# UCloud: A Simulated Hybrid Cloud for A University Environment

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*Abstract*— **Universities all around the world play a vital role in improving the society. But in the current economic crisis, they are facing difficulties in providing necessary resources for research and educational purposes. The solution of this problem is in the use of Cloud Computing. It is a new distributive computing model which provides applications and services over the Internet. In this paper, we investigate, study, and simulate a cloud for a university environment. We propose an architecture based on the hybrid cloud model which uses both the public and private clouds. It consists of two main parts, i.e., the Cloud Management System and the Hybrid Cloud. The proposed architecture is simulated using CloudSim. The evaluation of this architecture is performed for two separate scenarios. In the first one, the number of tasks is kept constant; and in the second, the number of tasks is changed. The results obtained are encouraging and support the use of a hybrid cloud solution for a university. The public cloud is used only to get a better performance or when the load is too high for the private cloud. The results show that high performance can be obtained while keeping the cost low.**

***Keywords—IaaS; PaaS; SaaS; Cloud Computing; Public Cloud; Private Cloud; Hybrid Cloud***

## I. INTRODUCTION

Cloud computing is an emerging technology which introduces a new computing paradigm for the development and distribution of both hardware and software resources [1]. Users of a cloud can access a pool of computer resources (e.g., machines, network, storage, operating systems, and applications) transparently without the need to specify the physical location and organization of equipment hosting these resources. Cloud computing aims to meet the business goals by providing hardware or software resources as services over the Internet to be leased and released by users as in an on-demand and "pay-per-use" fashion. It is more suitable for customers to use and pay for a service when they need it instead of the actual provisioning of resources. Cloud computing can be classified into public, private, and hybrid. In a public cloud, customers rent access to a large pool of scalable resources over the Internet as needed on a pay-as-you-go basis without the capital investment for a data center infrastructure. On the other hand, private cloud customers only get access to computing resources hosted within an organization's infrastructure. A hybrid cloud is a mix of both public and private clouds, in which customers can access computing resources from both cloud types.

The university as a service provider for its community can also benefit from cloud computing and avoid investment on extending their existing infrastructure for offering new services. The usage of resources in a university normally depends on the academic calendar or the flow of campus activities. Therefore, on-demand and "pay-per-use" fashion of cloud computing is better for universities than the investment of an expensive and non-scalable infrastructure, where the utilization of such an infrastructure might be very low at certain times during the academic year.

## II. RELEATED WORK

Wang and Xing analyzed the current technology being used for education in China and presented numerous advantages of replacing it with cloud technology [2]. Normally, a huge investment is made for a campus network while its full potential is never realized. And such campus network is fixed and does not change for years. Today's campus network should be able to support access through the Internet for online education and long distance education. The main advantage for an education institute is the cost savings. In China, Google has launched a cloud of academic cooperation programs with other universities. Tsinghua University was the first university to be a part of it. Other benefits of using cloud computing is making learning easy for the students. Students can connect to the cloud using a standard browser, can create a personalized learning environment, and can also communicate with the teachers anytime and anywhere. Educational institutes no longer have to spend money for commercial licenses, frequent upgrades, and maintenance of educational software. Thus, many came to the conclusion that the future of education technology is in cloud computing. And, this motivated us to design a cloud computing architecture for a University.

University of North Carolina State developed a cloud computing environment named VCL [3] to meet the university's computational and scalability needs. VCL provides the university with a virtualization environment that works as a hybrid cloud model. And, this provides the students and faculty members with services and infrastructure either as a private or extended public cloud.

Our work is an extension of the existing research on the cloud computing technology. We design an infrastructure based on the cloud technology exclusively for an academic environment. And, we base our proposed infrastructure on the

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hybrid cloud model which has not been explored in details in the previous works that discuss the use of the hybrid cloud in universities. The rest of the paper is organized as follows. Section II presents the literature review. Section III presents our proposed hybrid cloud design for a university environment. Section IV demonstrates the experimental and evaluation results. Finally, our conclusion is drawn in Section V.

## III. PROPOSED APPROACH

This project introduces a cloud design for King Fahd University of Petroleum and Minerals (KFUPM) using a hybrid cloud model. The proposed approach is to use a hybrid cloud for a research oriented environment. The private cloud consists of already existing resources at the university. These resources can include computers in the labs, existing grid computers, etc. The public cloud can be a commercial cloud provider such as Amazon EC2, FlexiScale, etc. The first step is to divide the services into 3 categories, i.e., *IaaS*, *PaaS,* and *SaaS*. The services are grouped based on their usage and type. Then, services were assigned to either the public cloud or the private cloud, based on the security requirements for each service and the kind of policies implemented in the University.

