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Key Opportunities and Challenges of Data Migration in Cloud: Results from a Multivocal Literature Review

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Abstract

Cloud data migration is the procedure of moving information, localhost applications, services, and data to the distributed cloud computing infrastructure. The success of this data migration process is depending on several aspects like planning and impact analysis of existing enterprise systems. One of the most common operations is moving locally stored data in a public cloud computing environment. This paper, through a multivocal literature review, identifies the key advantages and consequences of migrating data into the cloud. There are five different cloud migration strategies and models prescribed to evaluate the performance, identifying security requirements, choosing a cloud provider, calculating the cost, and making any necessary organizational changes. The results of this research paper can give a road map for the data migration journey and can help decision makers towards a safe and productive migration to a cloud computing environment.

Keywords: Data Migration, Cloud computing, Multivocal literature review, Cloud Vendors

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1. Introduction

Cloud computing is a business model for an enterprise, and it is now rapidly changing our lives with its impact on everyday life. Organizations are now more focused on a centralized and cost-effective solution with the maximum up-time. Everyone who is a part of cyberspace is part of cloud computing, either he or she is aware or not aware. The growing number of mobile users do not need to save their mobile data manually, anymore, and cloud computing is making it easy now. The prosperity behind cloud computing is that it offers your business with many services like business continuity, reliability, flexibility, work from anywhere, and scalability. The future business world will be considering the importance of the "4C": Cloud, Customers, Cost, and Convenience. As a consequence of the attention to the phenomena by industry and governments alike, academia is also analyzing the topic from a panoply of perspectives, being nowadays one of the most important research topics in computing science and information systems [1].

According to Forbes, there are now 77 % of organizations, having one or some parts of their systems in the cloud, stated as, "Enterprises predict they will invest on average $3.5M on cloud apps, platforms, and services this year" [2]. IBM recently acquired Red Hat for $34 billion and is becoming world's no. 1 hybrid cloud provider, IBM Chief Ginni Rometty said that this acquisition is a turning point and this will change the whole scenario about the cloud marketplace [3]. According to Statista, Amazon is leading with the highest market share in cloud computing, whereas Microsoft secured second, and Google ranked third position [4].

There are widely reported benefits to cloud computing adoption and data migration into the cloud, but there are some potential risks associated while moving data from on-site to the cloud storage. There is a possibility of a data breach during data migration if security solutions provided by the vendor are not planned, implemented, and executed correctly [5]. Another risk and issue regarding expectation management between user and cloud providers, without having proper written and authorized document e.g., SLA (Service Level Agreement) is that it may cause many ambiguities [6]. The major cloud providers like Amazon, Microsoft, and Google are seriously working on security challenges for making a long-term place in the cloud market. Microsoft is alone investing more than $1 billion yearly just for the sake of security [7]. The fourth architecture of cloud computing is "Security as Service (SaaS)", and is primarily focused on internet security and cyberspace risk challenges [8]. Apart from the intrinsic threats, there is also a need to conduct compliance efforts in cloud settings towards a governance scenario [9].

The fundamental objective of this paper is to present the opportunities and benefits of data migration into the cloud as well as highlighting the concerns of the shift to this paradigm. Additionally, focusing on how cloud migration strategies and models can help to mitigate these challenges. This paper is organized as follows. Section 2 discusses the research scope and research questions. Section 3 is about the method for conducting the research. Section 4 describes the search strategy. Section 5 talks about analysis and discussion. Section 6 focused on summary of results and findings. Section 7 depicts the limitation associated with the study. Finally, Section 8 presented our conclusions and recommendations for future work.

2. Research scope and Research questions

To achieve the objective of this study, three research questions are formulated. In this MLR, two researchers are associated with the selection procedure: the principal author of this paper completed the choice procedure and the second author assessed the process, checked the results and supervised answers to research questions. To address the goal of this paper, three research questions were formulated by the authors:

RQ 1: What are the reported advantages to store data into the cloud?
RQ 2: What are the key challenges to migrate data into the cloud according to the literature?
RQ 3: How cloud migration strategies and models help to deal with data migration concerns?

3. Method

The objective of conducting this study is to analyze the importance and consequences of migrating data into the cloud. This study will also lead to identifying the key opportunities and challenges while migrating data into the cloud. To accomplish all defined measures and possibilities, a multivocal literature review (MLR) is adopted as the selected method. MLR is a combination of academic literature and Grey literature, where the articles are not limited to scientific literature. In this case, other sources of information including blogs, post, websites, and white papers are

also taken into the account. The research conducted by following the guidelines for including grey literature and conducting multivocal literature reviews in software engineering [10].

