Towards Cloud Adoption in Africa: The Case of Nigeria

Akilu Rilwan Muhammad

Abstract— Advancement in Information and Communications Technologies (ICT) over the years has brought about changes to dynamic business in developed societies. However, due to lack of access to ICT infrastructures, majority of under-developed and developing societies are unable to take advantage of these business opportunities. The advent of cloud computing, a recent shift in computing paradigm presents the potentials for enterprises in under-developed and developing societies to embrace new business models and explore market opportunities, as well as cost effective and delivery of efficient services to government agencies. Despite the promised business benefits of cloud computing to enterprises and government agencies, its successful adoption is full of challenges, requiring in-depth understanding of different technologies and expertise in various domains, of which guidelines are currently inadequate for adoption and building trust. The contribution of this work is to provide clear understating of cloud computing, alongside the drawbacks and challenges for its adoption in the developing economies of African states (the case of Nigeria). Though cloud adoption is foreseeable in the near future, the research sought for convergence of efforts from both government and IT practitioners to overcome the obstacles to its adoption.

Index Terms— Cloud computing, Cloud adoption, Cloud services, Cloud providers.

1 INTRODUCTION

COMPUTING paradigm has witnessed a shift in technological innovations over the past years, from traditional distributed computing to grid computing and more recently the innovation of cloud computing, which is seen as the most significant trend in the IT industry and received attention for the benefits it offers to industries. Enterprises and government agencies such as the US Federal IT are trying hard to adopt this emerging technology to reduce the cost of investment especially on IT infrastructures. Kundra [1] notes that 30cents of each dollar spent on US Federal IT goes on to data center infrastructures, noting that by adopting cloud computing, approximately 30% of the US Government investment on IT would be saved. Cloud computing would screw up IT sector to reshape organizations in ways unforeseen. This shift in computing paradigm has received attention from both IT professionals and academicians with several research works [2], [3], [4] for the adoption of this *on-demand* service.

The adoption of cloud computing technology in developing countries is increasing. Cloud computing has open up ways for greater business opportunity for the developing countries [5], [6]. However, with all the benefits that cloud computing has to offer, its understanding is quite low even among IT professionals in developing societies not alone the decision-makers. IT managers in developing societies need to be educated about the vast opportunity for the adoption of cloud service. Recently, the global cloud computing service providers have given considerable attention to developing economies such as China, India and Brazil [7].

African economy is fast developing and the adoption of cloud computing technology in Nigeria will mark an improvement to the country's economic growth, especially with the recent reports that Nigeria will emerge as Africa's largest economy overtaking South Africa by the year 2025. This paper aims to explore the meaning and benefits of cloud computing to decision-makers and IT managers, to enable decision makers and government agencies take positive decision when planning to adopt the cloud services to boost their business strategies.

1.2 Research Questions

Cloud computing has brought about a number of changes to the IT industry [8]. However, the rate of the adoption of this shift in computing paradigm is low in developing societies especially in Africa. This research therefore, will explore the meaning and benefits of cloud computing and discuss on the following research questions:

- What is cloud computing? And what are the driving forces behind cloud computing?
- What are the benefits for the adoption of cloud services and what factors hinder its adoption in Nigeria?
- What are the factors that decision-makers should consider when deciding to migrates organisation's IT services to cloud?

1.3 Research Aim & Objectives

The main aim of this research work is to understand the thought of IT professionals and decision-makers about cloud computing, draw upon the contexts of the existing literature on previous research, and explore the factors that influence its adoption in Nigeria. To achieve the research aim, the re-

- ***Akilu Rilwan Muhammad*** *is currently a lecturer with the Department of Computer Science, Federal University Dutse, Nigeria. E-mail: akilrilwan@gmail.com*

searcher outlines the following objectives:

1. To examine the concept and trends that bring about cloud computing.
2. To investigate the benefits and drawbacks for the adoption of cloud computing in IT industry.
3. To explore the factors that hinders the adoption of cloud computing in Nigeria.
4. To identify the factors that decision-makers should evaluate in preparation to migrate IT services to cloud.

