Enhanced Multi-Tenant Architecture for DaaS, PaaS, IaaS and SaaS in Edu-Cloud

Simplifying the Service provisioning in Edu-Cloud by multi-tenant architecture

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***Abstract* – Educational institutions keep on seeking opportunities to extemporize, integrate and rationalize the way they manage their resources. Thus the technology of cloud computing can be one of the opportunities that an educational institute can make use during all the times and could prove to be of immense benefit to them due to its scalability factor, reliability, flexibility and cost-efficiency. Cloud Computing is a technology continuously evolving service criterion with a significant importance to the improvement of information technology in education. Cloud computing approach depends on various existing technologies such as Internet, virtualization, Web streaming and so on. Multi-tenant framework for provisioning, managing and controlling the services (DaaS, PaaS, SaaS and IaaS) gives a different facet to the users of Edu – Cloud. The centralized educational resources make the students/researchers can access them "anytime anywhere by any device".**

Keywords— Cloud Computing; Virtualization; Virtual Machine; Hypervisor; Multi-tenancy; Xen Server;

1. INTRODUCTION

The Cloud computing is a metaphorical for the internet computing, predominantly any service that is delivered through a hosted service over internet can be named as Application service provisioning in internet technical term [1]. Where as in cloud computing it is even though an Internet-based computing it involves shared resources running over a hypervisor layer. Basically cloud computing uses the concept of virtualization of resources that manages and maintains automatically [12]. The Service provisioning is done through the internet, it is a fabulous technology where the applications hosted on cloud can be accessed from anywhere from any device *(Ubiquitous)*.

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The Cloud computing is a technology that which helps to overcome these draw backs, through virtualization and resource sharing methods [9], they bring to education a heterogeneous range of options.

Edu – cloud is a community cloud which is aimed to change the current static way of learning methodology and integrating the class room and laboratory education with the cloud enabled platform. Edu – Cloud's mission is to make the better utilization of educational resources in the laboratory. It is a set of approaches that can help organizations quickly, add and subtract resources in almost real time. Providing the Infrastructure, platform and the application on demand through internet (Cloud), Users can work on multiple operating systems remotely by logging on to the server. Accessing the infrastructure by scaling up and down, depending upon the amount of computing resources they required, in fact it provide new choices for balancing system management, cost and security while help improving the educational services. The multi-tenant architecture based system is implemented [7] for the provisioning of different services. Edu – Cloud concentrates on provisioning [13] [8] SaaS – customized software, DaaS – Preconfigured Desktop application, IaaS – User defined configuration, PaaS – A building platform. Another prime focus is Ubiquity [2], meaning pervasiveness in accessibility. So, the user can access the services from any device at any time. It is completely build using open source hypervisor, operating system, and other tools.

2. RELATED WORK

The current work is an extension of the work done in paper [1] which explains how the service provisioning framework functions. The current work carries more enhancements compared to previous work; this includes three more services with enhanced multi-tenant architecture. [1] The service provisioning frame work architecture is enhanced by eliminating few dependencies and bypassing unnecessary calls and directly accessing the Xenserver. Multi-tenancy architecture is used to boost the efficiency [2] and accommodating multiple tenants on single instance of virtual machine. The heart of the cloud computing is hypervisor; it performs firmware resource management, memory management, processor controlling, and storage management. Hardware virtualization is a top most technology [15] that boils down multiple jobs on a single physical server without the intervention of any third-party software. The hypervisor used to create a

Virtual Machine, on which the guest software runs with full functionalities as it would run on a physical platform [15]

Variants in Virtualization

Hardware virtualization can be broadly classified into three catagories:[15]

i. Para Virtualization - In this method the hardware is not simulated by the VM instead the guest OS and programs need be modified which run in their own isolated environment. *ii. Partial Virtualization* - In this technique many instances are created by the VM of the underlying hardware environment. Each instance runs in an independent address space. The core factor of the partial virtualization is the address space virtualization. *iii. Full Virtualization* - This method allows the complete simulation of the hardware, with an unaltered guest operating system.