4. Search strategy

The required data were collected to conduct the research by using electronic libraries, namely, Google search and Google scholar. Google and Google Scholars are the most vital tools for information seeking by researchers and scientists [11]. The search result (**Table 1**) was derived from these two main sources.

Table 1: Search result after inclusion and exclusion

Studies	ACM	Springer	ScienceDirect	IEEE	Google Scholar	Google	Total
Studies retrieved	2	9	5	15	3080	340000	343111
Title, Abstract & Keyword selected	2	4	5	11	75	43	140
Studies after reading full text	1	3	4	10	45	31	94

Google and Google scholars choose as sole search engines to get the result from their predefined sources from the most popular academic publishers (e.g. IEEE, ACM, Springer, and Science Direct). The other sets of data also collected from grey literature which consists of other databases, websites, catalogs, and Google provider's reports, facts, and figures.
The MLR and the search were performed between January and February 2019. Following is the final search term formulated to be used in search engines.
("Cloud computing") AND ("data migration") AND ("Opportunities" OR "Benefits" OR "challenges" OR "Issue")

4.1. Study Selection: Inclusion & exclusion criteria

Authors included or excluded articles based on titles, abstracts, and keywords, as well as full-text reading. The authors conducted the submission of inclusion and exclusion criteria to titles, abstracts, and keywords. The following inclusion /exclusion criteria were applied:

- •Studies are based on the discussion on cloud computing.
- •Studies, which cover the advantages of cloud computing.
- •Studies, which highlight the challenges and issues regarding data migration.
- •Studies, which present the strategies and models in data migration.
- •Studies were published online in the period 2014 to 2019.

The following criteria state when a study was excluded:

- •Studies not presented in English.
- •Literature or studies, which are not relevant to the subject matter.
- •Studies not accessible in full-text.
- •Duplicated Studies.

The screening and selection of studies were based not only on the relevance, but the authors also considered the contribution of the selected research. The collection of studies purified through several considerations and principles through which any review can be included and excluded. At the initial screening stage, authors, just read the title and abstract of the candidate studies and decide to include or exclude the study for the review. If still, doubt remains about inclusion/exclusion of study, then, it is needed to read in depth the full-text of the paper. Building up the criteria for inclusion or exclusion in the start makes the procedure simpler to separate relevant materials for the review [12]. The core criteria of exclusion and inclusion of studies considered the fact of how well the designated article was helpful to answer the research questions. The papers trashed from a selection which were not justified the eligibility criteria of inclusion.

4.2. Data Abstraction

Data were extracted on this stage by refining and filtering the relevant information based on the research questions. At this point, related studies were entirely ready to extract from, all the needed information and ensure that the data was accurate. The inclusion criteria were based on the relevancy of prospective subjects to the inclusion criteria described by the authors related to the research questions, while, exclusion criteria were those characteristics that disqualify prospective subjects from inclusion in the study. To extract the data from the identified primary studies, the authors developed the following template: (I) ID (ii) Title of the publication (iii) Name of Author (iv) Database (v) Source (vi) Venue (vii) Year (viii) Abstract (ix) Reasoning.

5. Analysis and Discussion

RQ1: What are the reported advantages to store data into the cloud?

Cost-effective solution:

Cloud computing is a highly demanded technology because of its intrinsic features like scalability, reliability, and highly available model for organizations. Data migration to the cloud is a cost-effective solution as it is compared with on-premise costs like hardware, software, support, downtime, employees, and depreciation cost [13]. Price is one of the key benefits for organizations, so they can concentrate on their core business while placing their main infrastructure services to the cloud service providers. On the other hand, cloud computing is more environment-friendly compared to on-premises system, saves energy and provides cloud's green features reducing the number of physical materials [14].

Business continuity:

Cloud backup solutions play an essential role in a proactive approach to get maximum uptime like backup and recovery in a business continuity strategy. Many businesses, especially financial organizations, cannot afford downtime just for the sake of tracking and upgrading software's and systems [13]. The large pool of IT resources helps organizations to get the benefits of redundant computer resources without the constraint of geographical location.

Security aspects:

Data is vital for any organizations, and cloud vendors must consider the facts of integrity and reliability of critical information, which is essential in today's competitive business landscape [15]. Cloud vendor's obligation ensures that their infrastructure is secure, and their client's data and applications are well protected. Cloud service providers provide a high-level security protocol to verify data protection by using encryption mechanisms [16]. The complex data centers of cloud providers built on layered security approaches which include data encryption, key management, strong access controls, compliance with regular security audits [17].

