Future Private Cloud Architecture
for Universities

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Abstract. Cloud computing is one of the new and recently emerged research
field which offers resource on demand facility. Education is must for each
society, and this medium of education is imparted through schools, colleges, and
universities. Universities are regarded as highest and elite learning centers.
Technology is rapidly progressing day by day and so the universities have to
update their technical resources too like new tools, equipment, and so on, so that
students can learn new technologies and be better professionals in future.
However, this is quite tedious task as it involves lot of budget considerations.
Even some universities which cannot afford to cope with time due to inadequate
facilities are on verge of extinction. Thus, concept of cloud computing can be
implemented in Universities, and using cloud will not involve much expense as
compared to owning equipment. Hence, in this paper, theoretical concept of
architecture as how private cloud can be used in universities to impart better
education is proposed.

Keywords: Cloud computing · Architecture · Educational institutions

1 Introduction

Cloud computing is a kind of distributed architecture that centralizes server resources
on a scalable platform so as to provide on-demand computing resources and services
[1, 2]. In case of cloud computing, cloud platforms are offered to clients so that they
may use their own cloud as they desire by cloud computing providers. The concept is
same as that of Internet service providers who provide wide quality range of services to
their customers in terms of surfing speed, downloading speed, and much more other

services. It is an information technology deployment model that involves entrusting data to information systems managed by external parties on remote servers or "in the cloud." [1, 3]. Currently, there are three types of services offered by cloud computing providers which are Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS) [1, 4]. Besides, there are four types of cloud which differ only in the type of services, those clouds offer, and these are public cloud, private cloud, community cloud, and hybrid cloud.

With the time, technology is getting more sophisticated and so as the competition. The highest learning centers, i.e., the universities need to cope with very high pace in order to equip students with the must skills so that after their University studies, they can do something for their society by their intellectual ways, skills, and thinking. And getting cloud computing concept in education system is a must step for each University [5]. With the help of cloud computing, students within universities can make use of all tools or services which a cloud will offer, and University does not have to spend much amount of money as compared to getting new tools and equipment. The present research tries to address all this critical issue by proposing a conceptual model of cloud for implementation within Universities.

The organization of paper is as follows: Sect. 2 is related to the concept of cloud computing technology along with its services and types. Section 3 is related to proposed architecture for bringing cloud computing concept in educational institutions. Section 4 is related to benefits of using cloud in educational institutions. The paper is concluded in Sect. 5.

2 Cloud Computing

The concept of cloud computing is quite simple. It is that type of computing which relies on sharing of computer resources rather than having personal devices or servers to handle applications [6]. It is completely Internet-dependent technology, and each client is assigned its own cloud with the help of which that client can use different services like services of servers, storage, manage applications, and so on as per pay service basis. Here, the word cloud is used as metaphor for the Internet [6, 7]. In Fig. 1,
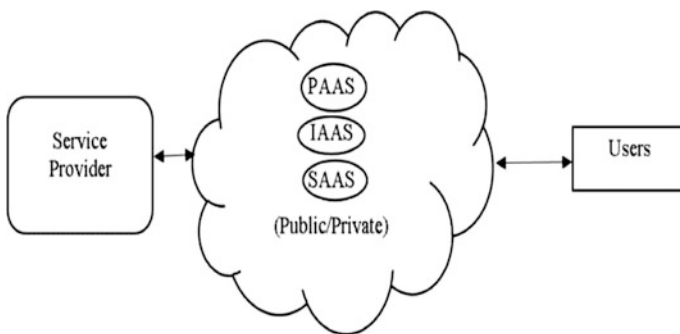

Fig. 1. Cloud computing [7]

general scenario of cloud computing concept is given. Cloud is to be adapted in between Internet service providers (ISP) and end users, where end users are allowed to select any type of required service like PAAS, IAAS, SAAS, and so on.

The primary aim of cloud computing is to perform computations in most efficient way and as fast as it can, say trillions of computations per second [6], and in order to achieve this, it makes use of large number of servers running low-cost consumer PC technology with specialized connections to spread data processing chores across them, and virtualization techniques are used to maximize the power of cloud computing [6, 7]. The cloud computing has four basic deployment models, which are private cloud, public cloud, hybrid cloud, and community cloud [1]. Following is the description of these four deployment models:

2.1   Private Cloud

It is that type of cloud which is private, i.e., owned, leased, or managed by any private organization. This kind of cloud is usually dedicated to single organizations compared to public cloud, that is dedicated to multiple organizations [1]. The users or service providers who use private cloud usually have improved security as compared to public cloud although private cloud is more expensive than public cloud. However, there is no further addition in terms of legal requirements, security regulations, and bandwidth limitations as compared to public cloud. It is more secure due to optimized control of infrastructure than public cloud [1, 7]. Eucalyptus system is one of the best examples of private cloud [8].

