

Evaluating Cloud Computing Challenges for Non-Expert Decision-Makers

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ABSTRACT

Non-expert managers in various types of organizations usually find it challenging to decide whether to adopt cloud computing services, which are internet-based, instead of the conventional in-house technologies, which are physically owned and controlled on-premises. This paper evaluates cloud computing management challenges that were selected and ranked by a number of non-expert managers through a decision-making survey. The outcome argues that the Urgent Support Availability aspect is selected as the most worrying factor amongst the majority of non-expert managers taking into account the associated cost, and future demand changes. In addition, multiple decision-making considerations are identified through a cloud utilization framework and evaluated from a non-expert management perspective in relation to performance, network reliability, integration, quality of service, and actual business benefits.

KEYWORDS

Cloud Computing, Challenges, Decision Making, ICT Management, Non-expert.

1. INTRODUCTION

A basic definition of cloud computing for non-expert clients is the use of the Internet for the tasks performed on computers. The Cloud here represents the Internet. Virtualization of processing power, storage, and networking applications via cloud computing platforms allows

organizations to operate heavy demand computing resources off-premises. While this approach reduces in-house costs and energy use, recent case-studies have highlighted complexities in the decision-making process associated with implementing various models of cloud computing. This complexity is due to the rapid evolvement of these technologies without standardization of approach by today's top providers. In addition, the difficulty of understanding and predicting ICT demand growth in organizations has caused managers not to take advantage appropriately of the cost-saving factor which accompanies cloud computing as marketed by top providers.

Non-expert managers look at cloud computing as the process of taking the services and tasks performed by computers and bringing them to the web. To a large extent this is correct. However, cloud computing technologies offer a wider range of processing, networking, and storage capabilities which assist organizations in performing many heavy or small ICT tasks at the cloud providers' datacenters. This is mostly achieved through on-demand, remotely-controlled, scalable, and pay-as-you-go approaches. In many cases, conventional in-house methods were observed not as cost-effective as current cloud-based services. Nevertheless, several challenges were observed in the long-run due to management aspects which can be summarized as follows: [1]

- Improper analysis of the organization's actual ICT requirements

- Unclear contracts with the cloud provider
- Unreliable internet performance which affects the entire cloud service-delivery process
- Security considerations and data integrity issues regarding the methods in which the cloud providers handle access to resources, store data, and secure the virtualized server infrastructure.

The above aspects can result in additional expenses and management complexities in the long-term as will be discussed in this paper. The different models and techniques of cloud computing deployments and services have a significant impact on the decision-making process in any organization's ICT environment. This paper discusses various management challenges of cloud computing, which were voted as most relevant by a number of non-expert managers through a risk-analysis survey. The outcome is analyzed against present decision-making considerations regarding the adoption of different types of cloud computing services. The study highlights non-expert clients as key users of the outcomes from this project given the diverse work objectives across today's organizations.

The structure of this paper is divided as follows: Section 2 will introduce briefly a background on cloud computing from the perspective of non-expert clients. In Section 3, a brief literature review will be discussed regarding cloud computing challenges and end-user potential risks. Section 4 will evaluate the client-cloud computing management challenges regarding the three cloud service delivery models (IaaS, PaaS, and SaaS). In Section 5, the selected client-cloud computing management challenges will be analyzed through a decision-making risk-analysis survey which targeted 54 non-expert management-level users. Following this, the paper will analyze data results and evaluate the outcome of the survey in relation to previously stated decision-making aspects. Section 6 will discuss a decision-making framework to potentially overcome the earlier challenges. At the end, conclusions and future works are listed.

2. BACKGROUND

Whether ICT clients realize it or not, cloud computing services are being used on a daily basis and for a long period of time. For example, internet email accounts, social networks, GPS locations, and numerous other forms of online data storage and sharing are constantly being accessed by millions of users worldwide [2]. These services are supplied by ICT providers that own virtualized datacenters for end-users to access through the Internet. In general terms, cloud-computing is a ubiquitous platform which provides on-demand ICT services through either the public Internet, or other privately-managed and secure tunneling networks like Virtual Private Networks (VPN) [3]. The Cloud concept came to life mainly because of the growing ICT requirements in almost each industry, which were not being fulfilled through previous models due to costly services and complex management procedures. However, multiple tradeoffs and challenges have risen as a result of the rapid evolvement of these technologies, while other challenges have remained from previous ICT models.

