International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 8 Issue 12 ǁ 2020 ǁ PP. 01-09

Cloud Computing the New Age of Computing

Eng. Mahnaz Hasan Qabazard
The Higher Institute of Telecommunication and Navigation

Dr. Saleh M. Sbenaty
Department of Engineering Technology
Middle Tennessee State University

ABSTRACT
Cloud computing is seen as an emerging technology that is highly utilized by different industries and businesses to optimize their processes and the conservation of financial resources. Its popularity opens various loopholes and barriers, which are useful, especially when improving its overall performance. This study is conducted to examine cloud computing further so that technological improvements could be suggested. This technology has been attractive to IT developers and end-users because it provides both parties with an increased revenue opportunity. The cost entailed for the purchase and maintenance of physical hosting has been drastically eliminated from them for the end-user. It is also true for the service providers since the increasing number of customers integrating cloud computing to their systems results in increased revenue. However, the technology is facing challenges with security and privacy, workflow optimization, provisioning, cloud interoperability, data management, and the need or architecture modifications. These barriers inhibit cloud computing from achieving their maximum potential in terms of the Quality of Service (QoS) and cost-effectiveness. Nevertheless, metrics could be monitored and measurements that could be done to examine cloud computing's overall performance for the benefits of both the operation and economic aspects. Thus, future studies could focus on these gray areas of cloud computing.

Date of Submission: 01-12-2020 Date of acceptance: 15-12-2020

I. INTRODUCTION

Computing as a service has seen phenomenal growth in recent years. The primary motivation for this growth has been the promise of reduced capital and operating expenses, and the ease of dynamically scaling and deploying new services without maintaining dedicated computing infrastructure. Therefore, cloud computing has begun to transform the way organizations view their IT resources rapidly. From a single system scenario consisting of a single operating system and a single application, organizations have been moving into cloud computing, where resources are available in abundance. The user has a wide range of choices. Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with service provider interaction or minimal management effort. Here, the end-user need not know the details of a specific technology while hosting their application, as the service is entirely managed by the Cloud Service Provider (CSP). Users can consume services at a rate that is set by their particular needs. This on-demand service can be provided at any time. CSP would take care of all the necessary complex operations on behalf of the user. It would provide the complete system that allocates the required resources to execute user applications and manage the entire system flow. This technology's emergence requires further examination to seek more room for improvement in terms of Quality of Service (QoS), operations, and other relevant factors. This study investigates the necessary information about cloud computing, such as the definition, variations, and its architecture and structure. Furthermore, the technology's challenges and loopholes are identified to determine the missing gaps and how future studies could fill them. The state-of-the-art, holistic approach of cloud computing as an emerging technology is also highlighted in the study.

II. CLOUD COMPUTING BASICS

Before understanding the complexities of cloud computing, it is essential to be knowledgeable of the fundamental concepts about it to have a full grasp of its core ideas. Furthermore, the foundation of cloud computing as an emerging information technology must be well-understood so that it could quickly identify the reasons why various industries are so much invested and hooked up with this tool.

2.1. Definition

Mel and Grance (2011) of the National Institute of Standards and Technology (NIST) has provided a sound definition of cloud computing. The concept of cloud computing boils down to allowing access to a shared pool of various computational resources such as applications, network servers, storage, and other services in an omnipotent, highly convenient, and on-demand basis retrieval of information. This system enables customers or clients to enjoy rapid provisioning and releasing. Management efforts are already entailed on the service provider, which gives the end-users tremendous leverage of its full functionality. Simply put, it is a service of providing access to end-users to the resources (tools or applications) that they need (i.e., additional storage of data, network servers, databases, networking, and various software) using the internet (Frankenfield, 2020).

Cloud computing has been highly useful for the end-users due to its on-demand self-service setup, broad access to networks, resource pooling, rapid elasticity, and measured service. Many industries favor this paradigm since it allows end-users to retrieve resources such as hardware and software via the internet in a scalable and virtual manner (Lewis, 2010). Consequently, could computing is not just about providing seamless operation for its end-users, but rather, offers an economic advantage over industries that utilize this IT paradigm. Since the delivery of the resources is via an on-demand basis, the service providers are charging its clients on a pay-per-usage basis. Thus, it gives a considerable advantage economically, especially that clients are considering cost-effectivity.

