Cloud Migration: Issues and Developments

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Abstract- **Cloud computing is a dynamic paradigm that is influencing activities in virtually all facets of the IT world. It has become quite easy to deploy applications on the cloud. Storage is also available based on user's needs and can be scaled up or down as required by the user. Computing resources have also been made available on virtual machines. Furthermore, applications are available to users supplied by cloud providers. The activities on the cloud has made migration to the cloud desirable to most organizations and enterprises. Adopting the cloud is expected to reduce cost and the need for investment in computing infrastructure. However, most organizations are still concerned about the likely challenges of migrating to the cloud. The goal of this paper is to provide an insight into cloud computing with respect to migration issues. The paper discusses cloud computing and the benefits of migration. It also examines the challenges of migration. Furthermore, present issues of migration as espoused by the industry are discussed. The survey observed that not much is being discussed in terms of current trends and procedures of migration.**

Index Terms - **Cloud Computing, Migration, Services**

I. Introduction

"CLOUD computing is a model for enabling universal, on-demand and convenient network access to a shared pool of configurable computing resources (e.g., servers, applications, storage, networks and services) that can be quickly provisioned and released with little to no management effort or service provider interaction" [1]. Cloud computing involves providing resources to clients by service providers over the Internet. Such resources could be in form of computing power, storage and user applications. Cloud computing provides immense benefits to organizations and enterprises alike. Organisations do not need to invest heavily on technical infrastructure because the infrastructure is available with the Cloud service providers (CSP) [2]. This leads to a considerable reduction in the spending both on installation and maintenance of computing infrastructure. Furthermore, services provided by a CSP allows an organisation to focus on ideas, training of personnel and more innovative ways of doing things [3].

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Cloud computing entails a user paying for only the workload or services utilized. This pay per use arrangement means that organizations will need to pay for resources utilized per time. Users will again save huge amount that should have been invested in the cutting-edge technology being utilized by the cloud service providers. Organisation will request for service as the need arises, and reduce their demands as the need reduces. [4] The obvious benefits associated with cloud computing has made cloud adoption or migration attractive to organizations. Cloud migration is the process of partially or completely deploying an organisation resources and applications to the cloud to be managed in any of the cloud deployment types [5]. Migration also involves moving an organization's applications from its data center to that of a CSP [6]. This could be accomplished using a private, public, community or hybrid cloud. Migration or cloud adoption can occur in three forms based on the service types. Cloud computing has three service models, the Software-as-a-Service (SaaS), Platform-as–a–Service (PaaS) and Infrastructure–as–a–Service (IaaS). Using the SaaS platform, a company may move an existing application to a cloud environment [5]. Such applications are made available to users online and users do not have to worry about the software license. The PaaS enables users to develop and deploy applications to a cloud environment utilizing the application programming interface provided by the CSP. IaaS allows migration of resources in terms of storage, compute power, virtual machines from on-premise for hosting by a CSP.

The benefits provided by cloud computing notwithstanding, it is important to know if cloud adoption will be beneficial or otherwise. Some migration issues are technical, such as the performance of an application when migrated to the cloud, while issues of cost effectiveness of a migration process are also important [3]. In addition, issues of security and networking is must be considered [6]. Cloud adoption may lead to exposing sensitive information about an organisation to the public, hence migration must be carried out with careful preparations [7]. The issues involved with migration can also be examined in terms of business and technical factors, including the ease of implementation [8]. On the other hand, there is a high overhead involved with maintaining a data center. Such cost includes the licensing cost, resources consumptions and support arrangements required to sustain such centers [7]. For large organisations it may be sufficient to migrate only a part of their on-premise resources to the cloud.

As new technology evolves, there is a substantial savings by such organisation because they can leverage on using the cloud. For start-ups, the benefits of access to latest hardware

and being able to jump start operations without investment in a data center makes migration an attractive option. From the foregoing, cloud adoption has obvious advantages and disadvantages. The focus of this paper, therefore, is to examine the process of cloud migration. Various aspects of cloud adoption will be discussed. More importantly, the recent developments in the industry will be highlighted. The motivation for this is to provide the requisite understanding to enable small and big enterprises decide on cloud adoption. The organisation of the remaining paper is as follows, Section 2 describes related work, Section 3 examines the process of cloud migration, Section 4 discusses current developments in cloud migration, and Section 5 concludes and suggest further studies.