Multi-tenancy [5] is a principle in software architecture where a single instance of the software runs on a server, serving multiple client-organizations (tenants). Multi-tenancy [3] contrasts with multi-instance architectures where separate software instances (or hardware systems) operate on behalf of different client organizations. Desktop-as-a-Service [6] paradigm derives from the software level Software-as-a-Service (SaaS) paradigm, which is cost-efficient, scalable and comfortable subscription service. The author presents a DaaS model with cloud server technologies on FPGA to address the problem of high power consumption and heavy network traffic. DaaS [11] is a cloud service that provides desktop environment of virtual machine running on the cloud. In a sense, it is regarded as GUI based IaaS (Infrastructure as a Service). Although only Web applications are used in SaaS [4], all kinds of applications can be used in DaaS, and describes how to construct efficient DaaS in an educational cloud. The author proposes two kinds of DaaS, single user DaaS and multi user DaaS, in order to improve the usability of educational cloud.

Minqi Zhou [14] discusses six categories of services namely Data as a Service (Daas), Software as a Service (SaaS), Platform as a Service (PaaS), Identity and Policy Management as a Service (IPMaaS), Network as a Service (NaaS), Infrastructure as a Service (IaaS), and these are brings them under three levels namely hardware,system and application level. The author classifies IaaS and NaaS under hardware level which provides CPU, storage space,and network. PaaS under system level which provides a platform to run end users' applications. IPMaaS, DaaS, and SaaS under application level since it provides a specific application for committed users. NaaS [14] come in many variants such as Internet services from carriers including wired or wireless network service, mobile service, and so on. Internet services, primarily focus on provisioning broadband bandwidth-on-demand services in cloud computing.

Infrastructure refers to CPU cycles, memory, network bandwidth, storage space so on providing these to the users through cloud turns to Infrastructure as a Service (IaaS)some of the cloud providers namely Amazon, Mosso, ServerPath, Skytap, Sun and so on. Among them Amazon web Services (AWS) uses stateful APIs, which provide different level of access control [14] Providing operating systems and associated services over the Internet without downloading and installing them can be called as PaaS. Some the providers are Google, Azure, Engine Yard, Salesforce so on.SaaS model is deployed by the provider by licensing and application to customers for use as a service on demand. AT&T, Media Temple, Grid Player, Flexiscale, Joynet and so on are some of the SaaS providers [14].

Thin Clients with Virtual Desktops are the best instruments to access the online services provided by the cloud over the internet says Sumita U Sharma [15]. Network latency causes major delay in transmitting a message or communication from one point to another. Many other external factors, like limitation of bandwidth, network congestion, storage capacities and the distance between two points also contribute to the delay.[15]

