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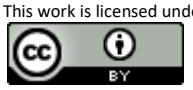

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CLOUD COMPUTING IN HIGHER EDUCATIONAL INSTITUTIONS

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Abstract: The dynamic education environment has compelled educational institutions to discover alternatives to optimize their data technology platform's costs and operational effectiveness. Cloud computing has developed as an important technology that could add more value by offering software and infrastructure alternatives for the university's whole IT needs on the web. In this article, the effect of cloud computing on academic organizations will be discussed and the main variables that make cloud computing excellent in educational institutions. The significance of using private cloud computing in education is demonstrated in a case study conducted at Al-Zaytoonah University (Jordan). The case study results indicate that cloud computing can save the cost and resources of university systems. It also shows that cloud resources offer learners and employees easy access and make cooperation more effective and efficient.

Keywords:Cloud Computing, Private Cloud, Higher Education, Virtualization.

I. INTRODUCTION

Cloud Computing uses a diversity of services, such as servers, storage and database systems, development platforms and software, over the internet, which frequently comes under the name of the cloud [1]. There are generally three cloud computing features, common among all the cloud computing providers [2]:

A cloud provider manages the back-end of the application (particularly the hardware). The customer or user onlypay as use for the services (memory, time and bandwidth processing, etc.).

Many cloud advances are strongly linked with virtualization. Services can be scalability, resource sharing, time sharing, and hardware simulation and emulation [3]. Cloud computing companies are in a position to pool funds which may be split between many customers, and are mainly responsible for payment on request and scale rapidly.

Cloud Computing is quite easy to use. The client does not need any detailed technical knowledge or previous experience in the cloud to utilize cloud services. The client is only communicating with the cloud and the cloud services will communicate with each other to serve the client [4].

Many Educational institutions have been trying in the latest years to restructure their IT operations to get involved in multiple technologies in order to achieve their teaching and learning goals. Educational institutions should always improve their software and hardware to involve learners and trainers and keep pace with rapid IT technology development [5, 6].

One of the challenges that face educational institutions is the software and hardware upgrading. The technology resources upgrading can cost the institute a fortune. Also, the software and hardware setup and integration can also be a headache [7]. Cloud computing is one of the solutions to the previous challenges. It was proved that cloud computing reduces the resource upgrade and installation costs by resource sharing. In addition, it involves the

students and lecturers more in the educational system by facilitating the technology resources reach and use to them. It provides a true opportunity for an institution to reconsider and re-craft services. Many universities, including Washington State and the University of California, greater education institutions in the UK, have acknowledged the ability and effectiveness of cloud computing in academic institutions [8]. This paper discusses the impact of cloud computing on educational institutions and identifies the main factors that make cloud computing beneficial and suitable to academic institutions.

II. CLOUD COMPUTING

A. Cloud Definition

Cloud computing is "*identified as a scalable Information Technology enabled capability in which resources of the computing infrastructure are provided as services over the network*"[9]. These services can be software, platform, and infrastructure. The cloud deployment can be in one of the four deployment models: private, public, hybrid, and community that together provide ways to deliver cloud services [10, 11]. Figure 1 shows a simple cloud computing system.

B. Cloud Deployment Models

The four Cloud Computing Deployment models can be defined as following [1]:

1. **Public Clouds**: The cloud infrastructure is accessible to the public audience or to a big business group and is operated by a cloud services company. Amazon Web Services (AWS), Microsoft Azure, IBM SoftLayer, and Google Compute Engine are examples of the public cloud.

2. **Private Clouds**: The cloud infrastructure that is only available for an organization itself, which means it is not accessible for the public or other organizations.

3. **Hybrid Clouds**: Combines private cloud with one or more public cloud facilities and proprietary software to allow the interaction of each product. A hybrid cloud approach allows companies to move workloads between cloud alternatives more flexibly as requirements and expenses fluctuate.

Community Clouds: Shared cloud computing business setting for small groups or staff (such as companies or directors of trading companies). The Community organizational concept varies, but society participants usually maintain comparable safety, privacy, achievement, and enforcement criteria. Members of the society may aim to invoke an autonomous system to monitor the persons requesting admission into the society.

