Design of Cloud Computing for Educational Centers Using Private Cloud Computing: A Case Study

Ghazwan K. Ouda1, Qahtan M. Yas2.
1Department of Computer Science, University of Diyala, Iraq
2Department of Computer Science, University of Diyala, Iraq
ghazwankhalid84@gmail.com
yahoophd@gmail.com

Abstract. Cloud computing is becoming a popular approach to solve many serious problematic issues since its introduction in 2000. Cloud computing includes data storage in addition to software and hardware sharing via using network infrastructure, computers, and other resources. However, the educational centers are still considered conventional and limited in terms of their existing hardware infrastructure. A case study of cloud computing deployment in the University of Diyala-ICC (Internet and Computer Center)-will be used to illustrate the situation. This study aims to develop a basic cloud-based design for improving the efficiency of ICC laboratories, as an educational center in the University of Diyala to make it a study and research center of cloud computing for computer science students in the university. The proposed design is built via using “Software as a Service” (SaaS) model. Cloud computing in ICC laboratories is designed using Private Cloud Computing. The proposed design provided flexibility to ICC and allows to improve the capabilities of computer network and helps in managing their resources easily.

Keywords: Cloud Computing, Private Cloud Computing, Software as a Service, Network Development Life Cycle, Service-Oriented Architecture.

1. Introduction
Cloud computing is one of the subjects that are often discussed and researched due to their importance, therefore, many universities are starting to get interested in using it and its offered services which are increasingly diverse [1]. Cloud computing helps small and large organizations and developers who are engaged in the field of IT. It provides many facilities including the ease of using the provided services, the ease of updating process for the used software because it automatically updates without the need to be manually updated [2]. Cloud computing works over the internet on a pay-for-use basis by the delivery of on-demand computing resources [3]. It is an abstraction of the complex infrastructure that is hidden and a computational method which is presented by information technology capabilities as a service so that users can access them without knowing what is inside, have experience with it, or have control of the IT infrastructure that helps it [4].

The role of cloud computing in universities should not be belittled, because it can provide significant gains in access to a wide range of research applications, educational resources, and tools. Educational
centers in universities suffer from many problems in both software and hardware resources. The large diversity of software provided by developers is a challenge for teachers due to the need to meet the software needs. Other problems are the high expense, and the difficulty of software update. As for problems of hardware resources, they comprise the difference in the configuration of computers, waste of resources due to data redundancy, and high maintenance costs [5][6].

Cloud computing is useful as a center of learning and research so that more useful educational centers can be built. With cloud computing it will be easier for educational centers to manage software and hardware as well as data that will be stored in a data center, so data security will be safer and more secure. It is expected to achieve flexibility, elasticity, and optimal resources management. Thus, users have a choice of accessing external software that is run on the internet by means of their browsers rather than the need to download the software from the internet. The access of external software via internet is one of the cloud services which is called Software as a Service (Saas) [5].

Private cloud is a type of cloud computing that refers to services delivery over private IT infrastructure in a single organization to meet specific business needs. Private cloud is the best solution for businesses that require direct control over their environments with dynamic computing needs to meet security, flexibility, and control benefits.

In this study, the proposed design comprises private cloud computing and Saas applications, a new approach for ICC laboratories, which focused on the design of cloud computing to meet the requirements of universities.

2. Previous Studies
Cloud computing has got the attention of educational communities. For instance, N. M. Nor et al [7], discussed the delineation of cloud computing in education, they studied the benefits and challenges of using virtual computing labs. Moreover, H. A. Ali et al [6], discussed the concept of virtual labs. However, they proposed a virtual lab architecture based on cloud. The architecture proposed a virtual lab hosted on a publicly accessible cloud-based infrastructure. Similarly, Y. Khmelevsky et al [5], presented an overview for using cloud computing at universities. However, they suggested a prototype design for cloud computing in universities. Furthermore, W. L. Encalada et al [8], proposed a model for implementing virtual computing labs based on cloud computing. This model is designed to assist in teaching practical information technology skills based on social clouds. S. Kumar et al, discussed the characteristics and deployments of cloud computing. They suggested prototype architecture for universities based on private cloud computing [9]. Whereas, G. Zou [10] discussed the problem of the use and management of educational resources in universities. However, he designs a user management system which is based on private clouds.

