

Efficient Utilization of Commodity Computers in Academic Institutes: A Cloud Computing Approach

Jasraj Meena, Malay Kumar, Manu Vardhan

Abstract—Cloud computing is a new technology in industry and academia. The technology has grown and matured in last half decade and proven their significant role in changing environment of IT infrastructure where cloud services and resources are offered over the network. Cloud technology enables users to use services and resources without being concerned about the technical implications of technology. There are substantial research work has been performed for the usage of cloud computing in educational institutes and majority of them provides cloud services over high-end blade servers or other high-end CPUs. However, this paper proposes a new stack called “*CiCKAStack*” which provide cloud services over unutilized computing resources, named as commodity computers. “*CiCKAStack*” provides IaaS and PaaS using underlying commodity computers. This will not only increasing the utilization of existing computing resources but also provide organize file system, on demand computing resource and design and development environment.

Keywords—Commodity Computers, Cloud Computing, KVM, Cloudstack, Appscale.

I. INTRODUCTION

COMMODITY computers form a large part of an academic infrastructure. These computers come from different vendors, have different configurations and generally have low computing power. An institution might have several departments and each of them may have several computer labs. In a typical lab setup, there are several such computers connected by a common network. Thus, the number of such commodity computers is large. It has observed in the laboratory setup utilization of commodity computer is as low as 1-10%. “*CiCKAStack*” has developed using cloud computing technology. Cloud computing is a new technology in industry and academia. The basic characteristics of cloud computing is Pay-per-Use, On-demand Self Service, Rapid Elasticity/Scalability, and Managed Services. Pay-per-Use: End User will pay only for whatever computing resource they are using, On-demand Self Service: End User requests are served without any human intervention, Rapid Elasticity/Scalability: System response gracefully the changing demands of users, Measured/Metered Services: Service/Resource usage has measured and user can query its remaining usage quota [1].

The cloud services are categorized as IaaS (Infrastructure as a Service), PaaS (Platform as a Service), and SaaS (Software

as a Service). Where IaaS cloud provides virtual hardware resources such as CPU, networks and storage with basic OS to facilitate the usage of virtual hardware resources. IaaS service providers are (Amazon EC2, Microsoft Azure, IBM Smart Cloud, and Google Compute Engine). PaaS cloud provides an environment for users to develop and deploy their applications, PaaS service providers are (Google App Engine, Microsoft Azure, Engine Yard). SaaS cloud provide web applications/software over internet network, running on cloud infrastructure, SaaS service providers are (SalesForce, Google-doc, mail, and calendar) [1], [2].

Further the cloud services are provisioned using private, public, community, and hybrid deployment model. *Private cloud* managed, owned, and operated by a single organization/institute. It provides highest level of security, and reliability. *Community cloud* is owned, managed, and operated by one or more of the organizations in same community. In *Community cloud* infrastructure may exist within any one or more organization premises. *Public cloud* is managed by cloud business vendors (Google, Amazon EC2, IBM, and Oracle) or government organizations. It may exist on the premises of the cloud provider and anybody can use this deployment model. *Hybrid cloud* model is a combination two or more distinct cloud deployment model (Private, Public, Community). The deployment model in which an organization provide and managed some resources in house and has others provided externally. For example one may use public cloud service such as Amazon-EC2 for computing but continue to maintain in-house data storage [1]-[5].

In this paper the focus is on to increase the utilization of commodity computing resources, keeping in view by providing virtual machine to students and instructors so that they can keep their files and personal setting organized and develop applications on provided platform. This is achieved by “*CiCKAStack*” which provides cloud services over unutilized computing resources, named as commodity computers. “*CiCKAStack*” also provides IaaS and PaaS together as a service using underlying commodity computers.

The remaining section of paper is organized as follows. Section II presents related work to cloud solution for academic institutions. Section III focuses on problem analysis, Section IV provides the proposed solution and architecture of “*CiCKAStack*”. Section V presents implementation and setup, Section VI performance analysis of developed cloud and section VII presents the conclusion.