2.2. Basic information

Kundra (2010) has provided useful statistics that must be pondered when examining how cloud computing has impacted end-users across industries. In her report released by the Federal Government, there is an anticipated savings of around $5.5 million over five years due to the transformation of the systems used for e-mail and other productivity tools into the cloud, which has affected 34,000 employees in the City of Los Angeles. Furthermore, the Department of Natural Resources in Wisconsin has increased its collaboration with the online meeting space that allows its constituents to conduct interactive meetings, information sharing, and conference calls. The report also mentioned that recovery.gov was the first to migrate its government-wide systems into a cloud-based domain. Since the Recover Board has been able to save after this system transformation, a $1 million budget allocation on computer software and equipment acquisition for waste, abuse, and fraud identification was made possible. So far, cloud computing has presented seamless opportunities across industries, including government, private sectors, small businesses, academia, etc. Moreover, this model's overview illustrates a holistic approach to how data and computational information could be managed.

In cloud computing, various deployment models are used to deliver the IT resources from the pool to the end-users; they are delivered via:
(1) public clouds
(2) private clouds
(3) community clouds
(4) hybrid clouds

Consequently, three service models differentiate one type of cloud computing from the other. These are the:
(1) Software-as-a-Service (SaaS)
(2) Infrastructure-as-a-Service (IaaS)
(3) Platform-as-a-Service (PaaS)

These deployment methods and service models will be discussed further in this paper. Nevertheless, the founding knowledge about cloud computing as an emerging IT model was provided, which is essential in understanding this tool's more complex view. Like any other IT tool, cloud computing has specific levels of addressing various computational issues or concerns. Thankfully, Vouk (2008) has provided a clear illustration of the levels of value of the solution for cloud computing. There are categories into which its value could be identified from the end-user’s perspective. The hierarchy includes types such as the service user, service integration and provisioning, service author, and the cyberinfrastructure (CI) developer. Figure 1 shows the schematic diagram of the hierarchy.

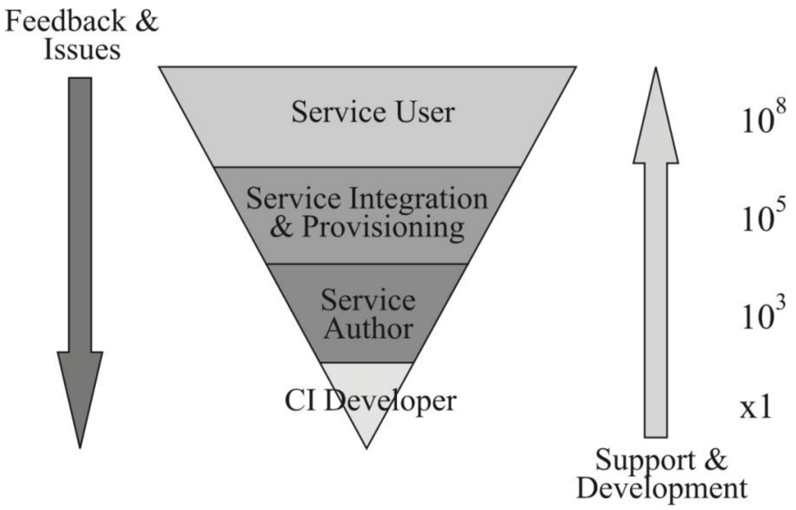

Figure 1. The value hierarchy of cloud computing (Vouk, 2008).

The value in terms of feedback and issues decreases from service user to CI developer based on the figure. It increases from CI developer to service user in terms of support and development. The hierarchy explains that the service user's feedback and issues positively contribute to the value of cloud computing. On the other hand, the CI developer's support and development capabilities are determinant of its value.

The surface-level understanding of cloud computing has been tackled so far. To dig deeper into the topic, the advantages and disadvantages, cloud economics, architectures, various challenges it faces, and some other cloud computing applications will be discussed further in this paper.

III. CLOUD COMPUTING DEPLOYMENT MODELS

Deployment models are used for two reasons: (1) to differentiate the type or classes of consumers of cloud computing and (2) to identify how the computational resources are managed and dispositioned (delivery of the services to consumers). There are two main types of cloud deployment models, namely, public and private clouds. However, two other types are also classified for special cases: the community and hybrid clouds. To better understand the difference among these deployment types, Table 1 summarizes the information about them and describe how one type differs from the others.

