network security director at a public hospital
Res4	Consultant Cardiology critical cases and IC at different hospitals (public and private)
Res5	Orthopedic doctor and manager of a private hospital
Res6	Head of cardiology emergency unit in a private hospital and Consultant Cardiology in a public hospital.
Res7	Neurologist Specialist
Res8	Network specialist in a governmental institute
Res9	Network engineer in a network-specialized company
Res10	Lecturer of information systems and Networks

Interviews will enable the researcher to extract more information from the interviewees and thus explore more about the relationships examined. Due to the emergent culture and new nascent nature of the topic, interviews may be needed to collect, explore data and better investigate the topic from various respondents from different backgrounds (Table 1). Interviews followed similar protocols through explaining the topic and purpose of the interview at the beginning of the presentation. Each interview started with rapport building to be able to attain

meaningful information from the interviewees and encourage participation [9]. The research presented several open ended questions in written form. The participants were instructed to describe their work and personal experience with technology and e-health. The questions changed according to the work background of the respondent four instance questions for technological experts were different from the healthcare actors such as doctors. (Appendix A.1 and A.2). The goal of the interviews was to explore the potentials of implementing cloud computing for eHealth in Egypt and the success factors for the implementation. Besides the interviews should discuss the benefits and advantages cloud computing may offer to eHealth sector as a whole and the benefits for the healthcare actors.

The interviews number weren't established in advance, however interviews were done until theoretical saturation was achieved and according to the limitations faced by the researcher.

The review of completed interviews was done to enhance the discussion and improve the quality of data gathered and to check the theoretical saturation by seeing if any new concepts appeared.

Critical Incidents technique

CIT what do you use to gain insights about individual perspectives regarding the challenges and opportunities of the cloud computing in e-health. See IT could provide reach qualitative information about significant incidence from the respondents through their experiences to understand the requirements for individual processes or systems. Given that a complete participants experience in technology and healthcare may encompass many incidents. Therefore, the CIT is deemed as convenient data collection methods through interviewing participants of their experience in their own words which could be positively or negatively memorable or encouraging.

To perform the CIT analysis, some major stages are performed . However, the three stages where divided into the following steps which altogether represents the three stages of CIT; collecting in assembling data, analyzing data in constructing an exploratory framework.

1. Data collection
2. Coding categories
3. Incident classification into categories
4. Trends identification
5. Explanation of underlying themes

4. Data Analysis

This analysis used to the CIT steps to identify the critical incidents in which the participants had technology or e-health experiences. Previous authors suggested that 50 instants are enough for building and over 100 instance could improve the reliability of the categorization [10]. Are the study surpassed the minimum threshold since the sample identified a total of 110 incidents. Categories were then created by developing groups within the instance after sorting the data. The study followed the grounded theory approach which derives trends from incidents themselves. The reliability of the coding analysis was assessed by asking an independent researcher to perform an another coding procedures. The results were compared with above 80% agreement rate. If the agreement is 80% or above, the coding system reliability is deemed as satisfactory [11]. Thus, the data coding for the study was considered reliable and valid.

Table 2. Research qualitative themes results

Theme 1
That cloud computing is a very important topic and can provide a lot of benefits to different sectors. However, challenges like culture, infrastructure as well as security may stand in the way
Theme 2

The private solution should be deployed since in the case of sensitive and governmental solutions, security and privacy are major concerns which can be satisfied with the private solution.

Theme 3

Risk Management and Management support as well as healthcare actors support are one of the main challenges in Egypt and a plan to overcome those must be put in place first.

Theme 4

There is a lack of knowledge, national mission and vision regarding the security of data. Besides, there is the lack of infrastructure.

Theme 5

there are some hospitals that have a healthcare information system to keep their patients' records like some private hospitals and in public like the hospitals related to ministry of interior affairs and ministry of defence or the educational hospitals.