Scalable IT resources:

By scalable IT resources, most service providers will allow organizations to increase their existing resources to accommodate their business needs or changes [18]. Some customers may require a quick adjustment in term of IT resources, and this will enable to support business growth without expensive modifications to existing system infrastructure [19]. Demand management can be handled through cloud recourses easily if any application is experiencing increased traffic, while it is not an easy task to increase demand on the resources through traditional computing environments [13].

RQ2: What are the key challenges to migrate data into the cloud according to the literature?

Choosing the right vendor:

Data management and data migration are essential research challenges, and it is never as simple as moving information from legacy to cloud [20]. Even after the SWOT (Strength, Weakness, Opportunities, and Threats) analysis, it is not trivial for an organization to choose a suitable cloud provider. In the cloud market leading key players, Google Cloud Platform (GCP), Amazon Web Services (AWS), and Microsoft Azure are continually searching for approaches to differentiate themselves from competitors [21]. Therefore, it is crucial that companies ask cloud providers if they have appropriate data migration tools to move data by considering the factors of vendor lock-in and portability (the ability of software to be transferred from one machine or system to another) [21].

Adaptability and process issue:

Change management is crucial for these kinds of endeavors. The possibility of training employees on a new system and software platform may add additional costs. Adding to that, the behavior of employees toward adaptability on a new system could is another challenge. A system failure does not always depend on hardware or software failure, In fact, digital transformation is based on successful IT practices and infrastructures processes [22]. In data and process migration, there is a need to design, execute, and monitor a plan to support the change.

Trust deficit about cloud security:

Although cloud market giants have been promoting their in-place latest data security model, the NSA snooping scandal creates doubt and rethink on storing all the critical and confidential data in the cloud [23]. This trust deficit impacts all major stakeholders like individual citizens, businesses, and governments. As data stored in the cloud is easily accessible from anywhere, data breach due to low password security or hacking can result in a compromise of personal and business data. The organizations hosted their data locally with having full control and authority. When they decide to migrate to the cloud, they may feel more vulnerable because hackers tend to target big data centers [24].

Cost-benefit analysis:

A good set of organizations in the globe is in the process of implementing cloud computing as a core component of its technology approach [25]. But despite this overwhelming cloud momentum, cost-benefit analysis models illustrating the business impact of cloud adoption are still a significant risk factor [26]. It is sometimes challenging to redesign your current IT infrastructure (server, network, storage) to meet the requirement before moving to the cloud. Cloud providers charge customers on a variable cost pay-as-you-go basis determined by the number of users and their volume of transactions [27]. Organizations are not readily willing to pay extra for system acquisitions, management, and additional bandwidth cost [21].

RQ3: How migration strategies and models can help to deal with data migration concerns?

Cloud migration strategies

Before any organization jumps into migration, effective planning is essential, no matter what is the current IT environment of your workplace [28]. Every cloud provider has its own set of strategies (shown in **Table 2**) that can accommodate your cloud-migration approach. The most central part of all this procedure is to remember your clients and end users at every stage of the migration [29].

Table 2: Cloud migration strategies with the definition

SN	Cloud Migration Strategies	Definition
1	Re-hosting	Re-hosting also known as "Lift and shift" technique is particularly effective in a large-scale enterprise, a migration strategy for moving an application or operating system from one environment to another – without redesigning the app [28].
2	Re-platforming	Re-platforming involves upgrading an application from its existing platform with the benefits of “backward compatibility” that allows developers to reuse the available resources [28].
3	Repurchasing	Repurchasing is a strategy of moving to a different product, for example swapping a self-run email system for an online email-as-a-service [30].
4	Re-architecting	This solution involves re-building an application architecture by using the cloud-native features of PaaS and changing application components, ideal for business who need additional features, scale, or performance [28].
5	Retiring	The process of cost optimization in which organizations just get rid of the un-used systems and applications [30].

Cloud computing service models

Cloud computing has several deployment models, organization chooses the model according to their size of business and complexity of their data. The top leading cloud providers like Amazon, Google, and Microsoft are currently offering their Services in any of these models, IaaS, PaaS, SaaS, SECaaS, and DaaS.