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II. RELATED WORK

Cloud computing has great importance in industry and academia [2]. Cloud computing provides the required computing resources on demand. So, that the service requester can focus on their respective work rather setting up IT infrastructure. The cloud provider guarantees to deliver required services to the service requester. All the required computation, storage, network development platform, software and simulators are the responsibility of cloud provider to available to service requester.

There are various cloud solutions are available for academia. Some genuine efforts which also help us to understand the importance of cloud computing for education institutes has presented.

A comparative study has performed by Telefonica Labs, Madrid, Spain on the usage of cloud technology and its impact on the performance of students. Study has reveals that *Infrastructure as a Service (IaaS)* will serve to conduct laboratory work for operating systems, Data Storage and Probing Routing. However, *Platform as a Service (PaaS)* is considered as easy to learn and use and may be a better choice for higher level education courses. However, as per usage of traditional systems are considered they are more appropriate for advanced system management courses [6].

Further, there are few cloud implementations available in Indian institutes as discussed as follows: A group of undergraduate student of IIT Delhi, India has designed and implemented academic cloud named as "*Baadal*". It is based on private cloud deployment model, which allows academicians and researches to request multiple instances of configurable (requesters are able to specify system requirement) VM (virtual machines). VMs can be assessable from remote desktop connection or command line interpreter. However, these VMs are highly modular, with each module is bundled with requested set of hardware configuration which is previously approved by the concerned faculty and cloud administrator [7].

Furthermore, a private cloud has implemented in IIT, Roorkee, to provide Infrastructure as a Service (IaaS) to the instructors, student and researches, because of deployment model its provide highest level for security for the users since all infrastructure has hosted in premises. The private cloud has developed using open-source cloud computing tool-kit OpenNebula [8].

In addition to these implementations there are various private cloud deployments in Educational Institutes/Universities around the world. Usually these cloud deployment called Virtual Labs or VLabs. VLabs are accessed through remote desktop connection or command line interpreter. VLabs are usually provided with operating systems to gain access to virtualized hardware with a facility to change underlying hardware configuration. Every VLab is configured with operating systems, office productivity suites, software developments, and statistical and mathematical modelling software, without the need to install it on physical workstations or on student-owned computers. VLabs are

successfully deployed in following universities that is shown in Table I.

TABLE I
VLABS DEPLOYMENT [9]-[12]

University	Hypervisor	Services
George Mason University	Apache VCL	General purpose computing laboratory
SUNY Buffalo University	Citrix XenApp	General purpose computing lab and common data storage
University of Alaska	VMware ESX and Lab Manager	Primarily supports engineering students
University of North Carolina	Apache VCL,	General purpose computing laboratory

So, literature review raises two important concerns. First the use of cloud computing technology is very limited in Indian institutions and second the cloud deployment is using Blade servers or other high performance CPUs which is not cost effective. However, there are large number of unutilized commodity computing resources are present in academic institutes.

As per Literature review there is no such solution exists that uses the commodity computing resources. So this paper proposed a solution which uses commodity computing resources to provide cloud services. Next section has discussed the problems that an academic institutes faces in their daily routine.

III. PROBLEM ANALYSIS

Commodity computers form a large part of an academic infrastructure. These computers come from different vendors, have different configurations and are generally used for low-intensity computations. A typical institution which uses commodity computers in Labs or for individual operations faces the following problems:

A. Utilization of the Resources is Non-Uniform

In a typical scenario, each student is assigned a computer for use during the lab timings. Now, one student might be using it for web-browsing and the utilization may not exceed 10%, while the other student may be running a multiple file compile which cloud take up to 90% of the available CPU resource.

Also the systems are heterogeneous with varying amounts of main memory and secondary storage, different architectures and thus different performance levels. This further intensifies the non-uniform usage. Thus, while one system may be running at its maximum performance level, another might be grossly underutilized. This leads to wastage of important computing resources which could be used more efficiently.