5. Results

To understand the current state of cloud computing in different sectors whether business or eHealth, interviews were carried out with Cloud experts in different organizations. The interviews aimed at understanding how multinational companies and cloud experts perceive the importance of cloud computing generally as well as within the healthcare systems. The interviews discussed the cloud experts' opinions of cloud computing implementation in Egypt, the challenges and the opportunities. Interviewing cloud experts produced a clearer picture of the real life situation and the proactive steps that can be taken to overcome the challenges. The study respondents were provided with a list of questions a few days preceding the meeting to permit time for thought of their responses. The meetings were directed in English mostly, kept going around 60 minutes, and, with the authorization of the members, were sound recorded. The transcripts were inspected through comprehensive examination to recognize, analyze, and report examples or subjects that have risen up out of the information [12].

Examining the interview results, the interviewees agree that cloud for eHealth is very useful and should be deployed however the existing infrastructure is not encouraging and needs to be enhanced (Technological factors). The structure in Egypt has changed in recent years ,however the healthcare sectors and especially the public sector suffer from budget burdens and old technological infrastructure which needs to be renovated in order to cope with the cloud computing infrastructure. In return represents burden on the government budget. Therefore, in order for the healthcare sector to use the cloud computing, technological infrastructure in hospitals needs to be upgraded.

It was deduced that human factors are very important, especially management support which others considered as critical while the healthcare actors 'support comes next. The implementation of cloud computing brings about a change in the way organizations carry out their daily activities. The process of change management is therefore a serious management issue because it will determine the success of the organizations cloud computing implementation

This is supported by:

“Of course there will be different challenges for implementing the cloud in eHealth in Egypt; the culture itself is a challenge as well as the lack of infrastructure and legal laws and security”

“Culture is the major challenge, when we deal with clients they don't understand why the shift, they always say we have our system on premises why shift. They lack the awareness that if they stuck to their system they won't be able to cope with any changes later, while if they used the cloud the scalability will enable them to cope with any technological changes.”

“The implementation of such system in Egypt may actually face a lot of challenges for a start there is no processes or procedures established to implement the system, no skilled employees, especially in the public sector, no infrastructure and no management rules or efficient decision makers.”

“Not at all, doctors aren’t trained to IT technology and no one offers the support to teach them. If this system was to be implemented, a training course must be given to the involved doctors.”

“..... The topic is interesting, but I think it may be impossible to be implemented the whole health care system needs to be enhanced, that’s why doctors may think that the budget to implement the system may be best directed towards the improvement of different hospitals in different districts.”

They also believed that security is very important and it is a vague area for the doctors that need to be addressed carefully. Notwithstanding the potential advantages of cloud computing in e-health administrations, data security is yet sketchy and complex, a security issue have turned out to be progressively confusing in the cloud models and requires extra speculations to actualize data management policies [13] Another concern of shared computing resources within cloud infrastructures is the identity and access management. Modern technology, increase their functionality and accessibility and it introduces additional needs in terms of information security, particularly authentication. Authentication using widely documented PINs is designed as a solution to overcome the fundamental issues that are usable and to secure through biometric-based techniques to user identity [14].

This is supported by:

“Security is the security of data and security of location, therefore there are physical and logical security. The logical security is concerned with the security of data while the physical is concerned with the security of servers, data centers and locations”

“If we are talking about the topic under study, therefore there are many healthcare actors each with his specific needs and views and therefore security isn’t only to access the cloud but also within the different views and privileges. Therefore the private solution is the best model to deploy”

“Security is a challenge is most technologies including the use of the internet, however the challenge here is the lack of infrastructure, knowledge and nation vision and mission regarding the security.”

“Actually, I think that when talking about any computer technology, security is very important. You must make sure that all the data is completely secure and against any breach and hence doctors and patients can use the system while they are worry free.”

Regarding the benefits of the cloud the respondents affirmed the advantages of cloud computing for e-health. This is supported by:

“Implementing this system may be of a great help because if the doctor knows his work will be audited, he will work even harder and even if there are any mistakes we can go back to the doctor and get a right diagnosis or even judge him for the wrong diagnosis which caused problems for the patient.” He also added:

“This is completely legal if the patient approves that and access rights were determined from the beginning.”