2 BACKGROUND

The shift in computing paradigm is putting steps forward to address such huge computing power demands, with three (3) technological developments emerging over the past two decades: the *cluster computing*, *grid computing*, and more recently the innovation of *cloud computing*. Cloud computing is envisioned to mark the next generation architecture of IT enterprise, enabled by the notion of virtualization, where high power computing resources from cloud service providers are pooled to consumers over the Internet servicing multiple of consumers, with the underlying infrastructures hidden from the cloud consumer without the consumer's control or knowledge of the resource location (data centers). These virtualized computing resources are characterized by the ability to quickly scale out and to rapidly scale in when released [9] in response to changing consumer needs.

Computing resources will in the near future be consumed as the fifth utility; after water, electricity, gas and telephony [4] providing basic level of computing resources not only to enterprise, but the community as well, to meet individual's daily needs of computing on a *pay-as-you-use* basis.

2.1 The Cloud Roots

The innovation of cloud computing can be traced back to the advancement in various technologies [9] most notably the advances in *hardware technology* (e.g. virtualization and multi-core chips), *systems management* (e.g. data center automation), advances in *Internet technologies* (Web services, service-oriented architecture and Web 2.0) and the notion of *distributed computing* (cluster computing and grid computing). This section examines the shift in these technologies and how they converge and eventually result to the emergence of cloud computing.

2.1.1 Hardware Virtualization

The concept of virtualization dates back to the introduction of virtual machines (an instance of a physical machine) by IBM in 1960s [10]. The notion behind using virtual machines (VM) is that VM enables time and computing resource-sharing (hardware). Thus virtual machines promote reduction of hardware cost and yet improving productivity by allowing multiple users simultaneous access to instance of a computing resource [11]. Hardware virtualization gives users the ability to run multiple software and systems on same physical machine, concealing the detailed characteristics of the physical machine to the users.

2.1.2 Autonomic Computing

The ultimate goal of autonomic computing is the provision of self-managed computing systems *"using the technology to manage technology"* [12], with little or no human interventions to tackle the complexity of systems integration and management, and total cost of ownership (TCO). Autonomic computing is characterized by four significant features: *self-configuration, self-optimization, self-healing,* and *self-protection,* [9]. Autonomic computing depends on the basis of monitored probes and sensors, and the autonomic computing that is equipped with some form automated management function.

2.1.3 Web Services and Service-Oriented Architecture (SOA)

The evolution of Web Services (WS) open standards has particularly contributed to the advances and support for business systems integration. These advances in Web services enable sharing of information between applications that run on different messaging platforms, thus making one application's internal information available to others over the Internet [9]. Web services were developed over existing well-known technologies (HTTP and XML for instance) and hence, are capable for provision of mechanisms to convey services and easier to implement Service-Oriented architecture (SOA).

Service-Oriented Architecture aimed to address requirement of loosely coupled, standard-based and protocol independent distributed computing [13]. The development of Web services enables the production of powerful services supporting ease of access on-demand in a consistent way.

2.1.4 Cluster Computing

Supercomputers have played a leading role for calculation-intensive purposes such as quantum physics and weather forecast applications [14], however, deploying supercomputers to carry out such tasks is not cost effective, thus the development of cluster computing. Computer clusters consist of a group of parallel and distributed computers working closely together to accomplish a task that would normally not be achieved with a single computer. Cluster computers are mostly linked over a fast Local Area Network (LAN). The main advantage of clusters over single computer is the provision for high availability, load-balancing and reduced-cost of deployment [15] compared to deploying a supercomputer. High availability of cluster computers is achieved through the use of redundant nodes such that the nodes can provide for services in the event of system failure.

2.1.5 Grid Computing

Started in the early 1990s, as a result of the need for computing systems to accommodate the then increasing need for very fast calculations and data-intensive scientific applications. The ultimate goal of grid computing is to bring together large distributed compute and storage resources and connect remotely located computers via a large network, thereby eliminating the geographical barriers and ensuring that idle resources are utilize to the best [16]. Thus, grid computing incorporate multiple administrative domains from different geographical locations to solve a single task [15] and are released quickly. The evolution of standard protocols from various grid computing processes provided the conveyance of computing resources over the Internet on-demand [9]. However, the realization of quality of service (QoS) in grids is the major challenge. Grid computing differs from cluster computing in the sense that grid resources are designed to be loosely coupled.

The foregone advances in computing technologies bring about the need for the delivery of *computing-as-a-service*, rather than *computing-as-a-product*. Fig. 1 below depicts the convergence of these technologies and the emergence of cloud computing.