B. User Files and Personalized Settings Are Unorganized

Lab computers are generally shared by several students. Now every student has their own preferences of the operating system, browsers, Word Processor, etc. Before using a particular system, the student spends a lot of time in installing their favorite application or configuring the system to their specific needs. Also, as with all shared systems, the student has to take care of their personal files. Student may upload it

on a cloud or copy it to a mass storage device. But ultimately that has to manage at the level.

C. Setting of Development and Deployment Environment Requires Significant Effort to Build, Configure, and Maintain

It has often seen that the setting of development and deployment environment is timing consuming and exhaustive which requires significant effort to build, configure, and maintain. So, rather the student concentrates on actual problem of application development his valuable time waste in setting environment. PaaS allows application developers to quickly and efficiently built and deploy web/mobile applications.

Further, the next section has discussed the proposed solution and architecture stack of “CiCKASStack”.

IV. PROPOSED SOLUTIONS

The “CiCKASStack” is a stack that has been design using following open source technologies such as Cent OS, CloudStack, KVM and AppScale. Fig. 1 represents “CiCKASStack” layered architecture design. The base layer contains the physical hardware such as CPUs, Storage, Network, and Database. To provision IaaS (Infrastructure as a Service) “CiCKASStack” has used OS based virtualization technique.

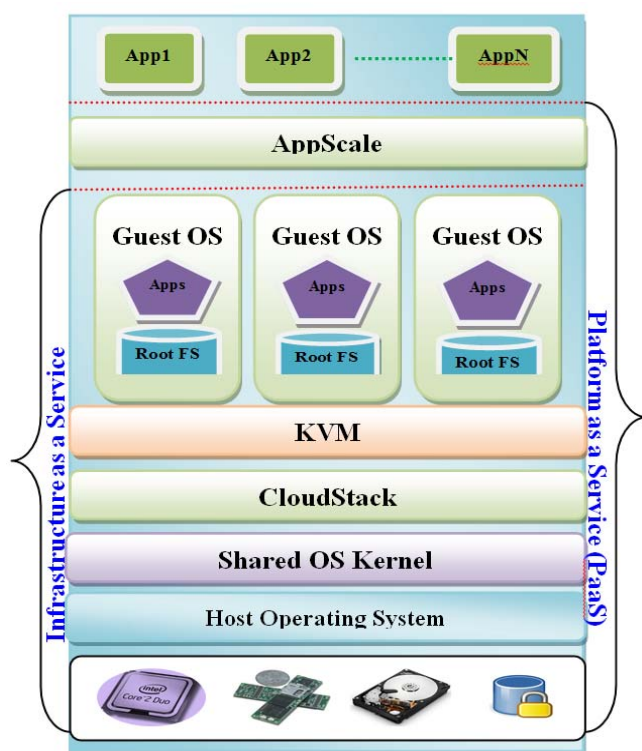


Fig. 1 CiCKASStack Layered Architecture

This virtualization technique uses single shared kernel to run multiple instances of virtual machine on single host operating system. This technique is ideal for to offer multiple

operating systems in secure and efficient manner to run applications. The OS based virtualization technique is achieved by CloudStack and KVM. CloudStack is open source software for providing Infrastructure as a Service to the end-user. It is design to deploy and manage large networks of virtual machines. It uses virtualization technique such as KVM, Xen, VMware, However, “CiCKASStack” uses KVM. KVM (Kernel based Virtual Machine) provides full virtualization solution for Linux. Using KVM technology provider can create number of virtual machines, each machine has private virtualized hardware such as cpu, storage, network and database. These three layers (base layer, CloudStack, and KVM) together provide IaaS [13]-[16].

On the top of IaaS, AppScale is used to provide PaaS (Platform as a Service). AppScale allows application developers to quickly and efficiently built and deploy web/mobile applications. As shown in Fig. 1, AppScale has been configured on guest operating system (say for example Cent OS 6.3) that gives an environment to application developers that they can design, develop and deploy applications based on some programming language like Java/Python/GO [17], [18].

