Factors Affecting Cloud Adoption and Their Interrelations

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Abstract: Cloud Computing has emerged as a paradigm that relies on sharing resources over the network and, therefore, potentially has cost advantages in terms of lower variable and capital cost. However, the adoption of cloud-based technology for a given IT (Information Technology) setting is a complex decision as it is influenced by multiple interdependent factors. To successfully adopt cloud-based services and evaluate their consequential impact, relevant factors, which denote the performance of such services, have to be identified. This paper, therefore, analyzes and identifies relevant technical, economical, and organizational factors. This is performed as exploratory research consisting of performing (a) a literature review and (b) multiple case-studies with 17 organizations, who have adopted or plan to adopt cloud-based services. Also, as these factors are not mutually exclusive, this paper discusses interrelations of these factors and its complexity.

1 MOTIVATION AND INTRODUCTION

Ever since the advent of Cloud Computing (CC) numerous definitions have been proposed. The definition provided by NIST (Badger, 2012) states, "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." In addition to the explicit listing of major technical characteristics of CC, this definition also hints at an economical and organizational impact of CC.

CC is based on computing technologies such as of virtualization, Service-oriented Architecture, Web 2.0, Web 3.0, and Distributed Computing. The major benefits being pay-as-you-go model, on-demand scalability, business agility, increase in economies of scale. Depending on the provisioning location, CC has four deployment models (1) Private Cloud, (2) Public Cloud, (3) Hybrid Cloud, and (4) Community Model. Initially, CC delivered three fundamental service models: Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS), and Infrastructure-as-a-Service (IaaS). But, today it is extended to XaaS (Anything-as-Service), which can include anything such as Network–as-Service, Database-as-a-Service, or Communication-as-a-Service.

As numerous cloud-based alternative solutions are available, in order to successfully adopt one in an organization it is important to evaluate value and impact of incorporating the cloud into business for fulfilling IT (Information Technology) requirements. Currently, many organizations tend to fail to retrieve the best return from the cloud-based solution. This is due to the lack of complete understanding of factors (both by cloud providers and customers) that impact organizations, which adopt cloud-based services to fulfill their IT requirements. Factors that affect CC depend on (a) requirements of the cloud-customer, (a) type of service model, and (c) deployment model. Therefore, in order to formalize the impact of cloud-based services, and to take a decision whether to adopt cloud or not, identifying factors from technical, economic, and organizational perspective is necessary (Garg, 2014b).

The identification of factors in this paper here is done based on exploratory research. In exploratory research, conclusions are based on the review of available literature/data, or qualitative approaches such as discussions, focus group, or case-studies. Therefore, for identfying major factors from the technical, economical, and organizational perspective, this paper uses (a) review of available literature and (b) case-studies with 17 organizations,

who have adopted cloud-based services, or plan to do so. Once relevant factors are identified, the method to identify interelations between these factors is discussed. This leads to assisting organizations in successfully adopting cloud-based services and predicting impact with a possibility of preparing counter-measures in advance in case a failure occurs in future.

The remainder of this paper is structured as follows. Section 2 discusses related work done in the field of the identication of relevant factors from all perspectives influencing the adoption of clouds in an organization. It also highlights existing gaps in this field and how this paper bridges them. Section 3 determines the research metholodolgy followed in terms of research questions addressed, the design, and the study. Section 4 summarizes and analyzes key findings and explains how interrelations between identified factors can be identified. Section 5 summarizes and concludes the paper.

2 RELATED WORK

According to a recent report of 2014 by the International Data Corporation (IDC), spending on public IT cloud services would increase to a compound annual growth rate of 22.8 percent over the next five years, hence making it a $127 billion value (IDC, 2014). In order to completely utilize benefits of CC, industry and research have tried to understand and solve challenges affecting the cloud adoption, such as that of security and privacy. However, these efforts have been concentrated mainly toward addressing technical issues, such as multi-tenancy, scalability, monitoring of cloud-architecture, or performance (Tang, 2014), (Kaur, 2013), (Kuyoro, 2011). There are some efforts toward optimizing cost or Return-of-Investment (ROI) of adopting cloud-based services (Chaisiri, 2012), (Misra, 2011). In addition, there are studies to understand and calculate how cloud-based services conserve capital and reduce ongoing cost. Comparing Total Cost of Ownership (TCO) of cloud-based service and on premise solution leads to an assessment of total costs involved in deploying these two models (Walterbusch, 2013), (Martens, 2012). However, efforts in both of these directions follow a narrow approach and do not identify and analyze the impact of adopting cloud-based services from all perspectives (Garg, 2014a).