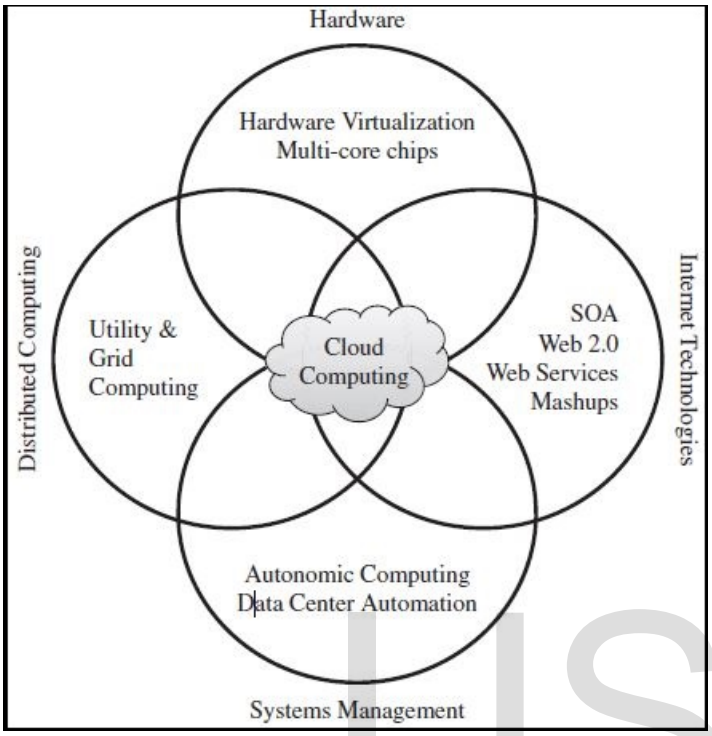

Fig. 1. The emergence of Cloud computing from the advancement in computing technologies. (Source: Voorsluys, Broberg and Buyya 2011)

2.2 Cloud Computing Definition

As cloud computing is fast gaining popularity, a number of researchers have given several definitions of cloud computing [18], [19]. However, the US National Institute of Standards and Technology NIST [20] provides a more comprehensive working definition of cloud computing, which describes cloud computing to have five *(5) essential characteristics*, *three (3) service model*s and *four (4) deployment models*". Cloud computing is closely related to cluster and grid computing [16], however, differs or build upon these technologies in some respects.

2.2.1 Cloud Computing Characteristics

According to the NIST definition of cloud computing, the cloud model promotes the availability of the following five (5) characteristics.

1. *On-demand self-service:* that is the provision of computing facilities to consumers (e.g server time and network storage) automatically as when they need it, without need for human interaction with cloud service providers.
2. *Broad network access:* this enables applications be accessed through a heterogeneous platforms (such as mobile phones, PCs, & PDAs)
3. *Resource pooling:* location independent pooling of computing resources for serving multiple consumers in a multi-tenant fashion, these resources are assigned and reassigned to consumer dynamically according to their demand, without the consumer having control or knowledge about the location of the provided resources.
4. *Rapid elasticity:* allows for scalability of the services provided, (which often appear to be unlimited) to *quickly scale out* and released to *quickly scale in.*
5. *Measured Service:* cloud computing provide automatic control and optimized resource use, metered in a pay-per-service use manner for the type of service provided. Resources used are thus monitored and control providing transparency to both provider and consumer.

2.2.2 The Cloud Services Models

Cloud computing service model refers to the type of service that cloud providers deliver to the consumers. Cloud computing basically provides the following three (3) service models.

1. *Software as a Service (SaaS):* the provision of software applications to customers by the cloud service providers typically running on the provider's infrastructures. The customer need not install the application on local machine, instead accessed the application via web browsers, thus save customer from purchasing the application, or be concern about future upgrades. Good examples of SaaS providers include Rackspace, Google Apps and Saleforce.com.
2. *Platform as a Service (PaaS):* this involves delivering to the customer the ability to create and deploy owned application using programming languages and tools from the provider's cloud infrastructures, such as servers, network and operating system, without the customer taking full control of the underlying infrastructures. Well known examples of PaaS providers include Google App Engine and Microsoft Windows Azure.
3. *Infrastructure as a Service (IaaS):* provisioning of fundamental computing resources such that customer can run own application, or store data to cloud provider's infrastructures in a manner that the customer has control of owned application, operating system or stored data. IaaS service providers include Amazon EC2 and GoGrid.