The problems discussed in Section III are resolve using “CiCKASStack”. The solutions provided by “CiCKASStack” are as follows:

A. Utilization of Resources Are Non-Uniform

The student can request for a virtual machine as per their requirement, on receiving the request from student the admin approve the request. After the approval, “CiCKASStack” provides a suitable virtual machine using virtualization technique. In this way computing resources has provided as per user requirement which simply eliminate the wastage of computing resources.

B. User Files and Personalized Settings Are Unorganized

Once a virtual machine has provided to the student; student can install their personalized software and use provided disk space quota to save their documents and other needed media files.

C. Setting of Development and Deployment Environment Requires Significant Effort to Build, Configure, and Maintain

“CiCKASStack” provides platform as a service to the developers. On the top of IaaS, AppScale is used to provide PaaS (Platform as a Service). AppScale install on our own cloud infrastructure and provide design, develop and deploy environment to the students. [18].

So, the problems discuss in previous section “CiCKASStack” outstands in terms of performance and provide an efficient solution which not only increase resource utilization but also increase the ease of use of the systems. Next section has discussed the implementation of “CiCKASStack”.

V. IMPLEMENTATION AND SETUP

The overall system consists of two types of nodes name as management node and compute nodes. The management node

performs the allocation of computing resources and virtual machines to host and assign storage and IP address to the virtual machine. The compute node or hypervisor use to host the virtual machine. The “CiCKASack” is developed in department laboratory where a large number of general purpose commodity computers are resided. We have selected 20 commodity computers having better configuration used as computing node to provide computation facility to management node. The other remaining systems are used as requester node which is using cloud service over network. The configuration of management server and host/hypervisor is as shown in Table II.

TABLE II
NODE CONFIGURATIONS

Node/Server	Management Server	Computer Node
CPU	17, 4Cores, 3.5 GHZ.	17/15/13, 4/2Cores, 2.4-3.5GHZ
Primary Memory	16GB	2-4GB
Secondary Memory	1TB	500-1TB
OS	CentOS 6.3	CentOS 6.3
Hypervisor	KVM	KVM
NIC Card	1	1

“CiCKASack” provides IaaS and PaaS using CloudStack, KVM and AppScale

The elements of CloudStack are shown in Fig. 2. These elements are required to configure with recommended settings and IP addresses to add to the management server.

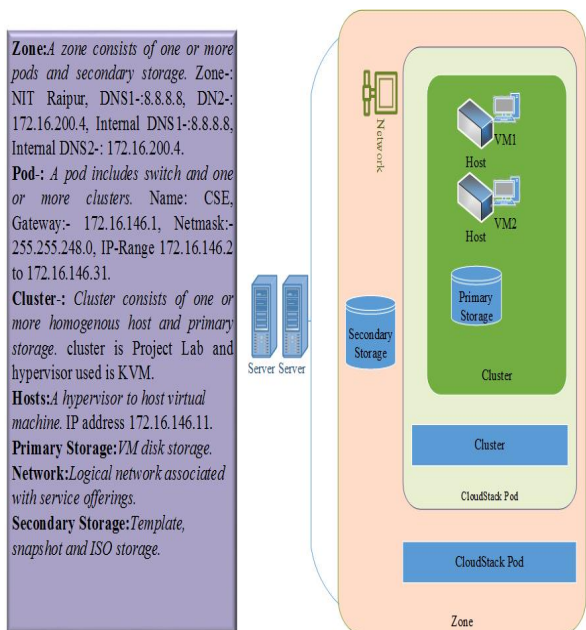


Fig. 2 Elements of CloudStack

A Management Server/Administrator add Host, Primary Storage, Cluster, Pod, Network, Secondary Storage, and Zone. After adding all the supporting elements the cloud is successfully created.