II. RELATED WORKS

In [6], a view of cloud computing is discussed extensively. The main focus was that developers must thoroughly consider cloud issues in terms of virtualisation in areas such as networking and storage. Both application and infrastructure software including hardware must be planned for in terms of the dynamic nature of the cloud. In [5], the relevance of cloud computing is examined in the perspective of both the users and the cloud providers. The issues of storage, networking and migration in terms of cloud computing was discussed. In addition, the idea of integrating existing system and technologies in the utilization of the cloud was examined. In [7], Cloud Computing – Research Issues, Challenges, Architecture, Platforms and Applications: A Survey is proposed. The approach was to examine popular cloud platforms viz-a-viz what is offered. Some issues relating to cloud migration were also discussed. In [9], Cloud Computing: Issues and Challenges is presented. The approach was to examine the relationship between cloud, service-oriented and grid computing. Various issues relating to the adoption of cloud computing was also discussed. In [8], Big Data and Cloud Computing Issues is discussed. The main focus was the planning and security issues associated with big data on the cloud. However, some other issues relating to general adoption of cloud computing were discussed. In [10], Cloud Computing in Nigeria: Prospects, Challenges and Operation Framework was proposed. The approach is to examine major obstacles to the successful adoption of cloud computing in Nigeria. A framework was proposed to mitigate the challenges militating against successful cloud migration in Nigeria.

In [11], Cloud Computing –Its Prospects and Challenges is presented. The main focus of the paper was to examine the advantages and disadvantages of utilizing the cloud. Some possible solutions to the challenges of using the cloud were also discussed. In [12], Cloud Computing Security Issues and Challenges is discussed. The approach was to examine challenges in the area of deployment and service delivery on the cloud. Major issues that could prevent migration to the cloud were also examined. In [4], Cloud Computing: Issues & Challenges is examined. The main focus was on the categories of areas to be considered to ensure successful adoption of cloud computing. In [13], Cloud Computing: Challenges and future directions is presented. The approach

was to discuss the benefits associated with cloud computing and the attendant risks. Thereafter various ways to make cloud computing attractive were proposed. In addition, suggestions were made in terms of government reforms. In [2], Security Analysis in the Migration to Cloud Environments is proposed. The focus is the security issues related to cloud migration process. Various approaches were analyzed in terms of the secured nature of migrating a process to the cloud. In [14], a five-phased approach for the cloud migration is presented. The paper provides an insight of migration issue with a view to guiding organisations in terms of migration. It considers the migration concerns as it relates to the type of enterprise that may intend to migrate to the cloud. In [15], a comparison of on-premise to cloud migration approaches is presented. Migration to the cloud is examined based on the various services available in the cloud. The role of the various actors involved in migration is also discussed. In [16], application migration to cloud: a taxonomy of critical factors is proposed. The paper discussing experiences in migration considering the programming and storage environment. A cost-benefit analysis was done to enable consumers decide on migration issues. In [17], Cloud Computing for Higher Education Institutes: Architecture, Strategy and Recommendations for Effective Adaptation is presented. The main focus is cloud computing utilization in tertiary education. The paper proposes five steps for seamless adoption of cloud computing.

III. PROCESS OF CLOUD MIGRATION

A. Types of cloud migration

A subtle generalization of cloud migration types is presented below, in order to provide distinction between the several approaches to cloud migration available [36].

- Replace activities with cloud capabilities: this is the least type of migration. In this technique, one or more activities (components) are replaced by cloud enabled services.
- Partial migration of some of the application functions to the cloud. This entails moving one or more application layers or a set of components from one or more layers to the cloud.
- Migrating the whole software application stack to the software. This type entails the enterprise maintain hardware components in-house and then enjoying software interactions from the cloud.
- To 'cloudify' the application entails a complete migration of the entire application activities and components.

B. Migration Strategies

With regards to the classification of migration of the various cloud computing service models, there exists varying classification cases in literature. This section presents the classifications highlighted in [37]

- Migration to IaaS: this strategy enables migration only by porting legacy systems to the

cloud. This migration strategy is relatively easy and cost effective, and it's the most adopted amongst enterprises.