2.2   Public Cloud

It is that type of cloud in which users have little control over the cloud, and the control is within third party. In this type of cloud, users simply use the services provided by any third party and are charged according to usage. The third party alone is responsible for all activities of cloud like installation activity, maintaining activity, or resource-providing activity to the end user. At a time, many organizations can use the same infrastructure, and users are given resources dynamically. In this kind of cloud, no access or authentication techniques can be implemented [1, 9]. One of the best examples of this kind of cloud is Google search engine.

2.3   Hybrid Cloud

It is that kind of cloud which is composed of more than one cloud deployment model. In this model, the transfer of data takes place through a hybrid model, which is composed of two or more different models in such a way that transfer of data through two models does not affect each other. The companies can outline the needed services and goals with the help of this model [8]. This model can be useful for some secure services like payroll processing or receiving customer payments [1]. However, there is a major drawback to this kind of cloud, i.e., to get different services from different sources and to implement that from a single location. Besides, even the implementation can get further difficult and complicated if there is an interaction between public and private cloud. Amazon Web services are a good example of Hybrid cloud [1, 10].

2.4   Community Cloud

This kind of cloud is just for a shared cause in which many organizations have some agreement and based on that agreement, these organizations use this kind of cloud and share the required infrastructure such as for banking purposes or any other domain [11]. This type of cloud can be managed either by group of companies or any other third party. One of the best and known to almost everyone is Facebook, which is a community cloud [12].

2.5   Services Offered by Cloud Computing

The services offered by cloud are numerous. However, the main services provided by cloud computing include: (Fig. 2).
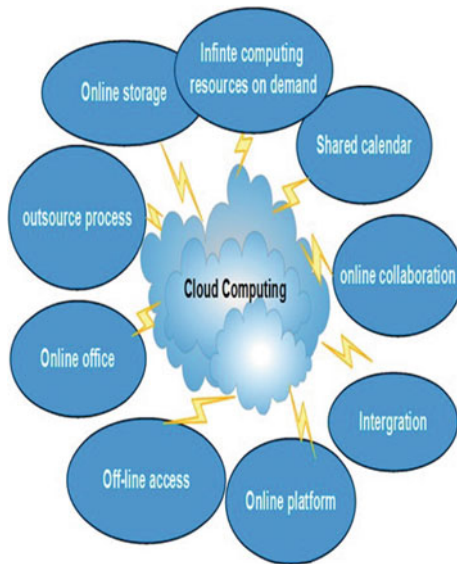

Fig. 2. Services of cloud computing [8]

2.5.1   PAAS (Platform as a Service)

This service is utilized by Web developers for the application development and deployment platform purposes over the Web. All applications with the help of programming languages and tools are developed here. And this service offered by cloud computing is very useful for the developers as they can use the equipment without requiring to have those equipment physically and can develop quality programs and then transfer to the end users via Internet, thus reducing both cost as well as complexity. This is where applications are developed using a set of programming languages and tools that are supported by the PaaS provider [8, 13].

2.5.2   IAAS (Infrastructure as a Service)

In this service, the users acquire computing resources like memory, processing power and storage from IAAS provider, and make use of resources to run and deploy their applications. It allows users to provide resources on demand without requiring any long-term commitment [8, 14].

2.5.3   SAAS (Software as a Service)

In this type of service, the users simply view the software developed by others through Web browser and offer a service to users to buy it. In other words, we can say that, in SAAS, readymade software is developed by some third party and then that particular software is made available to users for using that software. Besides, there are many advantages of this service like users do not need to bother about the version of software as the software gets updated automatically. Also, software will be globally accessible [14, 15].

3   Proposed Architecture

As mentioned above, there are many types of clouds like public, private, hybrid, and so on but in case of universities, private cloud is the best option as control is more in hands of the organization which is using this cloud as compared to public cloud, where control is more in the hands of the service provider [7].
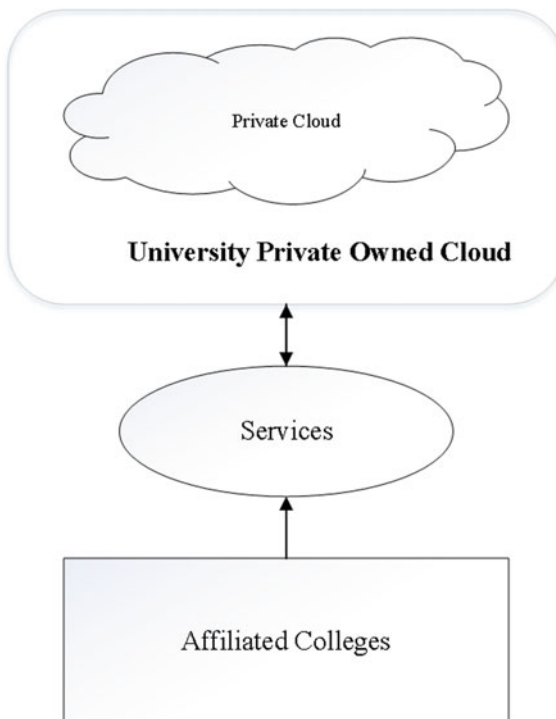
Fig. 3. General scenario of cloud computing service for University and affiliated colleges

