



UCloud: The Concept and Design

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Abstract: Cloud computing is an emerging new field of Information Technology both for industry, research, and the education sector. This technology can be utilized in the application areas where computer and related resources are needed for the data processing and knowledge management needs of the organizations. One of the most recent trends is to utilize cloud computing applications in the field of education. This paper presents a university academic cloud model and its necessary components. Since an academic cloud is definitely a new way of delivering knowledge to the community with minimum cost and less effort, it will be highly beneficial if it is deployed in areas where there are lot of problems like physical access to resources and lack of funds. The paper also discusses other important usage scenarios of the presented academic cloud. If implemented, such type of academic cloud can be an asset for a university as well as for the whole user community.

Keywords: Cloud Computing, Academic Cloud, Design and Components, Usage Scenarios

1. INTRODUCTION

Cloud Computing is a recent trend in IT and its basic idea is the utilization of resources which are not available locally in a system (Jadeja and Modi, 2012). Clients request for resources, use them and then give up the resources while paying for them without any installation and maintenance cost (Velte et al., 2009). The phenomenon of cloud has evolved from VPN (Virtual Private Network) which interconnects private and often geographically separate networks to each other, while using a public internet (Jadeja and Modi, 2012). Cloud computing deals with the utilization of distributed resources, minimization of computation time and excludes the overall cost of certain services provided by the service provider (Buyya et al., 2009). It is regarded as the fifth generation of computing after mainframe computing, personal computing, client-server computing and the World Wide Web (Khmelevsky and Voytenko, 2010). The idea of Cloud computing is to provide dynamic resource allocation to clients, resource pooling, on-demand access to the facilities, pay-per-use billing system and anywhere anytime access to the cloud.

National Institute of Standards and Technology (NIST) defines cloud computing as “. . . on-demand network access to a shared pool of configurable computing resources” that can be conveniently and cost effectively provided by the service providers and used by the users (Boutaba et al., 2010).

Cloud computing is being used successfully for different industrial and research related purposes around the world. Amazon EC2, Salesforce's Sales Cloud, Windows Azure, Office 365 and Verizon are some of the industrial application providers. They are providing the latest cloud computing facilities to the people around the globe. Academic clouds are also making their place very rapidly along with other cloud applications.

The paper is organized as follows. Section 2 explains material and methods including a background of the concept of academic clouds and its desired characteristics. Next, results and discussion section presents the concept and design of an academic cloud proposed for the universities of Pakistan, along with some usage scenarios. Section 4 concludes the paper.

2. MATERIAL AND METHODS

2.1 The Academic Cloud

There are certain areas in business and industry in which deployment of a cloud can produce optimal use of computing resources by decreasing the overall cost and maximizing the turn over. In the field of education, especially where computer technology is required, cloud computing can perform over the edge providing optimal and timely use of resources to a large number of users. According to Erkoc and Kert (Erkoc and Kert, 2011), cloud computing may reduce

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a university's IT cost and system's complexity like deployment of a new hardware according to the new updated releases of software. They have proposed a prototype of a university cloud where campuses are geographically distributed. According to them, if universities deploy cloud computing they can well collaborate with the industry and business people and open doors for research advancements. Teachers and students can work well on projects and research activities can be carried out anytime and anywhere according to the feasibility of the researchers and their mentors.

According to Masud (Masud et al., 2012), an academic cloud can be utilized as a personal workspace as every user has his own personalized account. It can be very convenient tool to make teaching and learning interactive. The cloud will have all the data in it and thus a user will not have to take the data with him in a flash drive wherever they go. A repository of data will be available over the cloud and whenever a user switches to another system, they just have to access their data from the cloud. High performance computing power will increase the throughput and response time of the applications as well (Masud et al., 2012).