2.2.3 Cloud deployment model

The NIST definition identifies four (4) models of cloud computing deployment [20]. These models according to NIST include:

1. *Private cloud:* this is a type of cloud deployment model that is operated by an organization, although might be managed by third party.
2. *Community cloud:* this is a type of cloud infrastructure that is shared by many organizations.
3. *Public cloud:* is a cloud computing deployment model in which infrastructures is made available to general public.
4. *Hybrid cloud:* this deployment model consist of two or

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more type of the above models.

2.3 Cloud Computing: Today and the Future

Technological innovation and development is often associated with two key fundamental dynamics: 1) transformation power, and 2) the urge for critical examination of existing models in that field [1]. To a large extent, cloud computing has brought along with it a number of issues worth to be address as the technology ripe. Most importantly, is striking a balance between data security, privacy and intellectual property, as well as ensuring global harmony of cloud standardizations.

Although cloud computing is seen to be a technology that is not yet matured, a significant number of cloud services especially SaaS are in used, without the users realizing that is based on cloud technology [21]. A survey of technology experts and stakeholders predicts that by 2020 majority of users will be accessing software and information exchange online and applications running from Smartphone using remote servers instead of investing and depending on installed application running on their PCs [22].

Notwithstanding, cloud computing is not a threat to traditional desktop computing. To support this, Jackson and Philpott [22] recognize that traditional desktop computing will be enhanced in a manner driven by remote computing (desktop-cloud hybrid) doing much of the task locally and utilizing the cloud for computing-intensive mission.

2.3.1 Business Benefits

In spite of its possible security and privacy concerns, cloud computing has the potentials to accelerate business strategies to both the public sector (enterprise) and government agencies. Table 1 summarizes the major benefits of cloud computing to business.

Business benefits of Cloud computing.

IT Costs	Greatly cut down the cost of IT savings enterprise spend on IT infrastructures (*pay-as-you-use).*
Focus on IT Shift	Clients need not worry about technological shift such as server updates and software upgrades.
Increased Storage	Enterprise has access to large elastic computing storage facilities.
Highly Automated	Ability to scale up and down in response to clients' need without providers interventions.
Flexibility	Offers more flexibility than traditional computing.
Mobility	Clients have access to data anywhere, easily accessed from variety of devices.

3 RESEARCH METHODOLOGY

In order to achieve the research objectives set out in Section 1.3, the researcher employs both quantitative and qualitative approaches. The two approaches were employed in the research process to complement each other [23] p.151, enabling the researcher to gather hard data earlier on, to serve as input in collecting soft data. The survey was administered online over a period of three weeks, using *Google Docs Form*. A total of 109 survey invitations were sent through email and 45 people responded to the survey invitations. Thus, the survey questionnaires received 41.3% responses from IT professionals working either in IT firms, employed in IT department of organisations or are actively involved in research and graduate studies in IT mostly from universities in Nigeria, the UK and Middle East. 80% of the respondents indicated interest to participate in the next stage of the research (interview).

3.1 Participants

The participants involved in the research were drawn from two categories: 1) IT professionals working in either IT firm as CEO, Business Executives or Technical Officers (in Nigeria) with years of IT experience; or IT professionals employed in organisations' IT department, mostly telecommunications companies, 2) IT professionals currently involved in research and graduate studies from universities in Nigeria, the UK, and Middle East. Table 2 shows participants' years of IT experience.

TABLE 1

TABLE 2

Participants' years of IT experience.

Age Range	Frequency	Percentage
Less than 5 years	12	26.7%
6 - 10 yrs	18	40.0%
11 - 15 yrs	6	13.3%
16 - 20 yrs	0	0.0%
21 - 30 yrs	6	13.3%
31 - 40 yrs	3	6.7%
Above 40 yrs	0	0.0%

3.2 Data Collection

The primary data used for the conduct of the research are: questionnaire and interview. The questionnaire (Appendix A) was administered online using *Google Docs Form.* The interview on the other hand was also conducted online, making use of the Interview Guide (Appendix B) and a digital voice recorder. Moreover, Skype, a free video/voice internet call software was used to conduct the interview sessions. The proceeding of the interview sessions was then recorded using the digital voice recorder to ease with data analysis.