- Migration to PaaS: this is achieved by migrating the legacy system to the cloud using system refactoring. In this method, the legacy system requires modification to fit the target platform, inability to properly modify the legacy system to fit the target platform can result in missing capabilities, resulting in risk.

- Migration to SaaS: this is divided into three (3) sub strategies, namely replacing by SaaS, revising based on SaaS and reengineering to SaaS. In the first sub-strategy, commercially cloud delivered software completely replaces legacy systems. This strategy greatly reduces migration efforts. In the second sub-strategy, only a portion of the functionality of legacy systems would be replaced by cloud services. Then in the third and final sub-strategy, legacy systems are reconfigured and reengineered into the cloud service. This strategy is usually very challenging, and may require redesigning the structure, reverse engineering, and so on.

Comparison and analysis shows that the seemingly degree of ease or complexity in setting up and running any of the migration strategy is not enough reason to choose one method over the other, the choice of which migration strategy to use must also accommodate considering the ability of the enterprise to perform any requirements involved by any of the cloud migration strategy.

C. Phases of cloud migration

Five phases of cloud adoption process were suggested in [8]

- Feasibility study: this helps to determine the cost and technical issues that must be resolved before cloud adoption. A thorough analysis must be carried out to determine if the cost and technical considerations are optimum.

- Requirement analysis and planning: in this instance, the nature of applications and data to migrate to the cloud is considered. Again, once a decision is made to migrate an application, a cost benefits analysis is done to ensure it is worthwhile.

- Migration: all simple applications to migrate will be migrated and tested, while more complex applications will involve a more rigorous deployment process.

- Testing and deployment: a parallel approach is suggested in which application or processes migrated to the cloud are still available in the premises data centre. However, applications on the cloud will be tested with in-house data and observations made to take care of any discrepancies.

- Monitoring and maintenance: after migration it is essential to keep monitoring the process for security and other reliability issues. Cloud monitoring tools

are available with some CSPs that can be utilized at this stage.

D. Challenges in Cloud Migration

Five major migration challenges were identified in the IDC survey of 2008.

1) Security

Security has always been a major concern with migrating to the cloud. The concern is premised on the issue of data in storage. It is believed it can be a subject of integrity and validity issues. Loss or hacking into an organization's database could result in enormous loss. In addition, multi-tenancy allows the sharing of physical machine using the process of virtualization [4]. A security issue could arise through multi-tenancy, if a malicious user shares resources with a regular user. Data belonging to the regular user could be affected and reputation issues could also arise.

2) Costing Model

The costing model focuses on communication, computation and integration [4]. It may be cheaper to migrate to the cloud in terms of savings or infrastructure, but issues of data transfer and pay-per-use of resources may lead to higher cost. Computer resources may be cheaper for CPU intensive tasks, while other smaller applications may not be cheaper if savings in cloud usage is not lower than data communications costs [4]. Data integration resulting from data utilization among various clouds can also lead to increased cost of migration.

3) Charging Model

The process of elasticity has made analysis of cost more difficult unlike when computing for static resources. A proper charging model must incorporate all aspects of cloud computing. The cost of redeploying and redesigning applications by SaaS providers based on the need for multi–tenancy could be very high. Overall, employing an optimum charging model is important for both cloud user and providers.

4) Service Level Agreements

Cloud consumers do not have control over the resources being provided by the CSP. There must be a means of ensuring that service providers meet their obligations to the consumers. SLA provides a means of striking this balance, but it is important that they are simple to understand and the providers ensure trust in terms of services provided. Based on security concerns, organisations are not subscribing adequately to IaaS as compared to SaaS. Storage and server utilization is low compared to collaboration and management applications.

IV. CURRENT DEVELOPMENTS IN CLOUD MIGRATION

Activities with respect to cloud adoption is very dynamic. There are developments relating to cloud computing on a regular basis. It has been observed that most enterprise applications are not meant for the cloud. Those that can be ported to the cloud required the same management they were receiving while at the on-premise data center. However, most infrastructure needed to support ported application are now available on public cloud [22]. Moving applications to the cloud now provides opportunities to optimize application

and network access. Identity management also needs to be centralized, but access linked into all required locations. In addition, controls that identify a user's location and devices, combined with options for authentication and a one-time password can improve security of an organization's data.