According to Singh and Hemalatha (2012), "Big Data" (Kaisler et al., 2013) is one of the main reasons of adopting cloud computing. In 2010, Okanagan College's Computer Science Department and King's University College's Computer Science Department started working on a project to develop a cloud computing prototype to be used by both organizations (Khmelevsky and Voytenko, 2010).

Virtual Computing Lab (VCL) at North Carolina State University delivered more than 220,000 user sessions to local students and faculty in 2009. The VCL provides facilities to 30,000 students and was developed as the education and research cloud computing system for NC State University (Rindos et al., 2010).

Many universities have already deployed their academic clouds developed by themselves or by using the expertise of cloud deployment organizations. For example, Amazon Web Services (AWS) has been used by the University of San Francisco, University of California at Berkeley, Harvard Medical School and various other universities for academic purposes. Other cloud applications and web services like ownCloud are also available for creating an academic cloud with certain features. There are certain other tools available in the market and on internet which can be used to create an academic cloud. Ulteo OVD system has been used for creating an academic cloud and is just a software development platform for

creating an academic cloud (Wang et al., 2012). Google Apps for Education and IBM Cloud Academy are also the two main cloud computing facilities for academia.

For any industry, migrating towards cloud computing needs a well defined strategy. Before migrating towards an academic cloud, certain requirements, drawbacks and issues must be addressed first. Storage of digital data is an important service and should be provided to a user on-demand (Masud et al., 2012).

Third world countries suffer from power outages, expensive hardware and software, accommodation of pupils, fewer amounts of books and learning material in hard form, and less faculty members or teaching staff. Due to these problems, education sector is suffering a lot. If there is an academic cloud for university students, it can help the students, teachers and researchers by providing those resources anytime and anywhere around the clock. Providing learning resources to the students whether they are present in the university or at home, living in a rural area etc. The cloud user needs an internet connection and a computer system for accessing the cloud. This is a smarter way of providing education to pupils around the clock and at their own ease.

The following sections present an idea and design of an academic cloud which can be deployed and used by the universities of Pakistan. As students from various near and far flung areas of Pakistan try to take admission in public sector universities but due to less number of seats and resources, universities cannot accommodate a very large number of students. A university academic cloud application will facilitate, further formalize and organize the concept of virtual universities and distance learning. There are certain other factors as well which account for the development of an academic cloud, which are discussed in detail in the following sections.

2.2 Desired Characteristics of an Academic Cloud

Cloud computing in education is relatively a new concept. This section discusses important characteristics of an academic cloud and some of the important service and deployment models that can be used and adopted according to the needs of the academic environment and institutes.

Following are some important characteristics of cloud computing in the context of an academic cloud.

- Students, teachers and general users can access the services provided by the academic cloud via a web-browser regardless of their physical location.

- Network resources like bandwidth etc. will be fully utilized as it will be managed by an expert team. All the users will get a fair share of resources on-demand.
- Universities' technical staff will be trained for installing and maintaining the whole academic cloud. Troubleshooting and dynamic resource allocation will be done by the technical staff after getting a proper training for it.
- Students' and researchers' huge computational tasks can be divided into smaller tasks and computation can be carried out on other systems over the academic cloud. The user won't be able to see where the computation is being carried out and the whole process will be transparent to the user.
- For those students or users which are not a part of the academic cloud but want to avail certain facilities from the academic cloud, will be charged for the services they use. Pay per use rule will be applied here.

2.3 Cloud Models

The followings section identifies different cloud models that can be a candidate for an academic cloud. The models are divided into two main categories.

A. Service Models

The basic three service models of cloud computing can be well integrated into an academic cloud. According to the different needs and requirements of academic users, there can be a different service model. There are basically three service models for cloud computing, namely SaaS, PaaS and IaaS. SaaS stands for "Software as a Service" and users are provided with the commercial software/s which they can use over the cloud (Dialogic, 2010). PaaS stands for "Platform as a Service" and it enables a user to avail the services provided by different platforms in order to run their own applications (Kaiserswerth et al., 2012). IaaS stands for "Infrastructure as a Service" and it enables a user to get access to the hardware related resources provided by the cloud like CPU, memory, bandwidth, computation/processing, storage etc. (Boutaba et al., 2010). Following are some of the scenarios of how these service models can be used in academic clouds.