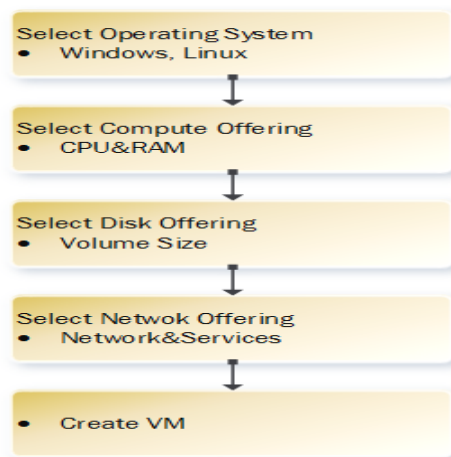


Fig. 3 Virtual Machine Instance Creation Steps

Further the cloud administrator can see the available infrastructure such as CPU, primary memory, secondary storage, available templates on dashboard provided by CloudStack. The dashboard provided information about current availability of system resources [13].

Further Fig. 3 shows the steps to create virtual machine instance. In “CiCKASack” an instance is created as shown in Fig. 4. The student/faculty member add instance, select a zone: NIT Raipur, select ISO or template: ISO CentOS-6.5x86_64-minimal.iso/Windows option can be selected, compute offering: small/medium/large select as per requirement, disk offering: small/medium/large, affinity: not any affinity group, network: default, and finally student/faculty member can check and review to confirm all the details before launching the VM. Further student/faculty member can see the number of VMs created from their profile.

Please review the following information and confirm that your virtual instance is correct before launch.

Name (Optional)	CentOS	
Add to group (Optional)		
Zone	NIT Raipur	Edit
Hypervisor	KVM	Edit
Template	CentOS-6.5-x86_64-minimal.iso	Edit
Compute offering	Medium Instance	Edit
Disk Offering	Small	Edit
Affinity Groups	(None)	Edit
Security Groups	default	Edit

Fig. 4 Virtual Machine Instance Creation

Now the student/faculty member can install required softwares, store large amount of files. So, “CiCKASack” successfully provide Infrastructure as a Service to the students/faculty members.

“CiCKASack” also provisioned PaaS (Platform as a service) to the students/faculty member. The administrator

adds new template AppScale in the Infrastructure as shown in Fig. 5. AppScale gives an environment to application developers, so they can design, develop and deploy applications [17], [18].

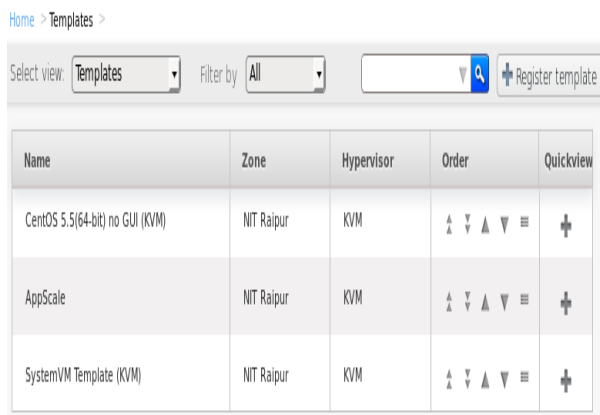


Fig. 5 AppScale added in Infrastructure

This section shows implementation of “CiCKASStack” which provide cloud services over unutilized computing resources, named as commodity computers. “CiCKASStack” provides IaaS and PaaS using underlying commodity computers. The next section presents performance analysis of “CiCKASStack”.

VI. PERFORMANCE ANALYSIS

In this paper “CiCKASStack” is developed and implemented. The developed stack has tested and analyze. When the stack is compared to traditional infrastructure utilization of commodity computer has increased. It has shown in Table III that virtual machine provided over physical machine have better computing power. It also provides design, develop and deployment environment for cloud applications. So, that the students/faculty/researcher are only focuses on development and coding of application without being concern about setting and maintaining underlying IT infrastructure.