Security as a service (SECaaS):

Security as a service (SECaaS) set up on the basis of pay-as-you-go subscription helps corporations to integrate their security services with the cloud service provider [8]. SECaaS is derived from "software as a service" model, and it is an information security model which does not require on-premises hardware or additional tools [30]. Cloud providers of security services model offer potentially significant advantages include authentication, anti-virus,

anti-malware, intrusion detection, Penetration testing, and security event management and audit the current security measures [31]. SECaaS works as a safeguard against the most persistent online security threats [32].

Data as a Service (DaaS):

DaaS is a centralized data store place, and it offers users to quickly move their data without having a high level of expertise in data migration [33]. Data as a service (DaaS) concept, is also derived from software as a service (SaaS), The objective of DaaS is to provide data on demand, which is stored in the cloud, regardless of the client 's geographical location [34].

Infrastructure as a Service (IaaS):

Infrastructure as a Service (IaaS), is suitable for large organizations with millions of transactions and having lots of physical hardware [35]. IaaS is fully self-service for accessing and monitoring assets like computers, networking, storage, and other services. It allows enterprises to purchase resources on-demand basis [36]. Examples of top IaaS providers are Microsoft Azure, Amazon AWS and Google Compute Engine.

Platform as a Service (PaaS):

(PaaS) empowers clients to utilize the vendor's cloud framework to deploy web applications and other programming software by using predefined tools provided by the cloud providers [37]. The physical infrastructure of this model is totally the vendor's responsibility. The customer only needs to control and maintain software applications. Examples of PaaS: AWS Elastic Beanstalk, Windows Azure, Google App Engine, Apache Stratos, OpenShift.

Software as a Service (SaaS):

Software as a Service (SaaS) provides cloud infrastructure and cloud platforms to customers with software applications. The end user accesses its applications through a web browser or using an IDE (Integrated Development Environment) eliminating the need to install or maintain additional software [38]. Same as PaaS in this computing model, vendor takes care of computer hardware and operating systems [36]. Example of SaaS includes Google Docs, Google Gmail and Microsoft Office 365.

6. Summary of Results and Findings

Cloud computing is a cost-effective solution with too many features which help enterprises to run business in an environment-friendly atmosphere. Easy disaster recovery helps the user in business continuity without having a high level of technical expertise. Cloud providers must ensure the reliability and integrity of data with strict compliance policies. Scalable IT resources can help the business expand existing resources to accommodate their business needs. The selection of the right cloud provider is an issue with respect to support, tools and approaches. The human factor is also a big challenge which means how people welcome the changes in adaptability. The trust deficit between client and cloud providers regarding a set of security protocols is also part of the findings. Sometimes many organizations do not want to invest in new technology components as they think it as an additional cost. The last section has summarized some remedies for data migration challenges, the first and most important part is the effective planning approach toward successful data migration. There are some strategies mentioned (shown in **Table 2**), any organization can choose any strategy, according to its mode and size of business. Cloud computing models describe the distribution of different IT components in the form of cloud computing service model. An organization will have numerous benefits from these models in the form of data, security, software or infrastructure.

7. Limitations

This research concentrates on studies that assessed the data migration into the cloud. There are a few limitations in this paper which are disclosed to clarify the exploratory procedure. The selected study period is based on 2014-2019 and this research is included only published papers and studies that are written in English. For controlling the biases and reducing missing relevant papers, the authors extend the research, keywords (defined in Section 4). However, still, there is a probability that some related work may have been missed. To control the factor of biases and reduce the risk of a validity, the research team uses weekly discussion meeting [18]. This study has been reviewed by a subject matter expert who inspected the work did amid all the total methodology of this MLR.

8. Conclusions and Future Work

This study provides an efficient and productive path of strategies, models, benefits, and concerns by using MLR, which helps in the decision of data migration in the cloud. Since the adoption of new technologies is a recurrently researched topic with models and theories that contribute to the subjected area from different perspectives. The reason why it is being investigated is that there is complexity within the adoption of technology that requires continuous attention in the form of research. Large enterprises are often in mature levels when it comes to the discussion and implementations of cloud computing to migrate their data into the cloud. This paper addressed the key opportunities and challenges involved in the process of building trust in the cloud for moving data to the internet. Every Cloud provider uses different approaches and strategies to gain the confidence of customers that are based on the on-premises computing environment of client.

To properly execute the conclusion and ideas shared in this paper, some additional work has to be done. The future of cloud computing must be in discussion with open source and closed source cloud environment and their set of security measures. Cybersecurity is a hot topic in all businesses these days, and it will remain significant in term of cloud security standards adopted by cloud providers.

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