3. Proposed Edu-cloud framework.

The intact Edu – Cloud frame work is divided into

1. Management system along with Security level – 2.
2. Security level – 1.
3. Storage in Edu – Cloud.

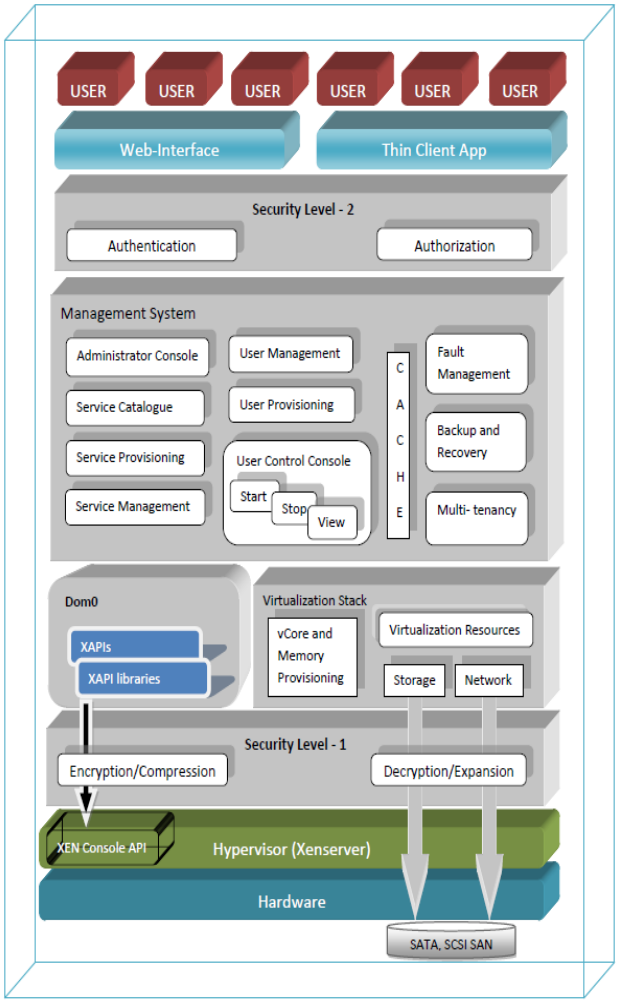

Figure 1 Edu-Cloud Framework

This paper concentrates on Management system (Use, Service and Xen management) and Security level – 2(Authentication and Authorization). The services offered by the framework are represented in the following diagram, each of these services are provisioned to the user with a particular algorithm which is explained in further chapter.

Services offered by Edu-cloud and their specifications

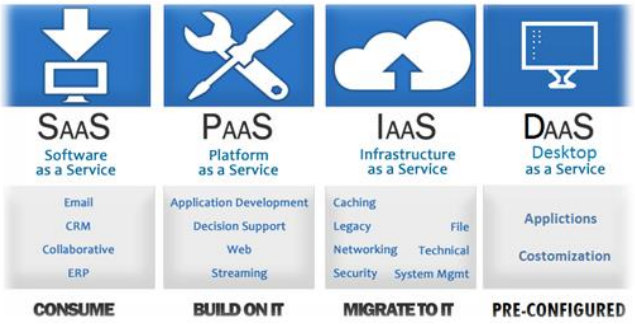

Figure 2: Edu – Cloud Services

Xen Management APl in Framework [1], this is an interface used for remotely controlling and configuring virtualized guests running on a Xenserver. The API reference uses the relative objects to make a call. Here an object is an instance of a class with its fields set to specific values. Objects are persistent and sit on the server-side.

Security layer – 2 authenticates the user credentials and controls over authorized service requests. The end user can choose any services from the service archive, and the selected service will be provisioned. Provisioning of the services like DaaS, SaaS, PaaS and IaaS is based on XenServer, using Xen API, PHP, applet initialization. Authentication, resource availability and other information are maintained at database server. MySQL, appliance.conf file and so on are used for this.

Service Provisioning Framework [1], an interface for remotely configuring and controlling virtualized guests running on a Xenserver. The user can select the services from the service archive, and the selected service will be provisioned. Authentication, resource availability and other information is kept in a database server. MySQL Database and appliance.conf file are used for this.

User Manager [1**] –** this module includes elemental user data, such as login details, creation and deletion of users. All the basic info related to the user is stored in the database, it is also responsible for managing the users and their VMs details.

Management System - Edu – Cloud contains a user manager module and service manager module. All these modules can be divided into the corresponding sub-modules.

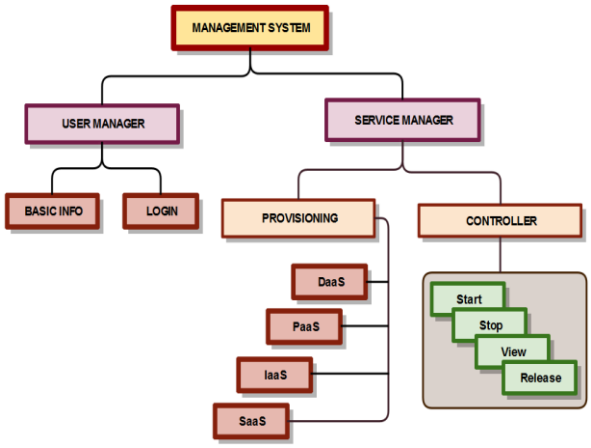

Figure 4: Major task in Management System

The Service manager - deals with the management of provisioned services of Edu – Cloud, provides all the facilities required to completely manage the cloud like: Request for DaaS, PaaS, SaaS [8] and IaaS and its controls like start, view, stop and release the service and so on, depending on the user rights.