The concept is quite simple and general as shown in Fig. 3. There will be private cloud from which University will access it all required services, and in return, other colleges affiliated with that University can also access the required services of the cloud. There can be use of proxy cloud also as shown in Fig. 4 that can communicate with affiliated educational institutions and offer them on-demand services which will considerably reduce burden of entertaining requests from main private cloud of the University.
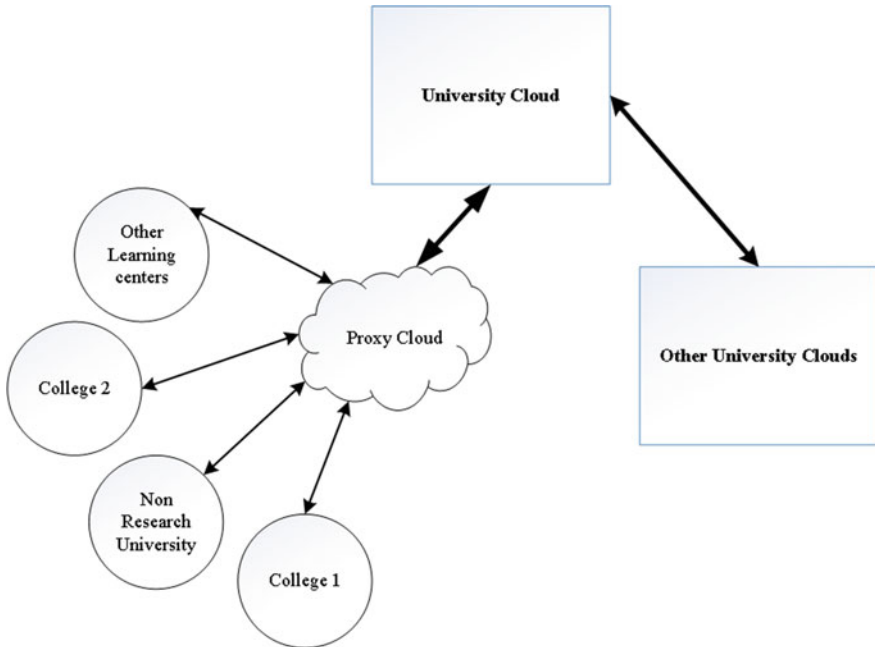

Fig. 4. Cloud computing service for University and affiliated colleges

The first step in this process will be to connect private cloud service within the main University campus itself like connecting its services with different departments and so on. And the second step will be to make use of this cloud service to the affiliated colleges of the University, and future work can be done to connect this cloud with clouds of other universities for further knowledge sharing and making education system more comprehensive and better. The main services that University cloud can provide include:

a. Access to latest software tools.
b. Access to Standard Digital Libraries like IEEE, Web of science, etc.
c. Access to E-books.
d. Access to simulators.
e. Access to networking tools.

f. Access to research grants available in affiliated universities.

These are few main services that can be implemented within the University cloud. Once implemented, the services can be added based on students and academician's feedback. The detailed overview of University Cloud is presented in Fig. 5.
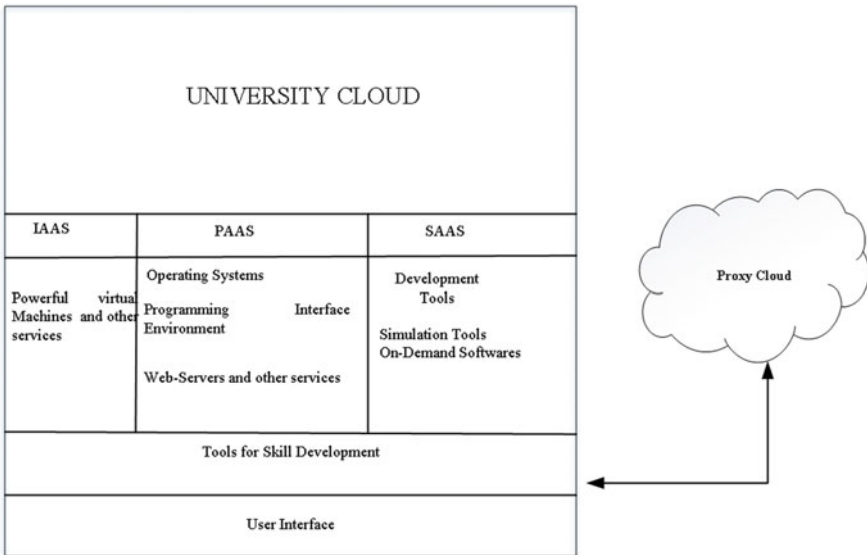