1) *Software as a Service (SaaS)*: Students and teachers can use Software as a Service. Different software/s can be installed to the academic cloud which can include data processing software, database software, Data Warehousing software, simulators etc.

2) *Platform as a Service (PaaS)*: Students working on their final year projects and researchers

working with certain extensive applications which require certain platforms to run like specific operating systems etc. can use Platform as a Service. Academic cloud can provide different platforms to researchers and students to run their respective applications on them. Also Platform as a Service is provided to the developers to build and deploy their applications.

3) *Infrastructure as a Service (IaaS)*: Infrastructure as a Service can include a wide range of services but for an academic cloud, the main service can be processing power and a large amount of storage space.

B. Deployment Models

An academic cloud can adopt any of the available four cloud deployment models according to the needs of the education environment and the requirements of the institute. There are basically four deployment models, as shown in Fig. 1, which will vary according to the requirements. The four deployment models are Public, Private, Community and Hybrid Clouds. Public clouds serve general public with the cloud facilities by charging them for per-use of the resources. Private clouds serve specific organization. A Community cloud is build for all those organizations which have similar interests and requirements and it is like a "shared infrastructure among a number of organizations". A Hybrid cloud, however, is a combination of different types of clouds; means different types of clouds can share data, applications, etc. For example, an organization's private cloud retains some data in it and also wants to share some of the data with a public cloud. The combination of these two clouds makes a hybrid cloud in this case (Kaiserswerth et al., 2012).

Following are some of the suggestions how these deployment models can be used in academic cloud.

1) *Public Academic Cloud*: This type of cloud can be deployed by those academic institutes which want to share their data and information with the general public. This type of academic cloud can provide education related services with pay-per-use criteria. Security, privacy and data integrity may be at stake.

2) *Private Academic Cloud*: This type of cloud can be deployed in a scenario where an academic institute doesn't want to share its resources with the general public. Only the students and teachers of that institute can use the services provided by the cloud.

3) *Hybrid Academic Cloud*: As the name indicates, a hybrid academic cloud can have a combination of all the other clouds. May be it can have a private and a public academic cloud etc.

4) *Community Academic Cloud*: A community academic cloud can be deployed to let academic

clouds of different institutes share information among them. It can also be deployed to let geographically distributed clouds of the same institute communicate with each other.

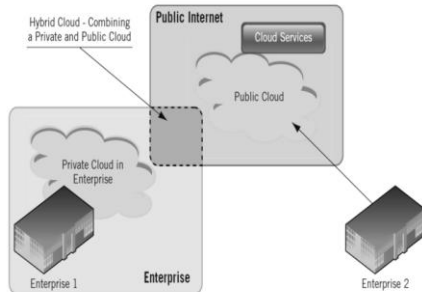


Fig. 1: Different deployment models for clouds (Dialogic, 2010).

3. RESULTS AND DISCUSSION

3.1 Academic Cloud for Universities in Pakistan

In the following sections we discuss the concept, design and requisite components of an academic cloud for the universities of Pakistan.

A. Design

The basic idea of cloud computing remains the same for academic cloud: education for all at anytime anywhere. The main purpose here is to provide education for those who cannot access the university easily due to certain problems. Those people who cannot leave their homes due to certain responsibilities or problems like housewives or handicap people, can easily access the learning material and take lectures at their own prerogative. Hence, the academic cloud's objective fulfills; providing education for everybody.



Fig. 2: Design of an academic cloud.

The academic cloud, as shown in Fig.2, will consist of class lectures, related course books, live video streaming, recorded video lectures, assignments, quizzes, student projects, access to digital library for researchers and teachers, research materials and guidelines, student results and applications. Along with that access to physical resources like computing facility, mass storage, data processing etc. will also be provided through this cloud.