Several cloud computing scientists and organizations have identified different characteristics, service-delivery models, architectural types, and legal aspects of a system necessary to support cloud computing. According to the NIST definition of cloud computing concepts, five essential characteristics were necessary: On-Demand Self Service, Broad Network Access, Resource Pooling, Rapid Elasticity, and Measured Services [4]. In addition, experts from The Cloud Security Alliance have identified a sixth cloud characteristic and named it Multi Tenancy [5]. Furthermore, another client-cloud computing characteristic was widely discussed by many organizations is the Economy of Scale [6], which indicates the distributed manner of computing access and sharing of resources across the cloud. This characteristic is significant to this paper given the security considerations needed for non-expert clients to evaluate before signing contracts with the cloud provider.

Cloud computing hosting models were divided into four interrelated models as follows:

- **Public:** Cloud providers offer a full range of computing services via online means, which enables organizations to outsource the entire ICT infrastructure into the cloud.
- **Private:** Organizations operate either on-site, exclusively managed, or via a third-party outsourced cloud, or a combination of both.
- **Community:** Multiple organizations with similar operational goals and security policies, share the same virtual ICT services and platform, which can be managed by one of the above, a third-party, or a combination of all.
- **Hybrid:** Often the most preferable cloud deployment method for end-users, as it ensures additional management flexibilities regarding security, risk elimination, information systems portability, and better standardization. The hybrid solution offers a mixture of various sub-components from previous deployment approaches. In particular, this model irrespectively combines the technical and nontechnical aspects from Private, Public and Community models [7].

Moreover, client-cloud computing potential benefits extend beyond obtaining cost reductions and management flexibility. On this note, multiple energy saving characteristics were pointed out by academics and service providers given that ICT virtualization can have a significant potential for eliminating plugged-in equipment, thus minimizing associated electricity consumption, space and management. The Green characteristics of cloud computing are summarized as follows: [8] [9].

- **Dynamic Provisioning:** The ability to reduce unwanted cloud computing components through better matching of server capacity with actual clients' demand.
- **Multi-Tenancy:** The ability to normalize and flatten unmeasured peak loads by serving large numbers of clients on a shared hosting infrastructure.
- **Server Utilization:** The ability to operate servers at higher utilization rates via virtualization techniques.

- **Data Center Efficiency:** The ability to use advanced datacenter features which reduce the overall power loss through improved methods of power conditioning, air cooling, and other methods.

3. LITERATURE REVIEW

According to Carrenza and HP, upgrading an existing ICT system for three consecutive years is more costly than the system itself. This was studied on applying intensive cloud solutions for several large organizations across the United Kingdom [10]. As a result, these providers identified several vital security aspects related to the concept of virtualization in which non-expert users must thoroughly understand before outsourcing their critical business applications onto the cloud. On that ground, several reliability concerns were raised by clients after adopting software, platform, or infrastructure cloud services for at least a 1-year lifecycle.

One report argued that a slower pace of virtual ICT adoption is currently spreading across large organizations, simultaneously with the rapid evolution of cloud techniques [11]. These risks were argued to range from technical, management, all the way to legal aspects of ICT employment. Furthermore, numerous standards for specific industries were argued to be missing regarding optimizing the way in which cloud services are disparately purchased, supported, and governed.

One of the major issues in standardizing cloud computing is the large range of different purchase standards and technical definitions. Currently, these were estimated to reach nearly 160 different definitions around the world [12]. These standards began developing in 1999 when Salesforce introduced the first online-based application [13].

A number of definitions and standards of cloud computing were published by top ICT providers such as Cisco, Microsoft and IBM. Many academics and papers stated that these cloud standards are developed inaccurately given that ICT providers usually tend to market their services in order to increase sales against other competitors

[14]. These actions cause decision-making challenges for non-expert clients as will be discussed in the next section.

Other general assumptions were arguing for the outsourcing of non-core ICT capacity into a third-party provider that owns the infrastructure. However, numerous growth-limiting barriers were explored concerning knowledge sharing and data breach risks [15]. Adopting a fully outsourced cloud computing solution is currently considered an unfavorable decision by most non-expert managers given the uncertainty of private data whereabouts and many other considerations related to less control over owned resources [16].

Other concerns regarding credibility and authenticity of cloud services were observed among managers from different organizations. According to a survey by the IDC Enterprise Panel in 2009, the following barriers were identified and rated depending on the level of concern in contrast to the acceptance percentages attained from purchasing on-demand cloud benefits (Figure 1) [17].