TABLE III
VIRTUAL MACHINE INSTANCE CONFIG

	Before	After
System	Physical Machine	Virtual Machine
CPU	Pentium IV	17/As per Request
Memory	1024 MB	4GB/As per Request
Hard Disk	250GB	As per Request

This development is also economically suited to the academic institutes since it provides better facility over existing physical resources. Further a comparison has drawn for the existing private cloud deployment in academic institutions with “CiCKASStack” shown in Table IV.

TABLE IV
COMPARISON OF EXISTING SYSTEMS VS “CiCKASStack”

Services	IIT Delhi (Baadal)	IIT Roorkee	“CiCKASStack”
IaaS	Y	Y	Y
PaaS	N	N	Y
Commodity Computers	N	Y	Y
Cost Efficient	N	Y	Y

The development of “CiCKASStack” provides cloud services over unutilized computing resources, named as commodity computers. The cloud development increases the resource utilization and overcome the important computation wastage which ultimately leads to provision of cost efficient commuting to academic institutes.

VII. CONCLUSION

“CiCKASStack” outstands in terms of performance and provide an efficient solution which not only increase resource utilization but also increase the ease of use of the systems. “CiCKASStack” provides cloud services over unutilized computing resources, named as commodity computers. It also provides IaaS and PaaS together as a service using underlying commodity computers. Further future work directed towards to deploy “CiCKASStack” over large number of node and even in multiple education institutes for better utilization of resources and to also support cpu intensive task.

REFERENCES

- [1] P. Mell, T. Grance, “The NIST definition of cloud computing,” *NIST Special Publication*, 2011.
- [2] MD. Anwar Hossain Masud, J. Y ong, X. Huang “Cloud Computing for Higher Education: A Roadmap,” in *Proc. 16th International Conference on Computer Supported Cooperative Work in Design*, Wuhan, 2012, pp. 552-557.
- [3] Ş. A. Rădulescu, “A Perspective on E-learning and cloud computing,” *Procedia - Social and Behavioral Sciences*, vol. 141, no. 25, 2014, pp. 1084-1088.
- [4] T. Ercan, “Effective use of cloud computing in educational institutions” *Procedia - Social and Behavioral Sciences*, vol. 2, no. 2, 2010, pp. 938-942.
- [5] A. José González-Martínez, L. Miguel Bote-Lorenzo, E. Gómez-Sánchez, R. Cano-Parra, Cloud computing and education: A state-of-the-art survey, *Journal of Computers & Education*, vol. 80, 2015, pp. 132-151.
- [6] L. M. Vaquero, “Edu Cloud: PaaS versus IaaS cloud usage for an advanced computer science course,” *IEEE Trans. on Education*, vol. 54, no. 4, 2011, pp. 590-598.
- [7] A. Gupta, J. Kumar, D. Mathew, S. Bansal, S. Banerjee and H. Saran, “Design and implementation of the workow of an academic cloud,” *Databases and Networked Information Systems (LNCS)*, vol. 7108, 2011, pp 16-25.
- [8] S. Horrow, S. Gupta, A. Sardana, “Implementing private cloud at IIT Roorkee: An initial experience,” in *Proc. International Conference on Advances in Computing, Communications and Informatics*, Chennai, India, 2012, pp 453-458.
- [9] <http://www.vcl.gmu.edu>
- [10] <http://ubit.buffalo.edu/software/virtual/index.php>
- [11] <http://assert.uaf.edu/lab.html>
- [12] <http://vlab.mgt.unm.edu>
- [13] <https://cloudstack.apache.org/docs/en-US/index.html>
- [14] <http://docs.cloudstack.apache.org/en/latest>
- [15] A. Kivity, Y. Kamay, D. Laor, U. Lublin, “KVM: the linux virtual machine monitor,” in *Proc. Linux Symposium*, vol.1, Ottawa, Canada, 2007, pp. 225-230.
- [16] http://www.linux-vm.org/page/Main_Page

- [17] C. Krintz, "The AppScale cloud platform enabling portable, scalable web application deployment," *IEEE Internet Computer.*, vol. 12, no. 2, 2013, pp. 72-75.
- [18] <http://www.appscale.com/>

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