There was effort invested in the direction of addressing how the decision of adopting cloud-based services can be taken (Geczy, 2012), (Hoesseini, 2011), (Saripalli, 2011). They do identify that this decision is influenced by multiple factors that can be interrelated. However, neither do these approaches list factors that should be considered to take such a decision nor do they identify that these factors belong to all technical, economical, and organizational fields. Also, the identification of interrelations is only restricted to the analysis of their relative importance and it does not include their interdependence in terms of their performance requirements and evaluation.

Table 1: Comparison of Related Work with Respect to Main Characteristics of Current Work.

Features	**Methods for Decision of Adoption of Cloud**	**Methods for Optimizing Technical Factors**	**Methods for Optimizing Cost**
Technical Analysis	×	✓	×
Economical Analysis	×	×	✓
Organizational Analysis	×	×	×
Inter-relations Between Factors	✓ (partially)	(only between technical factors)	×

As shown in Table 1, gap still exists in research efforts in terms of identifying factors, which influences the decision of cloud adoption. The comparison of related work to the work done in this paper is based on four key features; "✓" describing the presence and "×" denoting the lack of that feature. This paper, therefore, fills this gap by (a) identifying factors from all perspectives-technical, economical, and organizational, and (b) identifying interrelations between these factors.

3 RESEARCH METHODOLOGY

Given the lack of empirical data for these factors that should be considered, while evaluating impact of cloud-based services or decision to adopt cloud, this paper follows an exploratory method. This is a qualitative approach, to understand information in depth and analyze diverse and complex data. In order to identify relevant factors, two methods were used. First is that of a case study, wherein semi-structured interviews were conducted with organizations. Second is that of analyzing available literature, both from industrial and academic surveys.

3.1 Case Study Design

Case studies are useful for collecting data, where little or no information exists. It helps to understand a "case" from holistic and real-world perspective (Yin, 2013). This paper here lists and analyzes data collected from case studies conducted with 17 organizations, who have adopted or plan to adopt cloud-based services for fulfilling their IT requirements. These interviews were conducted between June 2013 and October 2014, and their duration varied between 45 and 60 minutes. These interviews were either conducted on landline phone or as face-to-face meetings.

3.1.1 Selection of Participants for Case Studies

The selection of organizations interviewed was based on random and convenience sampling. Random sampling is considered as a fair way of selecting a sample from a given population since every member is given equal opportunities of being selected (Gravetter, 2010). This was combined with convenience sampling, due to the availability and proximity of participants. Convenience sampling helps to collect information in more depth as participants are in proximity (Gravetter, 2010).
Bias, which can often result from convenience sampling, was avoided with two countermeasures: (a) Participants were selected with varied geographical scope and domain of expertise. This helped in collecting data, which can be representative of the complete population. (b) Questions were based on interviewees' experience of adoption of cloud-based services (varied as per their domain of expertise) and with general benefits or challenges associated with the adoption of cloud-based services, therefore, making generalizations possible. Details of organizations are listed in Table 2. Interviewees from these organizations were senior decision-makers with experience of assessing various cloud alternatives. Participation was voluntary and their identity is kept anonymous, while reporting and analyzing the data collected. This was mainly due to the confidentiality and sensitivity of data and opinions shared by the decision makers of various organizations.

Table 2: Details of Organizations involved in Case Studies.

Org	Domain of Expertise	Organization's Size[a]	Geographic Scope Served
C1	ICT Provider	60000	Europe, USA, Singapore
C2	Health Insurance	450	Switzerland
C3	Communications	20000	Switzerland
C4	IT Infrastructure Provider	5000	Europe, USA, Australia, China
C5	Financial Services	2600	Worldwide
C6	Property and Life Insurance	4000	Switzerland
C7	Professional Services	180000	Worldwide
C8	Networking Solutions	67000	Worldwide
C9	ICT Association	-	Switzerland
C10	Financial Services	140000	Worldwide
C11	Banking Services	255000	Worldwide
C12	Technology and Consulting	431000	Worldwide
C13	Technology and Consulting	305000	Worldwide
C14	IT services	318000	Worldwide
C15	IT Infrastructure Provider	107000	Worldwide
C16	Life Insurance	3000	Switzerland
C17	Digital Media Solutions	12000	Worldwide

[a] Number of employees as per October 2014.