Table 1. Cloud computing deployment models (Jansen and Grance, 2011).

Deployment Model	Description
Public clouds	The general public has been granted an available access to the IT infrastructure and its consisting resources that the end-user needs.
Private clouds	The resources are enjoyed by a single organization only, and the control over the access be either on the organization or a third-party. It could also happen that the environment is hosted inside or outside the data center of the organization. Furthermore, it provides a greater control on the organization as compared to what the public clouds could cater.
Community clouds	It is closely similar to the private clouds, but instead of one, the cloud environment is shared by two or more organizations that have similar security, privacy, and regulatory considerations.
Hybrid clouds	It has a more complex system since it is a combination of two or more deployment models (public, private, community) in which the distinction of each organizations is maintained using a standardized or proprietary technology.

IV. CLOUD COMPUTING SERVICE MODELS

As previously mentioned, service models have a vital role in the considerations included in cloud computing. Generally, it does two things: (1) it orders the scope and control of an organization on the computational environment, and (2) it describes the level to which the organization could abstract the resource elements for its specific usage. The three service models for cloud computing are the software-as-a-service (SaaS), infrastructure-as-a-service (IaaS), and platform-as-a-service (PaaS). Each service model will be discussed more extensively in the following subsections.

4.1. Software-as-a-Service (SaaS)

SaaS's focus as a service model lies in the delivery of business-specific functions by the service providers to their clients, such as e-mail or portal for customer management (Lewis, 2010). The good thing about this service model is it ensures that there is flexibility between the provider and end-users when it comes to the delivery of the services (Thomas, 2008). Furthermore, it enables the end-users to maximize the use of the application resources by scaling them up and down, depending on the customers' demand. In this way, the end-users are only to pay the resources that they were able to use. In contrast to the traditional hosting, this method entails a lesser cost to the end-users in the long run, if there is the proper execution of the entire process. This service model also allows the end-users to keep updated on most recent application versions, which does not cause much hassle to them compared to the conventional method. Moreover, there is a holistic approach to collecting detailed information from product defects and performance to usage patterns, which is highly beneficial to product improvement.

Meanwhile, there are some challenges faced by SaaS, which are essential to ponder. Since the service providers can simultaneously support various clients using a shared infrastructure, ensuring the security and privacy of clients' data is of great concern. Another one has something to do with the cloud provisioning. Under and over cloud provision remains baffling to the IT community. Although previously, the burden was on the organizations since they are required to acquire hardware in which they are paying for both used and unused resources; whereas, the concern was passed to the service providers through the rise of cloud computing. The study of Espadas *et al.* (2013) has attempted to create a model that would quantify the under and over-provisioning and suggest a backup plan to allocate the virtualized resources so that cost-effectiveness and scalability of the computational environment could be achieved. Another consideration for this is the multi-tenancy of the SaaS applications in establishing a model that would address SaaS resources' underutilization. Although the under and over-provisioning outcomes of the averages are lowered, underutilization is the only thing that has been improved statistically.

Some of the examples of commercially available SaaS are Google Apps, salesforce.com, and zoho.com. There is a wide range of open platforms that use SaaS as a deployment model maximized by most businesses and other industries.

4.2. Infrastructure-as-a-Service (IaaS)

The goal of the Iaas, on the other hand, is to provide an extended IT infrastructure via the internet for the organization and developer on an on-demand basis (Lewis, 2010). Such infrastructure includes the computing cycles and additional storage. Like SaaS, IaaS has an economic advantage since it allows the access to infrastructure that offers extended computing power, storage, and networking for the IT architects without shouldering its procurement and maintenance (Bhardwaj, 2010). Table 2 summarizes the IaaS service model in terms of its offering, unit of deployment, pricing structure, and customers.

Table 2. Summary of IaaS service model (Bhardwaj*et al.*, 2010).

Offering	Compute power, storage, and networking infrastructure. Some IaaS vendors may also provide Cloud services.
Unit of deployment	Virtual Machine Image
Pricing structure	Compute usage per hour, data transfer in/out per GB, IO requests per million, storage per GB, data transfer in/out storage per GB, data storage requests per thousand. All charges per billing period.
Customer	Software owner that could like an application hosted in the internet for their end-user.