3. Services Offered by Cloud Computing
Cloud computing can be implemented by providing the necessary components such as servers, hardware, and networks. Cloud computing users can also choose how to use cloud computing services offered as needed [11].

The US National Institute of Standards and Technology (NIST) describes cloud computing as a "Three services models: Software as a Service (SaaS), Platform as a Service (Paas), and Infrastructure as a Service (IaaS)" [7][12].

3.1. Infrastructure as a Service
In this service, the cloud provider affords virtual computing resources in the form of servers, hardware, and networks needed over the internet. Cloud computing users can install and run arbitrary applications they use on that infrastructure. Suppliers can provide such service as Digital Ocean, Amazon Web Services (AWS), Google Compute Engine (GCE).

3.2. Platform as a Service
In this service, the cloud provider offers a complete development and deployment environment which is needed to build applications that will be installed on the servers according to the needs of users. Then users build the applications needed on this platform and use them. This is similar to renting a house with its contents so that users can immediately use the house. Examples of vendors are: Oracle Cloud, Microsoft Azure, Google Cloud Platform.

3.3. Software as a Service
In this service, cloud service provider affords a software that can be accessed by customers over the internet. Cloud computing providers host these applications in their data center/servers and thus customers may access them via a web browser. Examples of these services are: Office 365, e-mail, Google Apps. Examples of vendors: Microsoft, Google, Amazon, and others.

4. Research Method
The methodology adopted for data analysis in this study was based on the application of the network development lifecycle (NDLS) approach. This approach is manipulated to design and develop a wired network infrastructure that allows monitoring of network performance and statistics. NDLC has the ability to develop network infrastructure appropriately and repeatedly. Furthermore, the search results require planning which includes; analysis of hardware and software requirements, user needs, and network topology. NDLC consists of six stages as mentioned in figure 1 below:

![Figure 1. The Network Development Life Cycle.](image)

5. Case Study-ICC Network Analysis
The case study was carried out using a computer network in ICC laboratories that are still conventionally built with Star topology with a central computer as a server used like network controller. The problem is that the application of computers in laboratories is still traditional and limited by the number of Core processors, Memory, and Hard Drive capacity. Another important problem is that data storage is still conventional, i.e. data is stored on computers or storage media such as Flash Disk and/or External Hard Disk by each user. Conventional storage methods are less efficient in distributing data, so they will affect the ability to access data. Therefore, traditional data processing methods are ineffective and automatically affect the performance of computers in the ICC. Moreover, the problem of software inconsistencies used on client computers which need to be constantly updated for each program should also be taken into consideration. Thus, SaaS and private cloud computing were used in the ICC to increase the efficiency of computer network systems. Figure 2 shows the computer network in the ICC laboratories:
6. Requirements Analysis
To achieve the requirements of the ICC network, there are several basic criteria that should be available for the data distributed during storage and processing as availability, security, flexibility and scalability. Generally, data processing and data storage are carried out by standard protocols during the data transfer process. Data storage is an online data storage with cloud computing technology, which is a cloud storage service equipped with a user management system, such as synchronizing contacts, files, audio, photos and other documents on all devices and allows online editing of basic files through the web.

7. Cloud Computing Topology
This section discusses the design of the cloud computing topology adopted to support the case study to achieve the study aims.

7.1. SaaS Component in Cloud Computing
The component of cloud computing application, namely, Software as a Services, is built in a form of services via using Services Oriented Architecture (SOA), with Web Services Standards as a proposed way to link all of these services and applications together. SOA is a methodology to solve the problem by utilizing a particular solution architecture based on the concept of loosely coupled services [13]. SOA solves such problems by building application systems that use a set of services each of which has been designed and built independent of its various implementations [14]. The aim of using loosely coupled services is to increase the maintainability and flexibility of the application because each component will be independent of each other.