“..... If implemented correctly it can lead to a revolution in healthcare imagine getting over all the obstacles we doctors face in our daily work life like trying to guess which medicines the patient take while he is describing the box since he forgot the name, other patients fake some symptoms and others don’t mention they went to another doctor and this is confusing because we have to make sure he has no allergies for the medicines to prescribe or even know his medical records so it is going to save a lot of time and effort and lead to better treatment.” He also added:

“Besides all that, we will have a wealth of health care information so we can have statistics and take proactive plans, as I told you earlier it is a revolution”.

6. Conclusion

This study examined the challenges for cloud computing adoption in eHealth in developing countries. The study also used Egypt as a case study and thereby interviews with cloud experts, doctors and hospital managers were carried out to achieve information saturation. Examining the interview results, the interviewees agree that cloud for eHealth is very useful and should be deployed however the existing infrastructure is not encouraging and needs to be enhanced (Technological factors). They also believed that security is very important and it is a vague area for the doctors that need to be addressed carefully. It was deduced that human factors are very important, especially management support which others considered as critical while the healthcare actors ‘support comes next.

Legal factors were considered as critical and some interviewees talked about the need for new laws to govern the new system if implemented and how this dimension or factor is very important and often neglected.

Risk management was considered critical, however the interviewees noted how this factor is neglected and often forgotten, but as implementing an entirely new system in a large sector assessing and preparing for risks may be essential.

Finally, financial factors were between critical and important. Some viewed the cost as essential in the adoption while others weighted the benefits against the cost and hence considered the cost as important, but not critical.

Therefore, all the interviewees emphasized the importance of the study and the how every factor is important for a successful adoption of cloud in eHealth. All the interviewees showed interest in the study and readiness to use the system in real life.

7. Future Work

The study opens the door for other factors to be examined which may be derived from other research contexts to uncover hidden factors which may influence the cloud adoption in eHealth in developing countries. Additionally, studying the culture of the population and how it influences the adoption of the cloud in eHealth is very important. The population, culture in developing countries tends to fear any services offered from the government that require them to submit personal information. Thus a socio-cultural study should be conducted to further examine the culture of the developing countries and the ways to deal with it and heal the injured pieces of culture to be able to successfully implement the technology and cope with the era they live in. Further studies on security issues should be discussed as well and categorized as local issues related to developing countries and general issues . Besides, ways to overcome the challenges of cloud computing should be discussed extensively.

Appendix A. Interview Questions

A.1. Interview Questions for cloud experts:

1. Are there any plans to implement cloud computing in your company?
2. To what extent have you worked with cloud computing?
3. What are the resources needed for using a community cloud?
4. What about the resources for the country to offer such service?
5. Do you think cloud computing can be useful for eHealth? How?
6. Are there any additional resources if considering cloud for eHealth?
7. What are the challenges which you might think can face Egypt if implementing health cloud?
8. How about the security of data?
9. What is the current state of cloud computing in Egypt from your point of view?
10. What are the factors which may be critical for successful implementation of cloud computing in eHealth in Egypt?
11. Are there any legal laws to protect intellectual property and information on the cloud?
12. How can the cloud vendor be reliable and transparent?
13. Please rate the following success factors:

	Critical	Important	neutral	Not important
Risk management				
Legal laws and compliance				
Cost				
Management support				
Healthcare actors support				
Security				
Infrastructure				
Ease of use				
Service quality				

A.2. Interview questions for hospital managers and doctors:

1. What is the current automation status of public and private hospitals and clinics in Egypt?
2. Do hospitals and clinics use computers in their daily transactions or keep record patient health records?
3. Are there any databases of patient health records?
4. Are doctors trained on IT technology? (Computer/Internet skills and proficiency)
5. Are there any current electronic health services offered to citizens or doctors?
6. Who will have access to the medical records when automation is complete (where relevant)?
7. What is the current automation state in your hospital?
8. If you heard of cloud computing? Do you feel secure about using the cloud for eHealth?
9. Do you think information security affects the successful implementation of eHealth?
10. What are the benefits of using eHealth systems from your perspective? Do you perceive it as useful? How?
11. Would eHealth be easy to use? How?
12. Does it matter from your own perspective if eHealth is on premises or through the cloud? If yes please state why?
13. Are there any laws that govern the security of patients' information?

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