Moreover, IaaS has shown a significant advantage in resource management, which includes the benefits enumerated below:
(1) Scalability
(2) Quality of Service (QoS)
(3) Optimal Utility
(4) Reduced Overheads
(5) Improved Throughput
(6) Reduced Latency
(7) Specialized Environments
(8) Cost-Effectiveness
(9) Simplified Interface

Conversely, there is a rising concern on resource management for IaaS as well, specifically on the following:
(1) Allocation
(2) Provisioning
(3) Requirement Mapping
(4) Adaptation
(5) Discovery
(6) Brokering

(7) Estimation
(8) Modeling

IaaS is crucial for SaaS and PaaS since it is their foundational layer. Thus, it is highly essential to ensure security measures since other service models are highly dependent on the IaaS layer (Arora *et al.*, 2012). Amazon Elastic Compute Cloud, Amazon Simple Storage Solution, GoGrid, IBM Computing on Demand, Microsoft Live Mesh, and Rackspace Cloud are examples of IT tools that use IaaS as their service model.

4.3. Platform-as-a-Service (PaaS)

The purpose of PaaS is to provide the IT developers an on-demand experience of hardware and software that they need in buying, housing, and managing them so that there will be a reduced cost entailed and ease in the development and deployment of applications via computing platform (Jansen and Grance, 2011). It is the most complex among all service models in cloud computing. The development and maneuver of application and its environment are in the full control of the end-user. However, the control over the platform's security and privacy is shared by both the service end-user and provider.

V. ADVANTAGES AND DISADVANTAGES OF CLOUD COMPUTING

Same with any other technology, cloud computing is associated with various advantages and disadvantages. The latter provides a vast room for improvement for this technology; however, there must be immediate action to address them since the technology is dealing with primarily security and privacy issues. A more comprehensive discussion about these will be discussed further in the subsections.

5.1. Advantages

Everything discussed in this part of the paper highlights the drivers that lead organizations to adopt cloud computing into their respective systems. These are the cloud computing features are that make it an emerging technology. Here are the advantages of using cloud computing.
(1) Availability
(2) Collaboration
(3) Elasticity
(4) Lower infrastructure cost
(5) Mobility
(6) Risk reduction
(7) Scalability
(8) Virtualization

5.2. Disadvantages

On the other hand, cloud computing disadvantages establish barriers over the entire end-user experience about technology and its overall functionality. Although cloud computing has been around the corner for long already, it is considered just as a recently emergent technology that needs to be improved to better how the technology functions. Here are some of the areas that need improvement for cloud computing.
(1) Interoperability
(2) Latency
(3) Platform language constraints
(4) Regulations
(5) Reliability
(6) Resource control and management
(7) Security and privacy

VI. GOVERNING PRINCIPLES FOR CLOUD COMPUTING

One of the exciting parts in studying cloud computing is the metrics that must be monitored to determine the technology's effectiveness, the pricing strategies, the revenues, and other relevant attributes. These parameters are discussed more intently in cloud economics. Furthermore, the structures and inner paradigms of cloud computing is highlighted by its architectures and topologies. Understanding these concepts is significant in the study of cloud computing as a new technological approach in IT.

6.1. Cloud economics

Under and over, provisioning still leaves concerns to the IT developers. There are two possible reasons for this: (1) resources are underutilized (over-provisioning) or (2) revenues are not being maximized (under-provisioning). To better understand this concept, Figure 2 illustrates the cases of under and over-provisioning.