The architecture of our proposed university cloud **(***UCloud***)** is shown in Figure 1, and consists of two main components: the Hybrid Cloud and the Cloud Management System.

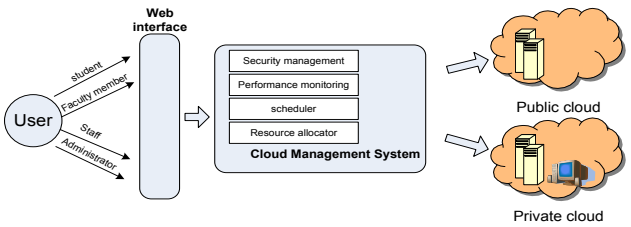


Figure1. UCloud Architecture

### A. Hybrid Cloud

Two types of clouds, i.e., public and private clouds are considered for use. A university needs the private cloud for the highly secure services, while it needs the public cloud for scalability and performance issues. The hybrid cloud offers a suitable environment for university needs, but it also introduces the complexity of determining which services and applications should be distributed across the private, public, or both clouds. Therefore, UCloud distributes the university applications and services over the hybrid cloud depending on the security and privacy requirements of the data content, as well as the performance and scalability requirements. UCloud uses the data evaluation that is already performed by Mircea and Andreescu [4] where the university activities are evaluated according to several criteria, such as mission criticality, importance within the university, sensitivity, confidentiality, integrity, and availability. Applications like Human Resources (HR) and Finance are served by the university's private cloud in order to give more security and control. Thus, only users within the campus can access this type of information. On the other hand, applications in which users require high computational systems or applications that use non-private data, e.g., content management systems (CMS), learning management systems (LMS), student management systems, and virtual learning systems (VLS) are served by the public cloud.

Moreover, the public cloud can offer a suitable infrastructure for those students or researchers who need to solve or test their problems which require high computations. It can also be used for the collaborative and interactive educational systems like virtual laboratory and classroom systems which need high performance resources and a better way of communication and collaboration over a heterogeneous environment.

### B. Cloud Management System

The Cloud Management System (CMS) is responsible of the administration of UCloud and contains some functionality such as security management, resource scheduling (e.g., immediate, on-demand, or for later use), resource allocator, and monitoring the university activities and performance. This information can be used to determine the required resources that need to be allocated in the future.

## IV. EXPERIMENT AND RESULTS

### A. Expermintal Setup

To show how this proposed solution could improve productivity of the university, we simulated a network of a private cloud and a public cloud (e.g., Amazon EC2). Two datacenters are modeled, one for the public cloud and the other one for the private cloud. All UCloud components are simulated using CloudSim [5].

Two classes of datacenter types are instantiated, one for the public cloud and another for the private cloud. The various characteristics of the datacenter can be configured by assigning different values to the predefined parameters in the datacenter class, e.g., by assigning the number 2048 to the variable 'ram'; we create a host which has 2048 MB of RAM. In this way, we simulate a private cloud's datacenter in which 200 machines are hosted and each machine has 2GB of RAM, one CPU which runs 1000 MIPS, and 10TB of storage. Similarly, we simulate a public cloud which has the following characteristics: 1.7 GB of memory, 160 GB of storage, and 1 EC2 compute unit [6] (i.e., 1 virtual core with 1 EC2 Compute Unit). These values for the public cloud are based on Amazon EC2's standard small instance type. In the first experiment, 20,000 tasks are sent to the private cloud as a workload to be processed. These tasks are submitted to the datacenter at the same time. Concerning the pricing policy, we used the Amazon's small instances business model and have chosen the cost of $0.10 per hour for an instance without considering the discount policy of the reserved instances plan [6]. Actually, the cost varies between $0.080 and $0.115, and therefore we have chosen $0.10 as an acceptable estimate for easy calculation.

### B. Evaluation and Results

Finally, we evaluated the proposed architecture based on the hybrid cloud model. The evaluation is performed in such a way as to reflect the real time use of the solution for a university, where there can be sudden peaks in demand for

resources or tasks based on the academic calendar. The following two scenarios are performed to evaluate the effectiveness of a hybrid cloud in reducing the tasks execution time at a reasonable cost. In addition, we evaluate the effectiveness of the hybrid cloud model for universities since the flow of campus activities is frequently changed.