3.1.2 Research Questions

These case studies were conducted as semi-structured interviews. Owing to the semi-structured format of the interview, the interviewer was able to adapt the interview based on individual circumstances. All topics discussed (major ones listed below) within this interview supported two research questions that served as trigger point for discussion.

- What are the factors (technical, economical, and organizational) that should be considered while making a decision to adopt cloud-based services for fulfilling IT requirements?
  - Key reasons for adopting a cloud-based solution.
  - Factors that decide the eligibility of candidate to be migrated to cloud-based solution
  - Limiting factors and risks for selecting a cloud-based service.
  - Factors that decided which deployment model will be selected.
- Are these factors interdependent? If yes, then how?
  - Impact of migration to cloud-based service on organization.
  - Evaluation of success or failure of adoption

3.2 Literature Study

The literature review is used as the second method to collect data in terms of factors affecting the adoption of clouds in an organization. This covered reviewing various technical and economic papers, white papers, and surveys provided by industry and academic research. Even though these efforts do not list factors from all relevant perspectives, they collectively give a valuable insight into challenges and benefits of the cloud adoption decision.

The topics covered in literature available can be broadly categorized into the following categories:

- Security and privacy issues related to the adoption of cloud computing
- Technical issues in migrating and integrating cloud-based services with existing systems to fulfill IT requirements
- Generalized benefits and challenges of adopting cloud-based services
- Structural changes in ROI and TCO models, including cost benefits

4 KEY FINDINGS AND ANALYSIS

The data analysis in this paper was based on the targeted result of identifying factors and their interrelations. In order to avoid any misinterpretations all case studies were fully transcribed. The data (both of case studies and literature review) was aggregated, converged, and aligned in a database, thereby helping in identifying multiple occurrences of factors and cross case-study synthesis. This enabled the identification of regularities and differences across and within various data sources and provided for plausible explanations on importance of a particular factor. Also, due to the presence of multiple data sources, result credibility was ensured. The qualitative data was categorized in three categories (technical, economic, and organizational). Factors, found in the exploratory research, can have a different priority or relevance for different organizations. This depends on overall requirements and expectations from the cloud-based service. Thus, key findings of this exploratory research in terms of technical, economic, and organizational factors and their interdependencies are derived as follows.

4.1 Technical Factors

CC has major benefits in terms of its technical

Table 3: Relevant Technical Factor.

Scalability
Availability
Elastic Resourcing
Network Quality • Bandwidth • Connectivity
Interoperability
Speed/Latency
Quality of Service
Portability
Compliance and Standards
Usability • Application Launch Time • Graphics Agility • Simplicity
Data Loss
Reliability • Elasticity • Disaster Recovery
Privacy
Compatibility with Existing Systems
Software Assurance
Customization
Integration
Management and Maintenance of Identity Platform
Management of Authentication Platform
Security Configuration and Maintenance • Confidentiality • Integrity • Availability • Auditability • Multi-tenant Trust
Functionality
Triability
Delay in Migration and Data Transfer
Vendor Lock-in
Process Redesign
Accessibility
Standards for API
Backup • Data • Application
Workload Management • Classification • Capacity Planning • Performance Management Configuration Management • Mission Criticality
Multi-tenancy

characteristics. Table 3 lists the key factors, which must be evaluated before adopting a cloud-based service. An IDC report reported 75% of the respondents mentioned security as one of most important factor to be evaluated, while adopting cloud-based services (Sultan, 2011). This is of utmost importance for the public cloud. Another important factor is that of sensitivity of data. As the provider has full access to the data, responsibility of data theft, loss, and adherence to legal and regulative guidelines for storage of data has to be carefully evaluated. This factor has higher priority in cases, when public or hybrid deployment models are selected (as compared to private deployment model). For Small and Medium Enterprises (SME), it is important to take measures to increase the network quality in terms of bandwidth and connectivity (Yeboah-Boateng, 2014). Network quality is important, because in many cloud architectures (*e.g.,* Amazon Elastic Block Store (EBS) architecture) the data storage layer is abstracted in the compute layer of the application. These compute and data storage nodes are connected via a network. If the network is not of good quality, the application can fail to respond (Joyent, 2014).