Outsourcing of responsibility on the cloud has led to loss of control by the user, but monitoring application performance can mitigate this risk Disaster recovery and business continuity processes is also important. Risk and Return on investment must also be considered. Utilizing multi region, multi-vendor solutions should be used in terms of time and expenses. Higher bandwidth, low latency connection between locations, and consistency model, could enhance storage and distribution of geographically dispersed data. Services providers offer dedicated links for privacy guaranteed bandwidth and reduced price. However, organisations are now co-locating equipment in cloud-connected environment called cloud exchange that offer high speed connection to multiple cloud providers [22]

A. Steps before Migration

There is a mix of infrastructure for managing an enterprise data on the cloud. Currently, 74% of enterprise managed data are on multiple public IaaS such as Azure, Google, and AWS. In addition, the average enterprise has more than 900 different cloud hosted applications serving different functions. Therefore, while moving on-premise secondary data to cloud storage, it is necessary to maximize cost savings and minimize risk. [23]

- The first step is to know what data is available to an enterprise. It is believed that 52% of an enterprise data is dark, hence there is no knowledge as to if the data is useless or priceless. According to Gartner, it costs about $5M to store and manage 1PB of enterprise data. 41% of dark data is stale, and 15% is ancient, that is, not modified within 3-7years. Therefore, it is essential to classify data to avoid sending dark data to the cloud and waste resources.
- The second step is to know where an enterprise data is. Data must not be put blindly into the cloud to avoid unnecessary duplication. It is believed that 33% of data in the average global enterprise is duplicated. Knowing what data and where it exists can help enterprise prepare for the EU's General Data Protection Regulation (GDPR) which takes effect May, 2018.

An enterprise must be sure that application servers will function and perform well in the cloud. It is possible to host an application server with a high compute and memory resources, but if the bandwidth is not commensurate, it will affect performance [3]. Application must also be portable before it is migrated to the cloud. An application that has external dependencies such as Active Directory dependency or requires access to on-premise SQL server database complicates migration. Another important consideration is scalability. It is true that a CSP can host hardware–intensive workloads with unlimited scalability, but it also comes at a price. IaaS providers charge customers a resources consumption based-monthly fee [3]. Also, it is much easier

to move on-premise workload to the cloud if the servers have been virtualized.

B. Current Trends

According to a recent IDG Enterprises Survey in [24], IT companies have moved 45% of their applications and computing infrastructure to the cloud already. Of the 925 IT decision makers, 70% have already moved one application or a portion of their infrastructure to the cloud. Currently, the average company has 45% of its IT environment in the cloud with 23% in private cloud 15% in public cloud and 7% in hybrid cloud. By the end of 2017, average IT adoption was expected to be 59%, with 28% in private cloud, 22% in public cloud and 10% in hybrid cloud. The average company planned to allocate 45% of its cloud budget to SaaS, 30% to IaaS 90% to PaaS and 6% to others-as-a-service model. The major reason for investing in cloud solution include lower total cost of ownership, replacing on-premise legacy system, business continuity and development.

According to the 2017 cloud migration survey report by Amazon Web Services [25], 28% of computing resources are hosted in the public cloud, 39% use VM, 23% use physical machines and 10% hosted in the private cloud. In addition, public cloud is expected to grow by 28% year-over-year and private cloud by 15%. Virtual machine and physical machine are to decline by 20% and 18% respectively. The top three considerations for choosing a cloud platform are price (18%), security and compliance (17%) and reliability (17%). While the top three drivers for migration are cost (23%), security (20%) and high availability (16%).

V. ANALYSIS OF ISSUES

Table I highlights certain topics worthy of discussion. These topics represent criteria used to compare how much research has gone into discussing certain issues in cloud migration. The analysis highlights four areas (challenges in cloud computing, phases of cloud migration, challenges in cloud migration, and current trends in cloud migration). Several literature were considered in coming up with the discussions and inferences. The authors are listed in no particular order. A total of 29 articles from different authors, spanning the four areas were reviewed and discussed in subsequent paragraphs.