In the first scenario, all the tasks are processed in the private cloud assuming that the university's activities or tasks do not reach a high peak. Then, the tasks are migrated to the public cloud (e.g., Amazon EC2) whenever the private cloud's resources become busy or unavailable. In order to simulate the use of a hybrid cloud, we initially use the private cloud's resources only, and then increase the use of public resources by 10% of the private resources till the use of public cloud resources reaches 100% of the private cloud resources. In each experiment, the private cloud resources used are fixed, while the public cloud resources usage changes by increments of 10% of the private cloud resources. We compute the workload execution time (the time difference between the start and finish of a sequence of jobs or tasks) in seconds as well as the cost of using the public cloud resources in each experiment.

Figure 2 depicts the cost and performance of different combination of public/private cloud. It shows that the performance can be increased with a reasonable cost. This cost includes the expense of leasing additional resources from the public cloud.


Figure2. Public Cloud's Cost vs. Task's Execution Time

The second scenario has a similar setup as the first one. However, in this case, the number of tasks is not fixed, but rather a variety of tasks are generated for the duration of a certain time period, e.g., academic year. The number of tasks is frequently changed to reflect the real load at a university during an academic year. The KFUPM academic calendar is used as a case study, in which most of the activities are happening during the periods of registration and course projects finalization. The migration of tasks to a cloud is simulated by instantiating a number of virtual machines (VMs) in the public cloud. The decision of allocating resources from the public cloud is achieved based upon the utilization of the private cloud's resources. Also, in this scenario, the tasks are allocated to a VM in a time-shared model, i.e., asynchronously. Figure 3 shows that the utilization of recourses from both public and private clouds depends upon the workload. It can be seen from the graph that there are durations in which the workload is very low and no public cloud resource is used. The public cloud is used only when the private cloud cannot handle the total workload. In this way, the public cloud is used only when necessary; and the cost is kept to a minimum. Thus, the adoption of a hybrid cloud for a university environment is a better solution than the investment of an expensive and non-scalable infrastructure.

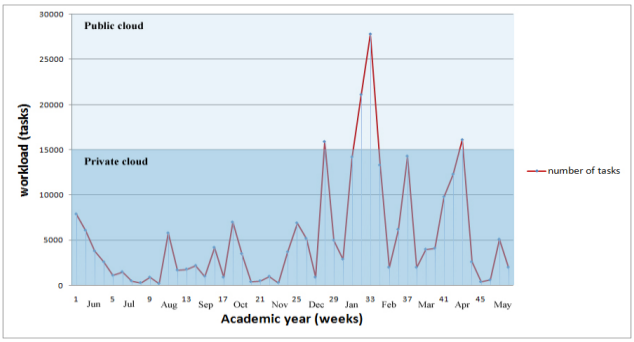


Figure3. Migration of Tasks to the Public Cloud during the academic year

## V. CONCLUSION

Cloud computing is a new paradigm which is a combination and evolution of virtualization, utility computing, *IaaS*, *PaaS*, and *SaaS*. Many governments and corporations have made their decision to support and invest in it. The many cloud-computing benefits are reduction in cost, more utilization of the resources, usability, and high scalability. In this paper, we investigate, study, and simulate a cloud for a university environment based on a hybrid cloud model. The results obtained show that the public cloud is not used all the time. It is used only when the utilization of the private cloud reached its maximum. This shows the applicability and efficiency of using a hybrid cloud model for a university.

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## REFERENCES

[1] Li Guo, YikeGuo, XiangchuanTian, "IC Cloud: A Design Space for Composable Cloud Computing", *In IEEE 3rd Int. Conference on Cloud Computing, 2010.*

[2] Bo Wang; HongYu Xing; , "The application of cloud computing in education informatization," Computer Science and Service System (CSSS), 2011 International Conference on , vol., no., pp.2673-2676, 27-29 June 2011.

[3] Carolina State University (NCSU) VCL cloud computing platform. http://www.ibm.com/developerworks/webservices/library/ws-vcl/index.html.

[4] MarinelaMircea, AncaloanaAndreescu, "Using Cloud Computing in Higher Education: A Strategy to Improve Agility in the Current Financial Crisis",IBIMA publishing, 2011.

[5] Rodrigo N. Calheiros, Rajiv Ranjan, Anton Beloglazov, Cesar A. F. De Rose, RajkumarBuyya, "CloudSim: A Toolkit for Modeling and Simulation of Cloud Computing Environments and Evaluation of Resource Provisioning Algorithms",2010.

[6] Amazon elastic computing cloud. http://aws.amazon.com/ec2/.