As pointed out by every organization, which participated in these case studies, vendor lock-in is an obstacle for a successful adoption of cloud-based services. It also has high negative impact in terms of cost and interoperability in case when the service provider has to be switched. It highlights the need of common standards for APIs across cloud-service providers, so that interoperability is possible. Public cloud tends to get significant advantage over private cloud for all organizations, which participated in the case study, because of its capability to handle unexpected hike in workloads. Therefore, a flexible infrastructure capacity and a provisioning time determine a critical factor for the adoption of a cloud. Organizations participating in this case study also mentioned usability and functionality as deciding factors. Not only the technological know how is important for a successful adoption of cloud based services, but also the ease-of use is crucial for these organization

4.2 Economic Factors

As found in these case studies (specifically pointed out by SMEs) and within the literature review, cloud-based services reduce upfront costs and operational complexities of converting small businesses into larger ones (Chaisiri, 2012), (Misra, 2011). These costs are shifted to data centers, which benefit from economics of scale and scalability. CC follows the Operating Expenditure (OPEX) model and offer elasticity in terms of scaling resources as per demand. This transfers the risk of over- or under-provisioning to the service provider. However, customers should evaluate, if scaling-up of resources (*e.g.,* increasing the power of server) or scaling-out of resources (*e.g.,* increasing the number of servers) is more appropriate for their specific use-case. This is specifically required as clouds operate at the large scale (Hasan, 2012). For example, in some cases, where the number of customers pre-decides the number of software licenses, increasing them later for an unexpected increase in demand will be very expensive or even impossible. Table 4 lists the key factors from the economic perspective.

All organizations, irrespective of its size and geographical scope, considered the reduction of their carbon footprint as one of the major goals. This leads to evaluation of alternatives of cloud-based services so that a best trade-off is achieved between performance, Quality-of-Service (QoS), and energy consumption of storing, processing, and transportation (Mouftah, 2012). Service Level Agreements (SLA) indicate the description of an agreed upon service, service level parameters, guarantees, actions, and penalties in case of failure or violations (Wu, 2012). SLAs help the organization to monitor the performance and billing of the service provider. If any of the guaranteed metric is not fulfilled, the provider incurs penalties.

Table 4: Relevant Economical Factors.

Cost • License • Maintenance • Back-up • Energy • Hardware • Migration • Future Requirements • Performance • Data Loss • Switching Providers • Integration
Operating Cost (OPEX)
Marginal Cost and Profit
Energy Use and Carbon Emission (Carbon Foot Print)
Contracts and Service Level Agreements (SLA)
Billing and Metering of Resource Usage
Traceability and Audibility • Data • Application
Return-of-Investment (ROI)
Total Cost of Ownership (TCO)
Migration Time

However, the major consequence of this is on the business continuity of the customer. Consequent economical losses due to failure of any cloud-based services can be very high. Another important factor is the calculation of the Return-of-Investment (ROI). For calculating ROI of a traditional IT infrastructure, the initial cost of project, the investment made, and the cost savings done owing to the new investment has to be identified (Chang, 2012). However, for calculating the ROI associated with cloud-based services, increase in profit, reductions in cost, license cost, and any implicit cloud costs have to be identified also. Based on the calculated ROI, the suitability of an adoption of a specific cloud-based service can be recognized (Misra, 2011).

4.3 Organizational Factors

As determined from both, literature review and case studies, currently organizational factors are the least evaluated factors for the decision on a cloud adoption. This is because understanding the significance and extent of impact of an adoption of cloud-based services in an organization on the management and operation of IT infrastructure is a challenge. However, the evaluation of a cloud-based service from this perspective is equally important. To name a few required changes in an organization due to CC are a change in the accounting model, the security model, compliance requirements, and the project management (Hoesseini, 2011). Table 5 lists other key factors from the organizational perspective, which must be evaluated before adopting a cloud-based service.

CC has a distinct disadvantage in terms of loss of control of both data and resources. This leads to issues of privacy and security. Also, as cloud-based services lack transparency in terms of location where data is stored and performance levels of the application as compared to the terms in the SLA, it raises problems related to legal and regulative issues (Battey, 2012). Legal risks also include the liability of the service provider to protect the data from security threats and privacy breaches. Security threats include the deletion of data, multi-level risks, physical attacks, and isolation failure (Kuyoro, 2011). On one hand, CC has advantage in terms of improved process efficiency and increased employee productivity by better internal collaboration. On other hand, CC can have a major disadvantage in the overall efficiency and productivity of the organization, if employees are unable to adapt themselves to changes brought by CC. A successful adoption of cloud-based services is dependent on how easily can the new technology be learnt by employees of the organization (Saini, 2012). As identified by organizations, which participated in case studies, CC has the capability of transforming business, as the employees need to concentrate only on the innovation of application, the cloud-service provider handles everything else. However, to achieve this, technical support from service-providers and the competence of employees of the organization are two crucial factors.

Table 5: Relevant Organizational Factors.