A. Challenges in cloud computing

[21] and [9] discusses the security challenges of cloud computing for the public sector. The author highlights performance, availability, how to integrate with the in-house ICT, ability to customize, on-demand cost, cost of returning in-house, regulatory requirements and sufficient CSPs as issues affecting cloud computing adoption. In [7][4] the authors discussed several generic issues associated with cloud computing including, privacy, reliability, legal issues, compliance, freedom, long term viability and cloud interoperability.

TABLE I.
COMPARATIVE ANALYSIS OF CLOUD MIGRATION ISSUES

References	Challenges in cloud computing	Phases of cloud migration	Challenges in cloud migration	Current trends in cloud migration
R. Craig et al (2009)	x			
S. Mehfuz and G. Sahoo (2012)		x	x	x
F. Sabahi (2011)				
S. Kumar and R. H. Goudar (2012)	x		x	
V. H. Pardeshi (2014)		x		
A. Weiss (2007)				x
D. Agrawal, S. Das, and A. El Abbadi (2010)	x		x	x
A. Youssef (2012)				x
C. F. Obodoeze, F. Okoye, and T. C. Asogwa (2014)	x		x	
V. Pardeshi (2014)		x	x	
D. G. Rosado, R. Gómez, D. Mellado, and E. Fernández-Medina (2012)				
M. Sajid and Z. Raza (2013)	x			
Mrs. Papri Das and Dr. Pravin Bhatawala (2014)	x			
Media.techtarget.com (2015)		x	x	
IDG Executive Summary			x	x
S. O. Kuyoro, F. Ibikunle, and O. Awodele (2010)			x	
Odun-ayo et al (2017)				x
S. Jodhpur, and J. Rajasthan (2015)			x	
K. Choo (2010)				
T. Dillon, C. Wu, and E. Chang (2010)	x		x	
A. Khajeh-Hosseini, I. Sommerville, J. Bogaerts, and P. Teregowda (2011)			x	
V. Vidhya (2013)				x

B. Phases of cloud migration

In [14] a five-phased model for migration, is highlighted which includes feasibility study, requirements analysis and planning, migration, testing and deployment, monitoring and maintenance as components of cloud adoption. [17] stated that the components of phased cloud migration model are the preparation phase, analysis phase, migration to cloud platform, concluding the cloud migration, maintenance and vendor management. [36] presented the five stages for cloud adoption based on Rogers Innovation Diffusion Model.

C. Challenges in cloud migration

[7], [35], [9] shows that challenges relating to the adoption of cloud migration includes security, costing model, charging model and service level agreement. [24] explains that while cloud adoption continues to rise, there is a constant increase in cloud tools and services which provides organizations more cloud choices than ever before. It also stated that more than half of the companies in the US are already migrating majority of their systems or plan to do so in the coming years. [12] discusses cloud migration challenges relating to particular cloud deployment models.

D. Current trends in cloud migration

[5], presents a future situation where all processing power would be moved to the cloud, and users would only have thin clients utilizing resources acquired from the cloud. [35] focuses on the process of shipping disk drives to cloud computing as a solution to the processing problem. Shipping disk drives is a process where cloud service provider receives disk drives from an enterprise and then transfers the data to a local server. [27] presents the adoption of SaaS for e-government on a hybrid cloud type. [33] presents the use of open source cloud computing, which adopts the use of the Hadoop framework, which divides the application into different clusters and assigns them to various independent nodes to carry out the work.

From the foregoing, virtually all the papers considered the issue of challenges of cloud migration. The least focus was on the phases of cloud migration. It was expected that most papers would also examined current trends to serve as stimulus for organizations intending to migrate.

VI. CONCLUSION

Cloud computing is providing reliable, available and cost–effective computing resources to users. In view of this, cloud adoption has been on the increase. The cloud adoption process was discussed showing the steps that can be employed and the challenges of cloud migration. Based on the fact that cloud computing is evolving at a dynamic pace the current trend in the cloud computing was examined using industry surveys carried out by IDG. A future work could be to carry out an analysis of the drivers for cloud migration.

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