Viewer console - The Edu – Appliance will stream the VMs using java applet. The user needs java supporting and java enabled device to view the VM console.

The Domain 0 referred to as Dom0 is launched by the hypervisor during initial system start-up. The privileges to access the hardware is only with the Xen hypervisor (Xenserver) [19] but not with any other Domain Guests. This feature allows it to manage all aspects of Domain Guests such as starting, stopping, I/O requests, and etc. and maintaining log information.

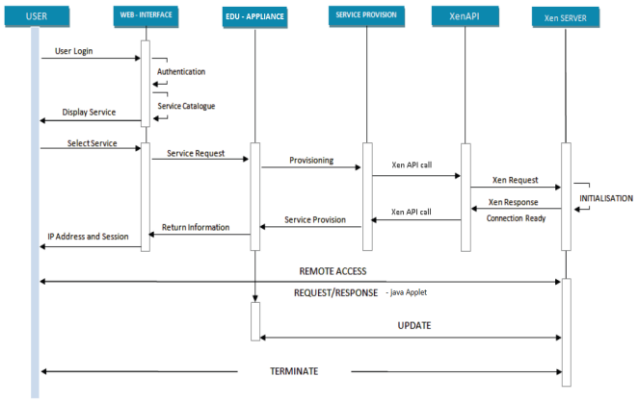

Figure 3 MSC interactions among the modules

Edu-Cloud or Thin Client –

The main theme of Edu-cloud is to overcome the problems of thin client and normal physical devices in other words the hardware required by these devices are expensive. So, Edu-cloud aims at provisioning of services to both thin and thick client devices. Thin client (lean, zero or slim client) is a computer or a computer program that depends heavily on its server to fulfill its computational roles as in cloud but varying in streaming techniques, user profile definition and so on. Even though thin client computing fits into different types of work environment it poses a lot of disadvantages in the perspective of IOT, some of them are a) Cost Intensive – Needs a dedicated hardware for setup, b) Single Point of Failure – Server failure will results in failure of whole system, c) Security – Admin can view or manipulate or even delete user data without noticing the user. d) Non Ubiquitous – Not accessible on all type devices, and does not support portability and working from outside the campus. Edu-cloud not only address these issues but also provides lot more other features and advantages such as a) Cost Efficient – Not special hardware required, b) Guarantied service – Backup servers will provide the reliable service, c) Highly Secure – Since the VM credentials are with the users the admin cannot do any operations on the VM and its contents, d) Ubiquitous – "Anywhere form Any Device", e) Portable – The VMs can be accessed offline also.

Benefits of Service Provisioning framework (SPF) - It automates provisioning tasks, and reduces the setup time, mitigate administrative costs, and minimize errors. Provisioning the respective services to the respective users.

• *Improved Process Management*—SPF manages multistep processes that can be executed without the need for a system administrator.

• *Task Automation*— the automation of frequent or complex tasks improves accuracy and by reducing the opportunity for human error.

• *Time Savings*— save times for managing, maintaining and updating application.

• *Lowered Administrative Burden*—Server-to-administrator ratio is improved, resulting in lower administration costs.

• *Lower Costs*—Operational costs are lower due to fewer on-site visits.

4. Experimental setup

The experimental setup is divided into four main sections, namely Registration and request for VM, Creating a requested VM/Attaching to Existing one, Mapping the user credentials with their requested services through Edu-Appliance, Managing user database and their VMs (includes provisioning and controlling). For the implementation of proposed framework and evaluation of results system configuration is mentioned in the Table I. Whereas the Client device (Thin/ Thick device) that has Java installed and supports Internet browsing with good internet speed.