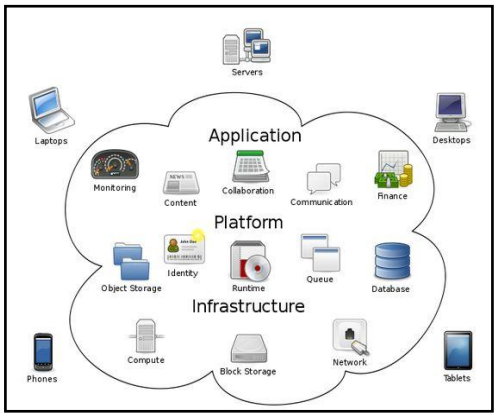

Figure 1. Cloud Computing System

A. **Cloud Service Models**

Cloud computing can be delivered through different service models. The most common models such as SaaS, PaaS, and IaaS. The following identifies and gives examples of each model [8, 12, 13]:

1. **Software as a Service(SaaS)** Applications are installed over a network or the web and accessible via web browsers or using a program interface. Google Apps (email, calendar, and documents) and Office 365 are examples of this kind of cloud architecture.
2. **Platform as a Service(PaaS)** This platform provides a development platform or environment that makes it simpler for the user to develop applications quickly and adopt them instantly. Google App Engine, Windows Azure, and Force.com are examples of PaaS architecture.

3. **Infrastructure as a Service(IaaS)** This platform offers an infrastructure and general purpose support services such as database, storage capacity, networking, and other resources. Amazon Web Services, CenturyLink, and Rackspace are IaaS models.

III. RELATED WORK

A sequence of fresh issues has appeared with an increased amount of people getting an education. For instance, since learning techniques are changing, current learning techniques are not suitable for supply and current learning equipment must also be constantly updated, with continuous development of education [14]. Cloud computing offers a fresh alternative to build a coherent, accessible and multipurpose network learning tool and to decrease access to hardware [15, 16].

The adoption of various technological innovations in academia has been accelerated by cloud computing infrastructures and educational institutions can access the facilities and resources of the educational institutions on request.

Praveena and Betsy [16] delivered a comprehensive overview of Cloud computing implementation at educational institutes. Delic and Riley [17] assessed the

current scenario in the leadership of corporate information and how it would be transformed into a more international, secure and efficient web computing setting. The discussion was held on architectural methods and related applications.
Existing learning architectures that use web technologies such as Web 2.0 and RSS. Also, Mitchell had discussed how educational institutions can benefits from cloud computing technology in sharing and managing the learning resources [18].
Erickson et al. [19] addressed the effect of the provision of cloud services in academia. They conclude by finding certain main values to guide the development of the cloud. Voas and Zhang [20] were implementing the use of OpenStack as a structure for virtual computer laboratories. It was aimed at adapting the web browser for mass activities. They conclude that OpenStack is appropriate for private cloud execution, but stress it is a complex system that requires thorough scheduling prior to execution. Doelitzscher et al. [21] studied the implementation of personal computation, they concluded that such alternatives can enhance computer leadership for programming experience.
However, using cloud computing in educational institutions is not the exception of using the cloud in other applications or institutions in terms of quality [22], legal, security [23] and disaster recovery [24] challenges. Therefore, educational institutions must consider these challenges when applying cloud computing techniques in learning and teaching practices.

IV. Using Cloud Computing in Higher Education

Cloud Scalability and Elasticity are the perfect fit to address higher education developments and difficulties in recent years. Higher education institutions promote a distinctive collaborative culture across professors, students and administrative personnel, often in the presence of geographically-dispersed universities, institutions, and campuses [25]. Today, almost 70 percent of higher education organizations in North America have shifted their management processes into the cloud or are in the phase of shifting them, and approximately 50 percent have embraced cloud-based data exchanging technologies across university [26].
Moving toward cloud computing in educational institutions will decrease the cost of IT infrastructure, release the stress in the Computer Centres, and helps in adapting and installing any new technology in less time and effort. Therefore, cloud computing is very useful for any educational institute.
Cloud computing has in recent years allowed academic organizations to provide many facilities voluntarily or cheaply, often much more than the shared information technology equipment can provide. Free or low-cost cloud-based facilities help teaching, personal communication, material building, publication and cooperation between students and teachers on a regular basis. For instance, Google Apps, YouTube, Twitter, and Dropbox are cloud-based utilities. The facilities connected to the education cloud are shown in Figure 2.

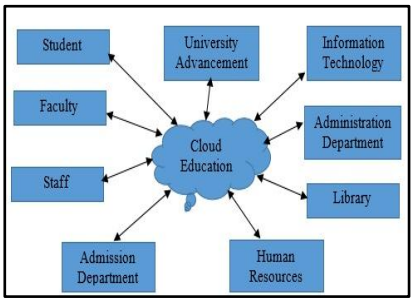

Figure 2. Service of Cloud for Higher Education System

Cloud suppliers compete to meet the requirements of distinct universities with technology and fresh business models. Figure 3 demonstrates how the facilities from cloud architectures can be used by separate agencies and university customers.