4 RESULTS AND DISCUSSIONS

4.1 Questionnaire

The survey questionnaire made up of 20 questions was designed to understand the participants': 1) knowledge of various technologies that form the bedrock of cloud computing, 2) perceptions of cloud computing and its adoption in Nigeria. Tables 3 and 4 depict a summary of the survey findings.

TABLE 3
Participants' knowledge of cloud-related technologies and service models

	Technology/service model	frequency
Cloud-related technologies	Virtualization	33
	Cluster computing	27
	Grid computing	21
	SOA	18
	Web 2.0	21
Cloud services	IaaS	39
	Paas	30
	SaaS	42

TABLE 4
Participants' perceptions about cloud computing

	response	Percentage (%)
Reduced cost of IT infrastructure	Very Important	73.3
	Important	26.7
Infrastructure scalability	Very Important	80.0
	Important	13.3
	Don't know	6.7
Cloud service providers' support	Very Important	53.3
	Important	40.0
	Less Important	6.7
Cloud adoption in Nigeria	Absolutely Possible	6.7
	Quite Possible	53.3
	Maybe Possible	13.3
	Not Possible	20.0
	Not Sure	6.7

4.2 Interview

An interview was conducted among ten interviewees selected from the survey participants based on their years of experience in IT and relevance of workplace. The interview guide focuses on determining interviewees' perceptions towards slow adoption of cloud computing in Nigeria. Results from the interview are summarized in the following subsections.

4.2.1 Lack of in-depth understanding of Cloud technologies

The rate of adoption of innovation is affected to a large extent by level of knowledge and recognition. Most of the respondents (interviewees) labelled the lack of in-depth understanding of cloud computing and cloud related technologies among IT practitioners as barriers to its adoption.

4.2.2 Inadequate power supply and internet accessibility

According to the results, respondents attributed the inadequate supply of electricity as a major factor to determine the successful adoption and implementation of cloud computing in the present state of the country's IT industry. This was perceived by participants to be responsible for the poor growth of IT industry in general and the inefficient internet services.

4.2.3 Fear of unknown and building trust

One of the major hindrances to the adoption of cloud computing is building trust for organisations outsourcing their data and security intensive resources over the hand of cloud providers or a third-party. Moreover, respondents' perception towards the security issues and trust in services offered poses fear of known and security breach even among IT professionals.

4.2.4 Legal framework for data protection & cyber crimes

Respondents reflected upon the need for legal framework for data protection and addressing the issue of cyber crimes, and how such framework can help IT industry towards the development of cloud computing. However, there is an argument about how the framework should be drawn to tackle the drawback in the growth of IT industry. Some of the respond-

ents consider that government should be responsible to enact appropriate law addressing the problems, others consider it a proper collaboration of the country's IT industry leaders to promote the level of trust in cloud computing among potential adopters

5 Conclusion

The adoption of cloud computing in the enterprises particularly organisations and government agencies in developing countries is a major challenge. Cloud computing is a recent innovation in computing technology and still under development. Though it received considerable attention of research in industrialized countries, and envisioned to be the next generation architecture of IT enterprise, its understanding and recognition is quite low even among IT practitioners in developing countries, this eventually leads to organisations and government agencies not exploring its full benefits.
Quantitative and qualitative approaches were employed in the research process to explore the factors responsible for slow adoption of cloud computing, data were collected and analysed and the findings led to the conclusion that though cloud adoption is foreseeable in near future, efforts are required from both government and IT service providers to overcome the obstacles to its adoption.

6 End Sections

6.1Appendices

6.1.1 Appendix A: Survey Questionnaire

Dear Respondent,

This is a research survey about the adoption of cloud computing in Nigeria. Please be informed that this survey questions are meant for research purposes only, neither your name nor your organisation will be part of this publication. Data collected for this survey will be used for research purposes only, as in accordance with the provision of section ISI, 4.5, 1985, of the International Statistical Institute (ISI Declaration on Professional Ethics, July 2010).

Thank you.
* Required

PERSONAL BACKGROUND.