4. EVALUATION OF CLIENT-CLOUD MANAGEMENT CHALLENGES

With regard to the three primary service layers of cloud computing (SaaS, IaaS, and PaaS), the following table was constructed to evaluate the reliability and security challenges from the perspective of non-expert clients and in relation to each cloud layer separately (Table 1).

Many ICT providers are currently analyzing the adoption patterns in which their clients are turning towards cloud computing [18]. Their objective behind this analysis is essentially to identify the key concerns and challenges regarding why many clients are still reluctant to adopt cloud computing services for businesses and heavy ICT tasks. The following section presents a risk-analysis survey which addresses the point of view of 54 non-expert decision-makers from different specialties.

5. SURVEY-BASED EVALUATION FOR NON-EXPERT MANAGERS

This paper conducted a risk-analysis survey which targeted 54 non-expert management-level personnel from different organizations. The purpose was to collect data on cloud computing tradeoffs and management risks by following the viewpoint of non-expert decision makers across different types of industries. This survey includes a single rating-scale question which offers 5 multi-choices as available answers.

The Likert approach was selected for this survey given the nature of opposing opinions among different non-expert managers [19]. This was identified by this study from observing different ICT management aspects, such as the degree of concern towards the utilization of novel technologies among managers with medium-level technical background.

Table 1. Evaluation of Client-Cloud Computing Management Challenges regarding each Service-Layer

Cloud Model	Description	Example	Evaluations of Challenges
SaaS (Software as a Service)	Users access applications via network-hosted infrastructure like the Internet or VPN (e.g. Gmail).	Gmail, Blogger, Cisco WebEx, Flickr, Windows Live Meeting, Windows Office Live	Given that SaaS is mostly offered free of charge, or accompanied as an additional service with larger paid solution, Software is not installed on the users' servers or personal PCs. Therefore, access can occur strictly on-demand. As a result, only confined functionalities, selected configuration, service availability issues, and limited control of programs -to underlying ICT developments- are provided by the provider following the SaaS approach.
IaaS (Platform as a Service)	Clients develop software via a fully network-hosted platform	Force.com (development platform), GoGrid, Facebook Developers	Underlying cloud solutions, in addition to several dependencies like storage, network, servers and operating systems, are not controlled by the service-requester. However, more control is available than the SaaS model, as the main IT environment in the PaaS approach is considered <i>Closed</i> or <i>Contained</i> [20]. Nevertheless, availability restrictions are still considered a trade-off for managers against the traditional physically-owned ICT infrastructure.
PaaS (Infrastructure as a Service)	The Cloud provider rents out hardware, software, networking bandwidth, processing power, or data storage via virtual, on-demand accessing policies	Amazon EC2, IBM Cloud-works, Windows Azure	Even though non-expert managers have, to some degree, the ability to control, deploy, and run user-created programs such as operating systems, privately developed software, and networking components, however, the underlying cloud solution, is again, primarily managed by the cloud provider. Therefore, security access of information, user-group permissions and other administrative dependencies are all identified as management concerns.

(Scale: 1 = Not at all concerned 5 = Very concerned)