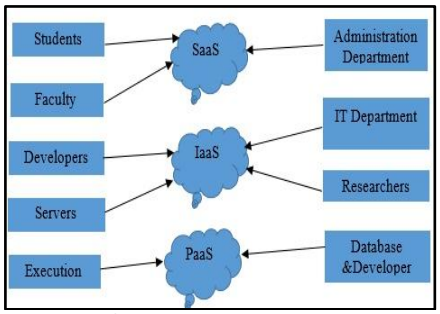

Figure 3. Users of Cloud Computing in Higher Education

C. Advantages and Disadvantages of using Cloud in higher Education

Cloud computing is simple and state-of - the-art technology to use. Cloud technology has many advantages in education as outlined in several studies. Cloud was mostly deployed by the learning management system and the student information system at higher education organizations [27-32].
Table 1 has the advantages and disadvantages of using Cloud Computing in Higher Education institutions.

D. Equations Cloud Deployment in Higher Education Institutions

Cloud technology's capacity for cutting the price of IT facilities, responding more swiftly to fresh possibilities and realizing their complete capacity for better informing future policy choices is quickly embraced higher education organizations. However, organizations of higher education have a distinctive culture and task that impacts cloud computing decision-making. Table 2 shows a review of the designs for cloud implementation and gives us the chance to choose one that is right for our case study.

V. Case Study of Private Cloud Computing Implementation at Al-Zaytoonah University

Al-Zaytoonah is one of the leading universities in Jordan and it has about 10,000 students and staff. One of its objectives is academic excellence and practical teaching skills to its graduates.

Al-Zaytoonah has become progressively dependent on its computing infrastructure to deliver education to its students. Over time, this need for computing infrastructure demands more responsibility from the team to provide IT resources. At Al-Zaytoonah, a class may have 25 students as maximum, and the university could only provide one server for each class or lab. The outcomes of a shortage of providing servers for each class will effect user acceptance, planning failures and activities not proceeding properly. In spite of this, a lot of these servers generally did not operate at full capacity. In addition, server's maintenance was consuming the IT team's time, and preventing them from focusing on more valuable projects. Al-Zaytoonah needed a solution that would agree on deployment flexibility, and enable timely and secure access to servers from portable devices without raising fees. As a solution to all these requirements, Al-Zaytoonah decided to build its own private cloud computing system. Private cloud based systems appeared to be the best option to meet Al-Zaytoonah requirements. The main reasons to select the private model were to reduce associated costs, deliver high quality and consistent services, and to ensure a stable system for students. As shown in Figure 4, the architecture of Al-Zaytoonah cloud computing is based on OpenStack architecture.

Table 1. Advantages and Disadvantages of Cloud Computing in Higher Education

Advantages	Disadvantages
• Enables full user's self-service • Facilitate a stronger learning environment • Cost proficient: pay per use, based on resources consumed • Leverage on big data analytics and mobile computing • Easy customization, continuous improvement • Release resources when no longer needed • Facilitates eLearning & distance education • Reduces cost take advantage of economies of scale across users of cloud • Rapid development/improved mobility • Enables dispersed groups of faculty to meet virtually & easily share information • Reduced system administration overhead • Increased utilization through sharing of resources • Increased/matched reliability and security • More flexibility: acquire resources on demand • Elastic scalability • Ability to mix and match public and private cloud as well as co-located and on-premises physical infrastructure • Choice and agility: 24/7 availability • Little to no maintenance • Built-in disaster recovery capabilities and expertise	• Performance inconsistence due to sharing of resources with various other companies • Not all applications run on cloud • Transparency: not getting a whole lot of insight into your network • Dissemination policies • Standard adherence • Organizational support • Platform inconsistence • Availability of features • Lack of control & options for scalability • Reliability & security • Security gaps & human errors • Organizational support • Network vulnerability

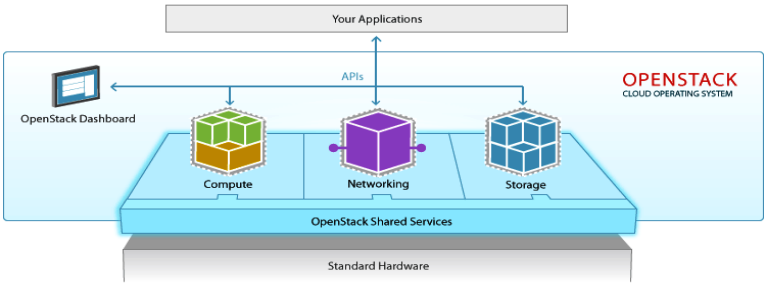

Figure 4. Private Cloud Computing Architecture at Al-Zaytoonah University[33]