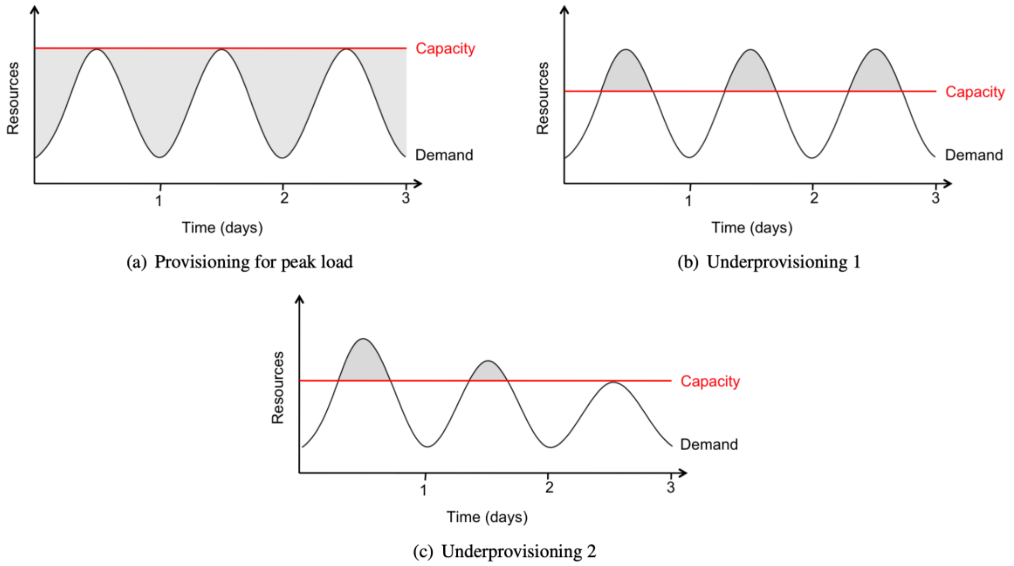

Figure 2. Three cases of cloud provisioning: (a) over provisioning with resource underutilization (shaded region); (b) Case 1 of under provisioning with compromised potential revenue from the end-users (shaded region); and (c) Case 2 of under provisioning with attrition of cloud end-users (Armbrust*et al.*, 2009).

Notice from the figure that provisioning issues result in revenue loss, in any way. For the over-provisioning in Figure 2(a), the resources not being utilized during the non-peak hours of the end-user operation lead to loss of potential revenue if those resources were only used. The revenue loss suggested in Figure 2(b) lies in the under-provisioning revenue opportunities, under-provisioning results in poor service in the end-user. Thus, it causes potential clients attrition because of bad customer experience, leading to a revenue loss, as seen in Figure 2(c). Therefore, it boils down to maximizing the provisioning so that revenue opportunity could be maximized as well.

To determine the higher profit opportunity for the customer, (1) is used. The equation compared the income opportunities between cloud computing utilization and fixed-capacity data center, considering its downsides. Whichever provides a higher revenue is regarded as the better option.

$$UserHours_{cloud}\ \ x\ (revenue - cost_{cloud}) \geq UserHours_{datacenter}\ \ x\ \left(revenue - \frac{cost_{datacenter}}{utilization}\right) \qquad (1)$$

In terms of cloud performance, certain metrics were developed in Lee *et al.* (2009) to understand the effectiveness of cloud computing operations. They were based on various quality attributes such as reusability, efficiency, reliability, scalability, and availability. The monitoring parameters in cloud computing are as follows:
(1) Functional commonality (FC)
(2) Non-functional commonality (NFC)
(3) Coverage of variability (CV)
(4) Utilization of resource (RU)
(5) Time behavior (TB)
(6) Service stability
    (a) Coverage of fault tolerance (CFT)
    (b) Coverage of failure recovery (CFR)
(7) Service accuracy (SA)
(8) Coverage of scalability (COS)
(9) Robustness of service (ROS)

The following equations describe the other factors considered for each metric. Proper solving of each parameter gives a sound description of how a particular cloud computing tool performs. Equations (2) to (13) provides these definitions. The summary of how these metrics are correlated to quality attributes is shown in Figure 3.

$$FC = \left(\sum_{i=1}^{n} \frac{number\ of\ requirements\ appling\ ith\ functional\ feature}{total\ number\ of\ requirements\ analyzed\ in\ the\ domain} \right) / n \qquad (1)$$

$$\text{NFC} = \left(\sum_{i=1}^{m} \frac{\text{number of requirements appling ith non-functional feature}}{\text{total number of requirements analyzed in the domain}} \right) / m \tag{2}$$

$$CV = \frac{\text{(number of variation points realized in the SaaS)}}{\text{(number of variation points in the domain)}} \tag{3}$$

$$Reusabilty = W_{FC} \cdot FC + W_{NFC} \cdot NFC + W_{CV} \cdot CV \tag{4}$$

$$\text{ROS} = \frac{\text{(available time for invoking SaaS)}}{\text{(total time for operating SaaS)}} \tag{5}$$