Fig. 5. University cloud features

In the above architecture, i.e., Fig. 5, the proposed conceptual architecture is given. As all are aware of the three main services, which cloud computing offers to its users, but for universities, these services must be classified further. Generally, students and faculty members do not need many services which professionals need. Usually, students need to use simple software tools for completing projects or they need some quality video tutorials for grasping any concept or they need any research material. Similarly, faculty members also do not need much heavy tools or services as compared to professionals. Thus, in order to make process simpler and without overloading the cloud servers, it will be best for cloud service providers to make their services further simpler like, in this paper, the main three services of cloud computing have been further divided into five more categories. By this classification, it will prove much useful to universities in terms of costs, functionality, speed, and so on. University does not need to attain full-fledged services of the cloud. University can only avail few major services like in *(i). Processing* area where universities can attain the benefit of using processing functionality of computers. Similarly, *(ii). reading content service,* where universities can avail the benefit having access to top tutorial, research papers, and so on. Similarly, there is another service of *(iii). innovative ideas*, which will be very useful for students. In this area, new ideas or future work-related concepts should be there so that students

can get the insight of latest trends and it will illuminate them further to get involve in research and invent new things. Other two services include *(iv). Development tools* and *(v). storage services.*

All facilities will be accessed via main server of University provided by cloud. Although, within universities premises, the access to services will be faster but for colleges affiliated to that particular University which is using cloud service, the access to services can be slower depending on the traffic conditions. For that purpose, proxy cloud server can be used as already mentioned above within each college, which can hold records of most widely used services in that college, and this will also reduce burden on main server of University. For example, in one particular college, huge demand is for reading material content, and proxy cloud server of that college can store requests for that service and can fulfill this service instead of main server. These proxy servers will also have to be handled by cloud service providers but based on limited functionality.

4   Benefits of Using Cloud

There will be lot of benefits/advantages for implementing cloud computing concept at University level. Some of the major advantages are listed below.

4.1   Average Hardware Specification of Systems

Cloud computing provides many wonderful services like online storage service, which means that there is no need to buy costly hard drives. It also provides services of processing/computing, which further means universities will not need to buy costly processors which are much expensive [8]. Thus, cloud computing will save considerable amount of expenses. However, University will have to pay cloud service provider the usage charges but still renting charges are always cheaper as compared to buy new equipment. Thus, cloud computing concept for universities will provide economical as a whole.

4.2   Savings in Buying New Operating Systems

Cloud computing will also remove the overhead of buying new operating systems from the vendors and then maintenance of those systems due to the fact that cloud computing will provide itself interface to the users. Users only need open-source operating systems, which are easily and freely available. Users have to simply open their browsers using Internet, and interface will be provided by cloud provider itself.

4.3   Ease of Access to Good Quality Study Material

Access to World topmost video tutorials, quality research papers, and other useful study materials can be provided to the students as well as to the University faculty members at one place. It will save time also for the students who have to surf Internet for some basic information or sometimes trying to find some video tutorial on Web sites like YouTube takes whole day.

4.4   Benefit of Using Latest Tools/Software

One of the most important features which will be most useful for the universities will be: Universities can request to upgrade the software, hardware, and so on, which will be useful for students as well as universities. It will be useful for the students in the sense that they will be always equipped with latest software and tools. And for universities, it will be useful in the sense that University does not have to buy latest hardware tools and software as that work will be done by cloud service provider.

4.5   Ease of Access to Share Information with Clouds of Other Universities

One more important feature of implementing cloud computing concept in universities will be: Universities can share their private cloud by making it public for some duration of time so that two or more universities can share some useful information among themselves related to knowledge-related matters or so on.

4.6   End to Pirated Software

Moreover, this concept of implementing cloud computing in academic institutions can at least stop 50% of software pirating as mostly students use pirated software as they usually cannot afford buying licensed versions of software.

5   Conclusion and Future Work

The main purpose and goal of this paper is to give a notation as how cloud computing can be implemented within educational institutions. In this paper, theoretical architecture is proposed. There will be lot of advantages of implementing cloud computing concept in educational institutions. Some major advantages include access to latest and licensed tools, access to reading content, simulators, enhancement of skill development, and so on. However, for a cloud service provider, it needs huge investment in the initial stages but later on same concept will prove beneficial for the whole world. At the very initial stage, government bodies can also help in setting up this kind of infrastructure. Future work will be to make this proposed architecture more concrete by evaluating flaws on simulator and finally implementing this proposed architecture to some University for verification.

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