Table I Server configuration

Hardware Specifications	
Name	*Intel Xeon W3520*
Specification	*Intel(R) Xeon(R) CPU W3520 @ 2.67GHz*
Core Speed	*2933.4 MHz*
Processor	
No. of Cores	*4 (max 8)*
No. of threads	*4 (max 16)*
Chipset	
Northbridge	*Intel X58 rev. 13*
Southbridge	*Intel 82801JR (ICH10R) rev. 00*
Graphic Interface	*PCI – Express*
Memory Type	*DDR3*
Memory Size	*24576 Mbytes*
Storage	*1000 GB*
Software Specifications	
Hypervisor	*XenServer (Bare-metal hypervisor)*
Operating System	*Linux (Fedora/ CentOS / Ubuntu LTS)*
JAVA	*Version jdk 7.0 and above*
Web server	*LAMP for Linux machine*

4.1 Registration and Request for VM:

The User has to register with his/her name, password and other require personal details. Along with this the users need to specify the required virtual machine configuration. A single user is allowed to request for multiple virtual machines. The initial registration and request for the VMs are done through a web based frontend. When the user clicks the submit button the user credentials and specifications are passed on the Edu-cloud webserver. The webserver will store the user details on to its database and one more copy is transferred into text file which is further useful creating the requite virtual machine.

4.2 Creating a requested VM / Attaching to existing one:

Creating a requested virtual machine includes a divergent approach in Edu-cloud; it depends on type of service that the user has been requested for. If the user has requested for DaaS machine then a clone copy of DaaS is created attaching the username with the VM. If the request is for SaaS then the user is attached to the particular software service along with secure storage. For PaaS the user will attached to web based command prompt with specific login and password. For IaaS the details are collected from the text file and a virtual machine is created for that specification.

4.3 Mapping the user credentials with their requested services through Edu-Appliance:

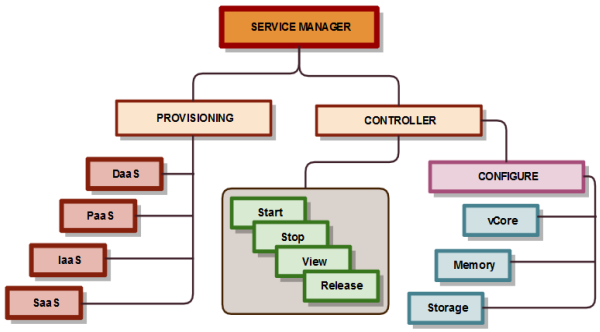

Figure 5 MSC to observe the interaction among the models

The service manager is the Edu-Appliance which will map the user credentials with their respective virtual machines. It is composed of two main parts one is service provisioning unit and controller. With the help of the text file the respective VMs are mapped and levels of accessing the VM (read/write/…) are also attached.

4.4 Managing user database and their VMs:

From the perspective of administrator as well as user maintaining of the database is very important. So, Edu-cloud provides a backup database is used to maintain the users and their VMs along with the VM details, status, so on.

5. WORKING SCENARIO

This section explains the complete working of our proposed model with reference to proposed architecture. We have explained it using two practical cases, which are as follows:

5.1 Flow of Algorithm in Edu - Cloud

This section describes the interaction sessions that take place in Edu – Cloud and Edu – Appliance based on Multitenant architecture. The flowchart below explains how flow of service provisioning in Edu-cloud.