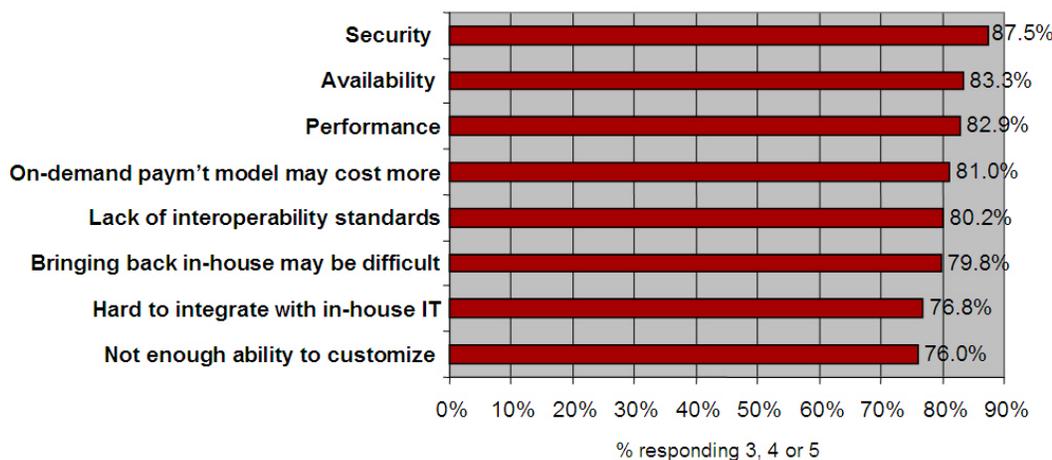


Figure 1. A 2009 Survey on Cloud Computing Management Concerns

The survey attempts to reflect the diverse attitude of these managers towards ICT budget acceptance, sustainability readiness, change management, and other organizational aspects [21]. The rating-scale survey was conducted via the popular online provider: Survey-Monkey. Furthermore, this survey was not structured to target a specific audience from a particular industry given that each relates to a different specialty and work nature, hence, is subject to dissimilar ICT requirements.

At first, we asked 54 decision-makers to select 12 statements of cloud computing adoption risks and challenges whereby in their opinion are most relevant to their organization. These were picked from a bigger pool of ICT risk statements and cloud adoption challenges which were picked from previous surveys and literature. We then asked the interviewees to rank those 12 categories according to their organization's priority by selecting one of five multi-choices which reflect five levels of concern. Table 2 presents the answers and the calculated percentages of the total ranking regarding each risk category. In addition, Figure 2 presents the completed survey findings via a bar chart, which was generated via Microsoft Excel from data inputs of Table 2.

It can be observed that the *Urgent Support Availability* aspect was classified as the most worrying factor among non-expert managers. This was demonstrated with a 4.13 average rate out of 54 participants in contrast to the rest of the statements. The *Government Hosting Regulations* came as the lowest concern and only received an average of 2.24. The two price-associated factors: *Unpredictable Costs in the Future* and *The 'on-demand' payment method of cloud computing might actually cost more than the traditional approach*; both came at positions 3 and 4 in order. In addition, the *security* risk category landed as the second most worrying aspect following *the rapid delivery of unpredictable maintenance*.

As mentioned earlier, given that the science of cloud computing is evolving at a faster pace than most of the other services provided by

various industries, it is important to identify the patterns and changes in collecting data results when performing similar surveys across time. This risk-analysis survey was intended to illustrate a relatively different viewpoint of earlier cloud computing surveys. For instance, the IDC survey in 2009, which was discussed in the literature review section previously, has covered slightly different risk categories of cloud computing. The IDC survey results have shown obvious differences in comparison to this paper's survey. For example, both *Security* and *Availability* aspects have received the highest ranking in terms of end-users' concerns. On the other hand, this paper identified the *Support* and *Unpredictable Future Costs* aspects as the highest worrying factors among managers. Moreover, while most surveys addresses operational and administrative issues of cloud computing regarding the control and access of resources, this survey has restricted the range of audience to management-level users with only a medium or low technical background.

It can be concluded from the previous survey that most non-expert managers have similar concerns when it comes to unforeseeable long-term costs, contract management issues, performance difficulties, and integration with conventional systems. This was concluded as a result of selecting different companies with various ICT processes and applications as an audience to measure cloud computing decision-making challenges. In theory, each concern was addressed based on current ICT limitations observed by these managers within their organizations. On that account, a future research work can be suggested at this point to develop an automated filtering and comparison rule, which compares each of the previous cloud computing risk statements against the *Urgent Support Availability*. This can potentially support previous findings by highlighting the *Unpredictable Maintenance Delivery* as the most worrying aspect of different organizations' existing cloud solutions.

Table 2. Risk Analysis Survey Results

Level of Concern	Not worried at all	Slightly Worried	I don't mind	I am more worried	Extremely worried	Total Number of Participants	Average Rating
Cloud Risk Category							
Government hosting regulations	46.30%	12.96%	18.52%	14.81	7.41%	54	2.24
Difficulties in going back to old hosting methods	28.85%	28.85%	26.92%	15.38%	0%	52	2.29
Unknown hosting locations	35.19%	16.67%	27.78%	16.67%	3.70%	54	2.37
Integration difficulties between the cloud and existing systems supplied by different vendors	15.38%	28.85%	26.92%	28.85%	0%	52	2.69
A complete service shutdown	3.92%	43.14%	17.65%	15.69%	19.61%	51	3.04
Contract management issues	7.55%	32.08%	15.09%	32.08%	13.21%	53	3.11
Performance issues	1.85%	33.33%	9.26%	50%	5.56%	54	3.24
Control over resources	1.89%	28.30%	9.43%	47.17%	13.21%	53	3.42
The 'on-demand' payment method of cloud computing might cost more than the traditional approach	5.66%	13.21%	3.77%	56.60%	20.75%	53	3.74
Unpredictable costs in the future	3.70%	14.81%	3.70%	55.56%	22.22%	54	3.78
Security (Data, access, permissions, sharing)	1.85%	16.67%	5.56%	46.30%	29.63%	54	3.85
Urgent support availability	0%	7.41%	7.41%	50%	35.19%	54	4.13