$$COS = \left(\sum_{i=1}^{k} \frac{\textit{(amount of allocated resources of ist request)}}{\textit{(total amount of requested resources of ist request)}} \right) /k \tag{6}$$

$$CFT = \frac{\textit{(number of faults without becoming failures)}}{\textit{(total number of faults occurred)}} \tag{7}$$

$$CFR = \frac{\textit{(number of failures remedied)}}{\textit{(total number of failures)}} \tag{8}$$

$$SA = \frac{\textit{(number of correct responses)}}{\textit{(total number of requests)}} \tag{9}$$

$$Reliability = W_{CFT} \cdot CFT + W_{CFR} \cdot CFR + W_{SA} \cdot SA \tag{10}$$

$$RU = \frac{\textit{(amount of allocated resources)}}{\textit{(amount of pre-defined resources)}} \tag{11}$$

$$TB = \frac{\textit{(execution time)}}{\textit{(total service invocation time)}} \tag{12}$$

$$Efficiency = W_{SR} \cdot SR + W_{TB} \cdot TB \tag{13}$$

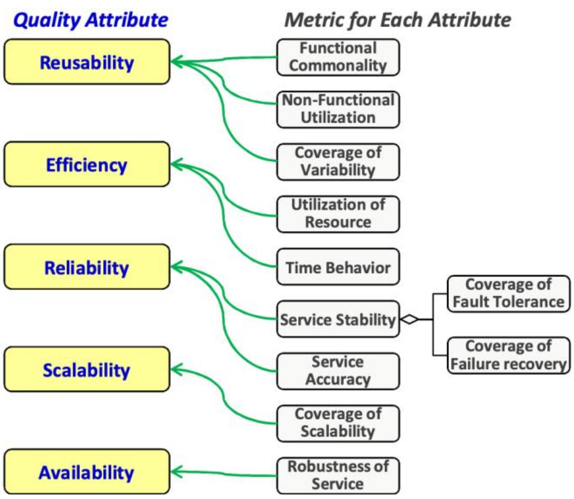

Figure 3. Metrics for cloud computing (Lee*et al.*, 2009).

6.2. Architectures

IT architectures are frameworks that are designed to interrelate the composition of a computing system, such as the hardware, software, protocols, and access methods, physically and in a logical manner (Gartner, 2020). In the context of cloud computing, its architecture consists of different computing layers, depending on the type of service models and the overall procedure. Figure 4 shows a comprehensive architecture of cloud computing.

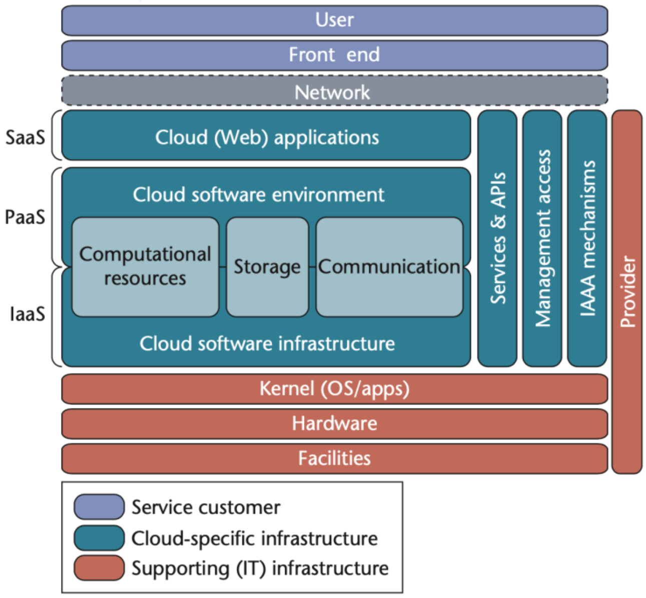

Figure 4. Cloud computing architecture (Grobauer*et al.*, 2011).

Notice that IaaS has the most vital function among the service models since other service models could not exist without it. The assembly of IT components within cloud computing is arranged in an orderly manner. The entire architecture is comprised of various components classified as a service customer, cloud-specific infrastructure, and supporting (IT) infrastructure.