1. Which of the following best describe your age group? *
   - 18 - 25 years.
   - 26 - 30 years.
   - 31 - 35 years.
   - 36 - 40 years
   - Above 40 years.
   - Prefer not to say.

2. Which of the following best describes your years of experience in IT? *
   - Less than 5 years.
   - 6 - 10 years.
   - 11 - 15 years.
   - 16 - 20 years.
   - 21 - 30 years.
   - 31 - 40 years.
   - Over 40 years.

3. Do you have any idea about Cloud computing? *

   Yes. No.

   Continue >>

Yes, I know about Cloud computing.

4. Which of the following technologies do you understand best? (Select all that apply) *
   - Virtualization.
   - Cluster computing.
   - Grid computing
   - Service-Oriented Architecture (SOA)
   - Web 2.0

5. Which of the following cloud services are you aware of? (Select all that apply) *
   - Infrastructure-as-a-Service (IaaS).
   - Platform-as-a-Service (PaaS).
   - Software-as-a-Service (SaaS).

6. What is your opinion about cloud computing? *
   - Quite Interested.
   - Beneficial.
   - A hype of technology.
   - Immature technology.
   - Unsecured technology.
   - Totally NOT interested.

HOW IMPORTANT TO YOU ARE THE FOLLOWINGS CONCERNING THE ADOPTION OF CLOUD SERVICES?

6. Reduced cost of IT infrastructure? *
   - Very important.
   - Important.
   - Don't know.
   - Less important.
   - Not important.

8. Scalability of IT infrastructure (up and down) in response to changing customer demand? *
   - Very important.
   - Important
   - Don't know.
   - Less important.

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- Not important.

9. Client data and applications security? *

- Very important.
- Important.
- Don't know.
- Less important.
- Not important.

10. Service availability? *

- Very important.
- Important.
- Don't know.
- Less important.
- Not important.

11. Cloud provider's support? *

- Very important.
- Important.
- Don't know.
- Less important.
- Not important.

12. In your opinion, state any three (3) factors you consider most significant to be the obstacles for the adoption of Cloud services in Nigeria. *

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13. Do you see the possibility of implementing Cloud services without getting rid of these obstacles (mentioned above)? *

- Absolutely possible.
- Quite possible.
- No Idea.
- Maybe possible.
- Absolutely NOT possible.

14. As an IT professional, do you consider Cloud services appropriate and fit for Nigerian IT Industry as at present? *

- Absolutely appropriate.
- Quite appropriate.
- No Idea.
- Maybe appropriate.
- Absolutely NOT appropriate.

15. Which Cloud service would you advise them to adopt first? *

- Infrastructure-as-a-Service (IaaS).
- Platform-as-a-Service (PaaS).
- Software-as-a-Service (SaaS).
- None of the above.

16. Why would you suggest the above service to be adopted first?

……

17. Do you think "Cloud computing" is an evolving concept that will mature soon? *

- Yes.
- No.
- Not sure.

18. Do you agree with the quote "Cloud computing will be the next generation architecture of IT Enterprise"? *

- Strongly agree.
- Agree.
- Don't know
- Disagree.
- Strongly disagree.

19. Overall, what is your opinion about Cloud adoption in Nigerian IT Industry? *

- Highly concerned.
- Concerned.
- Don't know.
- Less concerned.
- Not concerned.

20. Please leave your comment (if any) on what you think about Cloud adoption in Nigerian IT Industry.

……

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6.1.2 Appendix B: Interview Guide

Q1. Briefly describe your understanding and meaning of the followings:

- Software-as-a-Service (SaaS)
- Platform-as-a-Service (PaaS)
- Infrastructure-as-a-Service (IaaS).

Q2. Considering the possibility of Cloud adoption, what type of service would your company adopt first?

- Software-as-a-Service (SaaS) e.g. Google Docs and Gmail.
- Platform-as-a-Service (PaaS) e.g. Google App Engine and Salesforce CRM
- Infrastructure-as-a-Service (IaaS) e.g. Amazon EC2.

Q3. Should your company plan to adopt Cloud services:

(i) What are the risks you might want to draw management attention to?

(ii) What are the perceived benefits to the operations of the company?

Q4. Highlight the internal factors the company need to consider to adopt Cloud computing.

Q5. In your opinion, how would Cloud computing affect the competition in marketplace of IT industry?

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