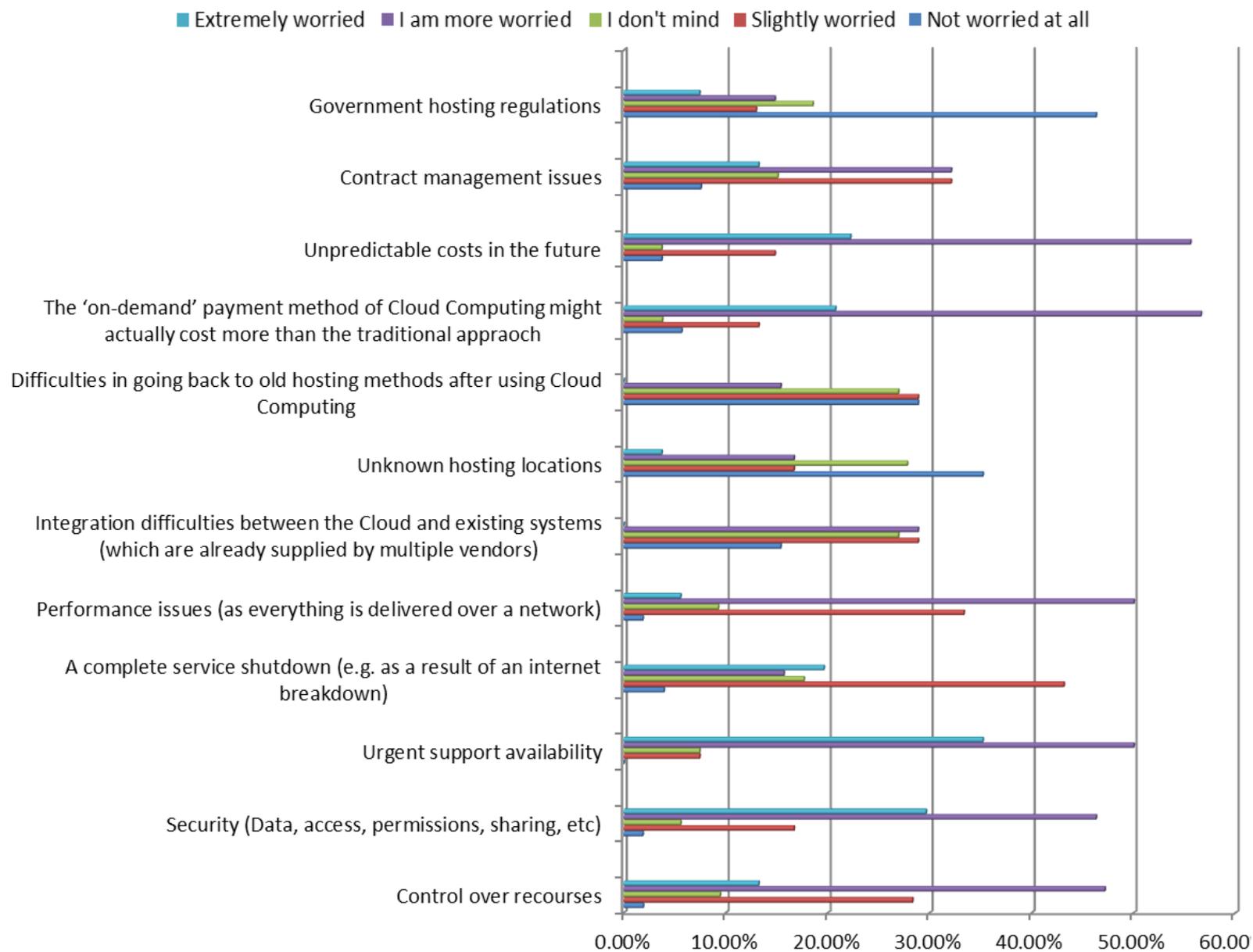


Figure 2. Survey Analysis: Microsoft Excel Representation of End-Users' Inputs

5.1 Summary of Results

The main objective of the earlier risk-analysis survey is to evaluate the level of concern of non-expert ICT clients towards cloud computing management and deployment. In conclusion, the previous collected data can be summarized in the following categories in relation to the highlighted cloud computing decision-making challenges:

Security and Privacy: According to IBM, the data security and privacy concerns rank top on almost all types of surveys [22]. On this account, cloud computing introduces another level of risk given that essential services are often outsourced to a third party, which makes the management process more challenging to demonstrate compliance, maintain data integrity, ensure privacy, support and service availability.

Actual Business Benefits: Most of today's non-expert managers are not convinced of the potential cost benefit of cloud computing. According to Netflix, in some heavy-scaling demand cases, cloud computing can be more costly than the conventional ICT approaches [23]. This can be determined in-house through a thorough identification of the organization's exact ICT requirements before adopting any models of cloud computing.

Furthermore, as noted from the earlier survey, one of the main concerns by managers is to realize the investment requisites to full potential, which adds value by making the cloud computing services part of their mainstream ICT portfolio. IBM argued that the return on investment (ROI) on utilizing cloud resources must be accomplished and verified by comparing certain management metrics of traditional ICT with cloud computing services [22]. As a result, this comparison will illustrate savings on future costs, which can lead to revenue, reduction in management effort and time, compliance, and better assessment of the

organization's ICT workload and changes in demands.

Support and Service Quality: As can be viewed in the previous survey, Service quality is one of the biggest factors that non-expert managers highlighted as a challenge against outsourcing their ICT environments and business applications onto the cloud. On that ground, if the cloud providers' Service Level Agreements (SLAs) are not sufficient to guarantee the requirements for deploying applications on the cloud, then in most cases, these non-expert users need to ensure their contracts states that the provider will cover business loss for the amount of time the service was unavailable. These considerations are especially highlighted against the availability, performance and scalability sections in the contract with the cloud providers. Most of today's cloud computing contracts include a limited guarantee on service quality assurances. As a result, managers are reluctant to outsource their critical business infrastructure to the service providers' cloud datacenters.

Integration: Most organizations own legacy systems which require integration with specific types of cloud computing systems when outsourcing part of their applications onto the cloud. These applications usually have complex integration requirements to interact with other cloud or in-house systems. Non-expert managers often sense that in terms of cost, effort, and time it is challenging from a technical and administrative perspectives to complete any needed integration with cloud-based systems. As a result, in many cases these managers would rather upgrade and invest more on existing in-house technologies. On this note, a proper evaluation of the cloud contract with the provider must be thoroughly examined given that most organizations have a major requirement to integrate cloud applications with the rest of the company's systems in a quick, easily-managed, and cost-efficient manner.

Performance: Most of today's cloud business applications require intensive bandwidth and a reliable internet connection whether delivered via software, platform or infrastructure cloud solutions. Cloud computing providers usually inform clients before signing any contracts that the performance of delivering complex services through the cloud is going to be unpredictable if the network bandwidth is not reliable and adequate. Therefore, as pointed out earlier, it has been observed that the majority of non-expert managers prefer to hold off any cloud outsourcing until an improved bandwidth with lower costs is made available by their organizations.

6. DECISION-MAKING FRAMEWORK

As discussed earlier, the delivery nature and characteristics of the current cloud computing services are constantly changing by top ICT providers without a unified standardization of their services. This was observed to result in gaps and unclear contracts between non-expert clients and the service providers regarding support, future costs, and other management concerns as discussed in the previous survey. This makes the management of cloud computing cost strategies, contracts, and resource control a difficult task across different sizes and types of organizations that employ ICT systems.

This paper has constructed a decision-making framework in order to assist non-expert clients in minimizing cloud computing potential threats to their in-house ICT management. The objective is to reduce deployment tradeoffs and support the decision-making process before outsourcing any core business applications onto a cloud computing platform. Another purpose of this framework is to assist non-expert managers to make effective decisions to minimize expenses and achieve a sustainable cloud computing environment with minimum management effort. The next section will

discuss each stage of the decision-making framework separately as follows (Figure 3).