VII. CHALLENGES FACED BY CLOUD COMPUTING

According to the study of Abrishami*et al.* (2012), workflow scheduling has seen to be one of the issues that need to be addressed in cloud computing. Included in this concern are the questionable quality of service (QoS) and the cost entailed in executing a workflow. Since provisioning is one of most researchers' main concerns, it is a remarkable achievement if workflows could be optimized to achieve maximum performance and revenue generation. Another challenge that must be highlighted is the security and privacy issues concerning cloud computing (Grobauer*et al.*, 2011). Nonetheless, current efforts are exerted to address this issue, such as proposing strict security measures that must be monitored and establishing certification schemes for security purposes. Other concerns raised by most studies have something to do with cloud interoperability, data management, and improvements in hardware and software architectures.

VIII. CONCLUSION

To summarize, cloud computing provides many options for the everyday computer user and large and small businesses. It opens up the world of computing to a broader range of uses and increases the ease of use by giving access through any internet connection. However, with this increased ease also comes drawbacks. There is less control over who has access to an organization’s information and has little knowledge where it is stored. Being aware of the security risks of having data stored on the cloud allows more control over some issues raised in cloud computing. The cloud is a big target for malicious individuals and may have disadvantages because it can be accessed through an unsecured internet connection. Nevertheless, the seamless, holistic approach of cloud computing has provided many breakthroughs for both the service providers and end-users.

REFERENCES

[1]. Abrishami, S., & Naghibzadeh, M. (2012). Deadline-constrained workflow scheduling in software as a service Cloud. Scientia Iranica, 19(3), 680-689.

[2]. Armbrust, M., Fox, A., Griffith, R., Joseph, A. D., Katz, R., Konwinski, A., . . . Zaharia, M. (2010). A view od cloud computing. Communications of the ACM, 53(4), 50-58.

[3]. Arora, P., Wadhawan, R., & Ahuja, E. (2012). Cloud Computing Security Issues in Infrastructure as a Service. International Journal of Advanced Research in Computer Science and Software Engineering, 2(1).

[4]. Bhardwaj, S., Jain, L., & Jain, S. (2010). Cloud computing: A study of infrastructure as a service (IaaS). International Journal of Engineering and Information Technology, 2(1), 60-63.

[5]. Espadas, J., Molina, A., Jiménez, G., Molina, M., Ramirez, R., & Concha, D. (2013). A tenant-based resource allocation model for scaling Software-as-a-Service applications over cloud computing infrastructures. Future Generation Computer Systems, 273-286.

[6]. Frankenfield, J. (2020, July 28). Cloud computing. Retrieved from Investopedia: https://www.investopedia.com/terms/c/cloud-computing.asp

[7]. Gartner. (2020). Architecture. Retrieved from Gartner: https://www.gartner.com/en/information-technology/glossary/architecture

[8]. Grobauer, B., Walloschek, T., & Stöcker, E. (2011). Understanding Cloud Computing Vulnerabilities.

[9]. Jansen, W., & Grance, T. (2011). Guidelines on Security and Privacy in Public Cloud Computing. Gaithersburg, MD: National Institute of Standards and Technology.

[10]. Kundra, V. (2010). State of Public Sector Cloud Computing. CIO Council.

[11]. Lee, J., Lee, J., Cheun, D., & Kim, S. (2009). A Quality Model for Evaluating Software-as-a-Service in Cloud Computing. 2009 Seventh ACIS International Conference on Software Engineering Research, Management, and Applications, (pp. 261-266).

[12]. Lewis, G. (2010). Basics About Cloud Computing. Software Engineering Institute, 1-7.

[13]. Mell, P., & Grance, T. (2011). The NIST Definition of Cloud Computing. Gaithersburg, MD: National Institute of Standards and Technology.

[14]. Strowd, H. D., & Lewis, G. A. (2010). T-Check in System-of-Systems Technologies: Cloud Computing. Software Engineering Institute, 1-43.

[15]. Thomas, D. (2008). Enabling Application Agility - Software as A Service, Cloud Computing and Dynamic Languages. Journal of Object Technology, 7(4), 29-32.

[16]. Vouk, M. A. (2008). Cloud Computing – Issues, Research and Implementations. Journal of Computing and Information Technology, 235-246.