As shown in Fig.3, the communication between users (students and teachers) and the academic cloud will be carried out via an authentication server. The Cloud will have the personalized account for each and every user and they have to pass through the authentication server. They will have to verify their identity before having access to the cloud's resources in order to ensure the security and integrity of the cloud's data.

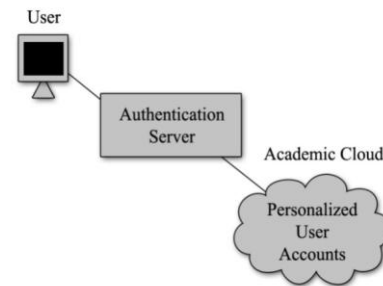


Fig.3: Communication between client (user) and cloud

B. Components of Academic Cloud

The university academic cloud should have the following components, as shown in Fig. 4:

1) *User Account Management*: Every user whether a student or a teacher will have a personalized account. They can access those resources which will be made available to them and can utilize them. A user account manager will manage all the accounts; keeping their information private while providing security.

2) *Storage for Uploaded Data*: A central repository will have storage facility. All the lectures, books, documents, quizzes, presentations, projects etc. will be kept there in separate directories specific to the course.

3) *Processing Servers*: For processing user requests, resource pooling and running various applications simultaneously, there will be processing servers with high processing power in order to meet the on-demand requests from a large number of users at a time.

4) *Resource Management System*: All the resources, whether teaching material, servers, applications and storage, will be managed by the resource management system. It will monitor and control the resources which are available for use and those which have been occupied by the users.

5) *Online Digital Library Management*: For researchers and teaching community, access to the digital library will be provided in the cloud and the library will be managed for the accounts for which it is being provided.

6) *Metering and Billing System*: Those people who want to get certain course contents for learning purposes or want to use a certain application but are not a part of university, will be charged for cloud usage. Same pay-per-use idea will be deployed here.

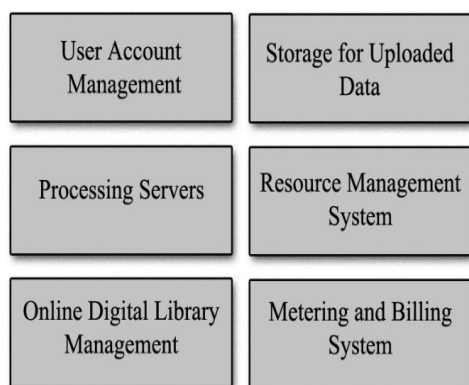


Fig. 4: Components of an academic cloud.

C. Usage Scenarios

Following are some of the most important aspects in which an academic cloud can be very well utilized.

1) *Final Year Projects*: One of the main applications of academic cloud will be to provide assistance to students and teachers in the final year/semester projects. Documentation, data, source code, executable files etc. will be saved to the cloud storage component. Students will upload their already done work over the academic cloud. This will have two main benefits; one is that the most recent updated version of students' work will be available for the whole group and the teacher and second is that there will be no need of taking backup of each and everything on local systems and servers. The academic cloud will have the entire project and related data present in it 24/7.

2) *Research and Development*: The second point in focus is to provide R&D facilities to the research students of software engineering and other disciplines. The academic cloud will have all the research related data, updated news of the upcoming

and already done symposiums, conferences and workshops, proposal formats, bibliographic software along with their respective editors etc. This research portal provided via academic cloud will be highly beneficial and creative as it is going to assist the researchers and their mentors, providing the research facilities and communication, irrespective of their physical location.

3) *Access to Digital Data*: The students enrolled in university can access the digital learning material from anywhere and anytime by using just a computer, laptop, PDA, smart phone etc. and an internet connection. Those students who cannot attend university lectures due to certain reasons can get live lectures (live video streaming) and those who even cannot take live lectures can take recorded lectures in video form.