7.2. Computer Network Design with Cloud Computing
The new design of computer infrastructure manipulated a private cloud computing infrastructure with the SaaS method. Nevertheless, the Star topology is still used but with connecting cloud computing to it. The resources, in the proposed network model with private cloud computing, are provided with a private network of ICC to meet the needs of users and to ensure network security and the availability of required data.

ICC must be able to build and manage its own computing resources needed in private clouds and also be able to maintain existing networks and the security of the network itself. ICC can use its own cloud server to improve the capabilities of computer networks and make the services offered to students enormous and increasingly diverse. Figure 3, shows the network topology which is designed with private cloud servers:
The addition of a private cloud server aims to give more flexibility for ICC to customize its cloud environment to meet specific needs and to improve security by placing the server behind firewall and by adding data security services. As well, private cloud provides other capabilities such as the ability to offer resources as a service, and resource-sharing.

7.3. Management of Private Cloud Computing
The management of private cloud computing faces many challenges, a fact which is considered a source of significant concern for each developer. Policy issues for private cloud computing are a major challenge that may pose a risk to them, so these policies should be built at a high and reliable quality level to ensure optimal performance of the system.

There are several management stages applied by developers to regulate the performance of computer networks and ensure their optimum performance. Those stages are:

7.3.1. Access Management
Access management is achieved through using Secure Sockets Layer (SSL) certificate that activates the HTTPS protocol and ensures secure connections between client and server. In addition, the authentication of each account includes a user name and password. Additionally, each account has storage limits as well as a limitation in the maximum size of files uploading and downloading.

7.3.2. Applications Management
Applications management take advantage of the services available by SaaS, therefore, the software on client's computer can be managed and controlled. Therefore, a client cannot install software carelessly without permission from server which makes network security easier to maintain.

7.3.3. Security Management
Private cloud computing services was built and run behind a Firewall Gateway system so that they can enhance and guarantee computer network security when accessing cloud services through internet.

8. Server, Computer, and Network Specifications
The recommended specifications for server, computer, and network are as follows:

1) Recommended Server Specifications

Private cloud computing is a cloud computing service that is provided to meet a company's needs through local and internet network access [15]. Hardware systems are chosen to provide the right support now and, in the future, namely:

a) Intel XEON Processor with Quad Core 8 MB Cache,
b) Memory with 8 GB or more,
c) Hard Drive with 1TB SATA or more,
d) DVD/RW,
e) LCD Monitor.

2) Computer Client Specifications

The recommended specifications of the computers used as clients are as follows:

a) Processor: Intel Core i7,
b) Memory: 8 GB DDR4,
c) Hard drive: 350 GB SATA,
d) Network adopter,
e) Operating System: Windows 10,
f) Software: Web Browser, Java Plug-in,
g) DVD R/W,
h) LCD monitor.

3) Recommended Network Specifications

The recommended network specifications are as follows:

a) Category 5 cable,
b) Modular connection type RJ-45 Cat5,
c) NETGEAR (48 port) switches with 10/100/1000 mbps ports,
d) Star topology, making it easier to install, wire, and to detect faults and remove parts from the network that has been built.

9. Conclusion

Developers of educational centers cannot ignore cloud computing services. ICC as an educational center in the University of Diyala suffered some issues and challenges such as the conventionality of storage methods, the non-integration of data processing, and the non-uniformity of software used in client computers. This study discussed the services offered by cloud computing and adopted NDLC approach to analyze the network data of ICC. This study proposed a design of a cloud computing in the ICC to make the software and hardware of computers in the laboratory work better and more efficiently. The proposed design is based on private cloud computing using SaaS deployment model.

Software as a Service is used in computer laboratories to make them better and easier to control. Users of SaaS cannot arbitrarily install and update the software without getting the approval of the server, so there is no disruption of computer networks.

The use of private cloud computing aims to more easily supervise and regulate computer networks in computer labs. Private cloud computing that is built with the service-oriented component approach is an architecture capable of providing an efficient interface for the process of using software and hardware on ICC client computers in computer labs through local and internet network connections.

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