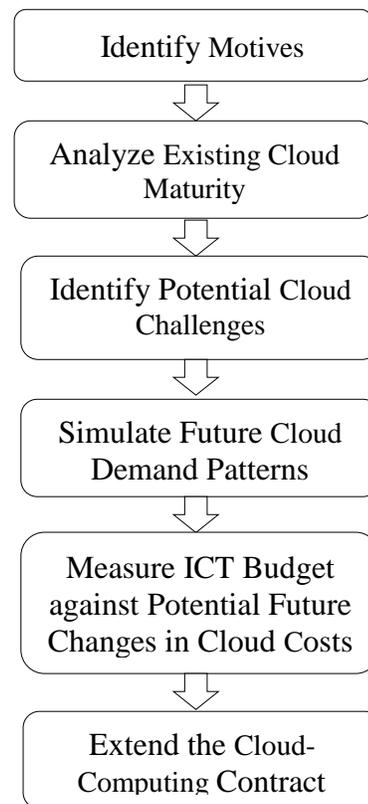


Figure 3. Cloud Computing Decision-Making Framework for Non-expert Clients

As illustrated in Figure 3, this paper has identified six key stages of the overall decision-making framework as follows:

- **Identify Motives:** It is recommended for any organization to thoroughly identify the main drivers of change and reasons behind moving certain applications onto the cloud before committing to any contracts with the service provider.
- **Analyze Existing Cloud Maturity:** As mentioned earlier, most organizations are already utilizing various types of cloud computing services. On that ground, a special management consideration is required before adopting new cloud services given that newer

features might include a duplicate of existing ones in some aspects, therefore, unnecessary costs can be added as a result of duplicating the same cloud services and purchasing unneeded resources.

- Identify Potential Cloud Challenges:

Organizations adopt different work objectives and have various attributes such as size, ICT demand, and budget. As a result, particular cloud challenges can have more impact over the others as concluded in the previous survey. Therefore, it is recommended for organizations to identify the relevant areas of concern to their businesses and management processes. As a consequence, this can mitigate the level of concern by emphasizing on those aspects when signing a contract with the cloud provider. This can be achieved by requesting additional assurances and SLA guarantees from the cloud provider.

- Simulate Future Cloud Demand Patterns:

As discussed earlier, one of the main cloud computing characteristics is the dynamic scalability which allow users to scale the capacity of their cloud resources up or down in a flexible, remote, and instant manner. This forms the fourth stage of this framework, which recommends non-expert managers to simulate their organizations' demand patterns across the off-peak and heavy demand periods prior to any actual cloud computing utilization.

- Measure ICT Budget against Potential Future Changes in Cloud Cost:

Cloud computing providers such as Google and Amazon have changed their cloud pricing calculations and associated service features on several occasions in the last two years [24]. On that ground, this paper suggests that non-expert clients are recommended to measure results obtained from the previous stage with their allocated ICT budget for 3 to 5 years in advance. This stage is argued to help managers in predicting price changes in their

cloud services across time, which as a result would enable them to define and elaborate on these rules with the cloud provider at an earlier stage.

- Extend the Cloud Computing Contract:

This forms the final stage of the decision-making framework after the non-expert cloud clients take into account all the previous stages. The main objective of this stage is to identify the potential threats and areas of ambiguity in the contract with the cloud provider, which can affect the organization's future ICT spending, management effort, and support.

7. CONCLUSION AND FUTURE WORK

Constructing long-term, sustainable, and cost-efficient strategies for any cloud deployment depends on the thorough identification of required services in-house and off-premises. This study points out that most of today's heavy-burdened organizations are outsourcing these services to costly independent suppliers which causes contract limitations, unnecessary management efforts, additional costs, and other decision-making complexities. These efforts are better employed by managers to enhance core competencies in their organizations, which potentially increases growth and attracts new business opportunities. On that ground, this paper has evaluated various management challenges of cloud computing, which were voted as most relevant by a number of non-expert managers through a risk-analysis survey. The outcome was analyzed against decision-making considerations for adopting different types of cloud computing services. The study highlighted non-expert clients as key users of the outcomes from this project given the diverse nature of the operational objectives in today's organizations.

Future work is structured to investigate and compare each cloud computing risk category

identified by the earlier survey with the actual cost, environmental, and management benefits obtained when cloud computing services are utilized. This analysis will highlight real-life examples of management issues and barriers experienced across those organizations, which as a result will allow decision-makers to measure the actual levels of management feasibility and efficiency from adopting cloud computing services against costs and other game changing factors in their ICT infrastructure.

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