4) *Evaluation and Examination*: A university's examination criteria can also be benefitted from the cloud. Students will be able to take the exam from any location at a specific time. Teachers can upload the exam questions on a particular date and time and students will be able to get the questions and start solving them. This kind of an exam can be carried out easily by managing the respective user accounts. The examination portal opens up at a particular date and time, pupils get the exam questions, solve them online and then at the specific time the portal closes. In the end, teacher gets all the solved papers, as in the traditional examination and uploads the result after marking them.

5) *Assignments and Quizzes*: Teachers can upload assignments for students, projects and online quizzes. Examinations and quiz results will be uploaded for students. Research students will get benefit from digital library access from home or from anywhere with internet access. Various computer programs, editors for making documents, presentations etc., and image editing software/s, tools, and applications required for research and development purpose will be made available to the users on the cloud for development and general purpose usage.

6) *Communication*: Academic cloud users will be able to make groups and will be able to have a live conversation within the cloud community. By using already existing communication software/s, users will be able to do work in a group online; having data and all the group members present at a time.

7) *Hardware Resources*: Apart from all the software facilities provided by the cloud, there will be some hardware related resources as well which will contribute to the overall resource pool of the academic cloud. Users will get benefit by the storage capacity of the servers present in the cloud. They will be able to store a large amount of data over the cloud.

8) *Data Warehousing*: The university academic cloud will be able to provide “Data Warehousing” (Rainardi, 2008) facilities as well because there will be a large number of storage servers in the cloud. Data warehousing tools will also be available in the cloud. Students and researchers working in this field will be greatly benefited by this because data warehousing tools have certain compatibility issues with different operating systems. By installing the tools over the cloud and providing a huge amount of storage space, the students and the research community will be highly supported.

9) *Incompatible Tools*: There are certain tools which have compatibility issues with different operating systems but are necessary for carrying out research. Such tools are very popular among industry people and are frequently used by students in their final year projects. If these tools are installed on the cloud, then the researchers and students can access them and carry out their work without modifying their local systems.

10) *Data Mining*: Researchers working in the field of “Data Mining” (Thuraisingham and Ceruti, 2000) will also get an edge by this cloud. The data needed by them will be available on the cloud as per their requirements. They will be able to develop the rules and execute the algorithms related to their data mining problem over the cloud with the help of the related data and the tools.

11) *Simulators*: For all the virtual pilot studies, the use of simulators is very common and highly beneficial as it saves time, money, effort and human resources. Researchers working in the fields of networking and middleware need up-to-date and high performance simulators. If these virtual environments are provided to the researchers over the cloud then they will be able to test and validate the results obtained from the simulation and can save the cost of installing the setups over different systems redundantly.

12) *Software Project Management*: Software engineering covers all the fields of computer science involving software development, project management, people etc. Academic cloud gives benefit to the software engineering students and researchers as well. This is done by opening doors to the newly adapted methodologies by the industry people and providing project management expertise to the software engineering researchers. Other related industry practices and expertise can also be available to the researchers and students if the university academic cloud well collaborates with the industry.

4. CONCLUSION

Academic cloud for the universities of Pakistan will be very useful as many rural areas are still

unreachable due to certain factors like distance from main cities, social restrictions like female education, security issues, etc. Students belonging to those areas can make use of this cloud facility to receive proper training and education from their homes without physically attending a university.

Hence, an academic cloud can prove to be a very good solution to the resource problems being faced by the field of education and education will reach to those areas where it is almost impossible for teachers and resources to reach.

Designing an academic cloud for universities in Pakistan is highly beneficial. If the academic cloud is being deployed according to the most specific requirements of the education field, it will prove to be a very good solution to the existing problems in the field of education. The resources will be managed while providing a good level of security and data integrity. The academic cloud design presented in this paper can be successfully deployed if proper funding and expertise is available to build the academic cloud and then manage it in future.

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