Size of Organization
Degree of Centralization
Managerial Structure
Competence of Employees
Control
Transparency
Business Flexibility and Agility
User and Technical Support from the Provider
Legal and Regulative Compliance
Skills and Expertise of the Cloud Providers

4.4 Relation between Factors

The factors outlined above can have numerous and complex interrelations based on use case-specific requirements of the organization. Therefore, understanding and identifying these interrelations is equally important to completely evaluate any cloud-based service. Figure 1 illustrates an example of how factors can be interrelated. Scalability leads to cost savings, which can be used in acquiring end user systems and training. To manage failures, such as that of an uptime time failure or a data loss, many cloud-service providers recommend customers to maintain multiple levels or redundancy. This, however, leads to higher capital and operational cost for establishing and maintaining such a system. The lack of standards causes major difficulties, when a decision is made to move applications or data between clouds. These problems include (a) security levels, (b) handling data movement and encryption of data, and (c) setting up of network with the same configuration as that of the source cloud. These issues consequently have an economic impact in terms of cost and ROI. Security and privacy issues associated with cloud computing include multiple issues as that of (a) regulatory compliance in terms of liability of data, location of data storage, (b) proper means of data segregation so that availability, reliability, and confidentiality of data is ensured (Kaur, 2013), and (c) a cloud-based solution that has be able to replicate data across multiple sites to ensure proper recovery in case of any disaster

(Kuyoro, 2011). These issues affect the cost, performance, and control an organization has on a cloud-based service. The costs of cloud-based services are lower, mainly owing to the sharing of resources. This, however, means less guarantees of performance. Therefore, it is important to have strict SLAs, where each relevant performance metric is identified with an expected level of performance.

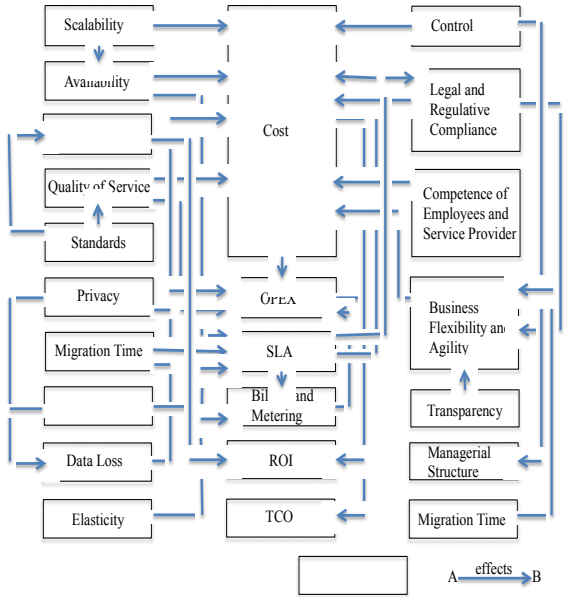

Figure 1: Interrelations between Factors.

As cloud-based services allow scalability and variable levels of resource usage, billing and metering as per the usage is essential. Cloud-based services contribute primarily to business agility and flexibility, but it also restricts an organization in terms of control it has on its own data and applications. Cases of data loss or the need to move data between cloud providers can lead to huge losses. A successful adoption of a cloud-based service is also dependent on the adaptability of the organization in terms of its managerial roles, structure, and competence. Identification of interrelations leads to a systematic evaluation for all tradeoffs and risks involved in considering specific clouds (Garg, 2014b).

5 SUMMARY AND CONCLUSIONS

This paper has bridged the existing gap between identifying relevant technical, economic, and organizational factors and their interrelations. To achieve this, exploratory research was used in terms of a literature review and 17 case studies with organizations that have either adopted or plan to adopt cloud-based service in the future. In turn, the work showed that interrelations exist between factors of multiple domains and how these relations can be identified.

In conclusion, these factors and their interrelations have a clear influence on (a) the decision of the adoption of cloud-based services and (b) on the impact analysis of a cloud-based service. These lists of factors developed classify available cloud-based services. This classification can be done on the basis of a capability of cloud service providers to fulfill the expected level of performance for each of these factors, thereby aiding organizations to select the best alternative as per IT requirements and business objectives. Furthermore, organizations can ensure that all relevant and critical factors are specified in the SLA with a guaranteed level of expected performance. Lastly, it has also been identified that areas of standardization, interoperability, security, and privacy need to evolve (*e.g.*, ease in encryption of data while in transit between cloud service provider). This is because of their wide impact in terms of technical, economic, and business value.

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