A. *OpenStack Components[33, 34]:*

- **Compute (Nova):** The controller for the web computation structure handles ponds and works with virtualization technology, raw materials, and high-level computation settings.
- **Image Service (Glance):** OpenStack Image Service provides digital computer picture discovery, registration, and restoration.
- **Object Storage (Swift):** OpenStack Swift generates unnecessary, scalable memory of available information to record petabytes.
- **Dashboard (Horizon):** Horizon is the approved OpenStack Dashboard application, the only graphical tool for automating cloud-based assets.
- **Identity Service (Keystone):** Keystone offers a key database of customers to which they can tap, plotted against all OpenStack facilities. It integrates with current back-end facilities such as LDAP and acts as a prevalent cloud-based verification scheme.
- **Networking (Neutron):** Neutron offers networking capabilities such as OpenStack network management and IP addresses. It guarantees that the network is not a restricting variable in satellite operation and that the network configuration allows customers to self-serve.
- **Block Storage (Cinder):** OpenStack Cinder supplies specific memory equipment for OpenStack compute instance applications.
- **Telemetry (Ceilometer):** Ceilometer provides a single point of touch for accounting services to obtain all measures for client accounts across all key parts of OpenStack.
- **Orchestration (Heat):** Heat is a resource used by the AWS Cloud Formation model method for organizing various composite cloud applications using both the Query API and the OpenStack natives REST API.

Our private cloud is managed by an IT team. The team is responsible for monitoring its physical condition, virtualization software, hardware and software, open API and enhancing the safety of the software platform.

By using the ID management system, Al-Zaytoonah can assign an ID to all students and staff and this improves management efficiency and security.

For Example, the IT faculty has many labs where installed different tools, web and database servers. To increase the performance and efficiency the IT team creates images and instantiates 20 virtual machines from these images for each lab depending on their needs. The results show that virtualized servers are more reliable than traditional local servers. They had the ability to work and communicate in the educational environment without taking into account space and time. Al-Zaytoonah offered (24 hours/7 days) access to server resources in a cost-effective manner.

To evaluate cloud computing at Al-Zaytoonah, a real test was conducted. General students were able to request the virtual infrastructure they required. The test was done in the second semester of the school year 2018/2019. Table 3 shows values for some performance indicators in Al-Zaytoonah private cloud computing.

Table 2. A Comparison of Cloud Deployment Models

Comparing Cloud Deployment Models	**Public Cloud**	**Private Cloud**	**Hybrid Cloud**
Cloud environment	Multi-Tenancy-Shared environment.	Single tenancy-only for single use of an organization.	Both single tenancy and multi –tenancy.
Data center location	Anywhere – where the cloud service provider's services are located.	Inside the organization's network.	Inside the organizations network for private cloud services anywhere for the public cloud services.
Resource sharing	Server hardware, network and storage.	Hardware, storage and network are dedicated to the use of a single client or company.	Very secure; integration options add an additional layer of security.
loud storage	Public cloud delivers storage as a service on a pay per use basis. Best for backups as a part of a disaster recovery plan as well as archiving email and static non-core application data.	Private cloud delivers internal cloud storage that runs on a dedicated infrastructure in a data center.	Manages streamlined storage that uses both local and off-site resources and serves as a gateway between on premise and public cloud storage.
Scalability	Instant and unlimited	Sacrifices scalability but provides greater control and security.	On demand unlimited resources.
Pricing structure	Prices charged on the usage basis.	Comparatively expensive.	High but delivers competitive advantage
Cloud Security	Good, but depends on the security measures of the service provider.	Most secure.	Secure.
Performance	Low to medium	Very High	Very High

Table 3. Applying Cloud Computing in Al-Zaytoonah results

Variable	Peak hours	Off-peak hours
Max. number of concurrent access	100	40
Stability (number of system failures)	1	0
Availability (in %)	99%	100%

The results shown in Table 3can conclude that all considered indicators are at an acceptable level. The Parameters were measured during peak time where the period of the highest system load and during the off-peak time where the periods of normal system load.

The measured parameters include the maximum number of students that access the system concurrently (number of access), the number of system failures (stability), and system availability in percent. System availability was computed by using the following formula:

$$AV = \frac{NA - ST}{NA} * 100\%$$

Where AV = availability, NA = number of access, ST = stability.

VI. CONCLUSION

Cloud computing could be a rising computing paradigm and next-generation platform which will offer suitable, on-demand access to a centralized resource that will be deployed with negligible management overheads and with nice potency. Changing to cloud computing would change instructional establishments to supply an efficient educational setting to their students and workers while not taking into consideration place and time. It reduces IT Complexity and costs for higher education institutions. In this study, we have a tendency to mention the factors that create cloud computing engagin g to educational establishments, and additionally examined the variations between totally different cloud readying mod els with relevancy their infrastructure, advantages, and drawbacks. Finally, many general samples of the simplest practices for cloud computing usage were provided and a case study from the Al Zaytoonah University was given.

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