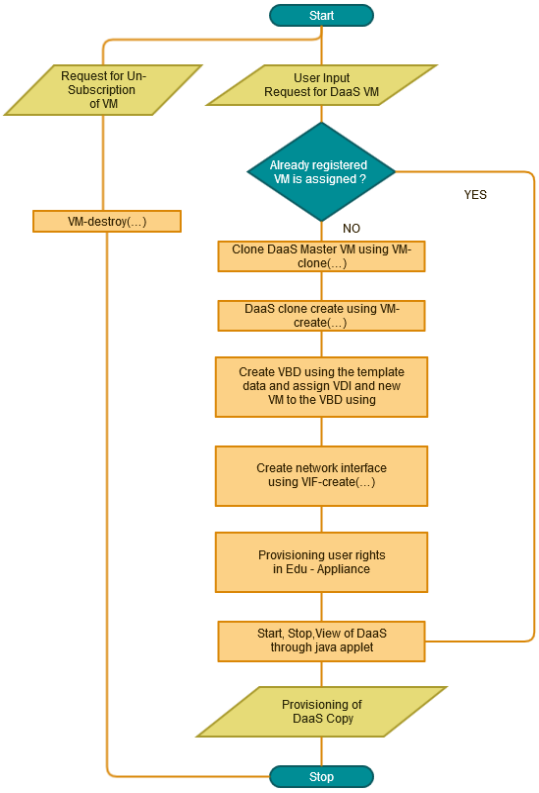

Figure 6. Flowchart for DaaS VM creation and Provisioning

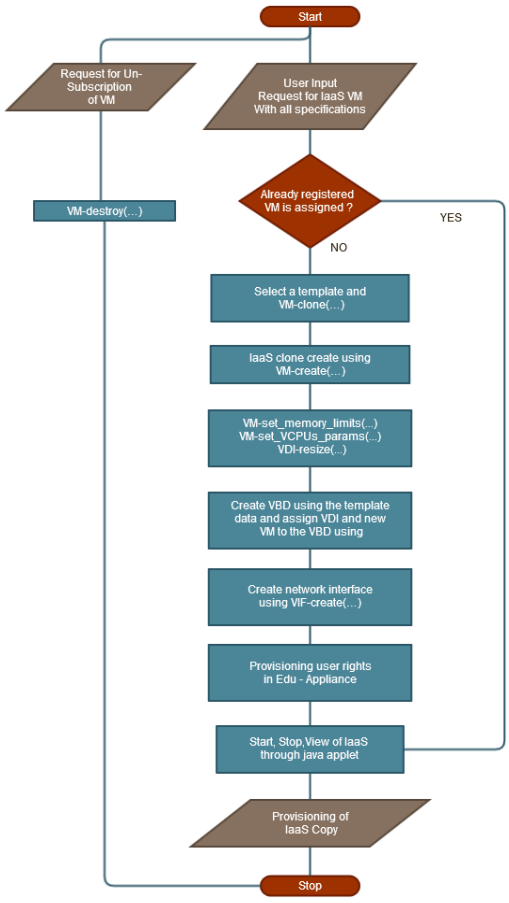

Figure 7: Flowchart for IaaS VM creation and Provisioning

5.2 Service Provisioning of DaaS, PaaS, IaaS and SaaS

Service provisioning is the process of preparing and equipping a system to allow it to provide services to its users.

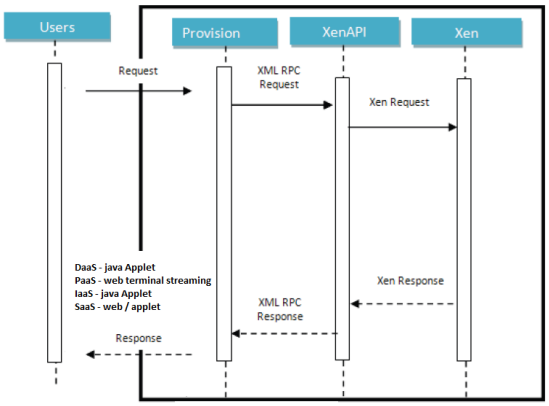

Figure 8. MSC representations of Service Provisioning in Edu–Cloud

6. RESULTS

The result of Edu-cloud is users can login and register to the services which they wish, then the respective virtual machine is created and they are attached to the users. Then the users can login to Edu-cloud appliance through their credentials the screenshots in Figure 9 shows the home screen of Edu-cloud, Registration panel, Users view, and Administrators view. The user can access the VMs through thick devices or through smart phones.

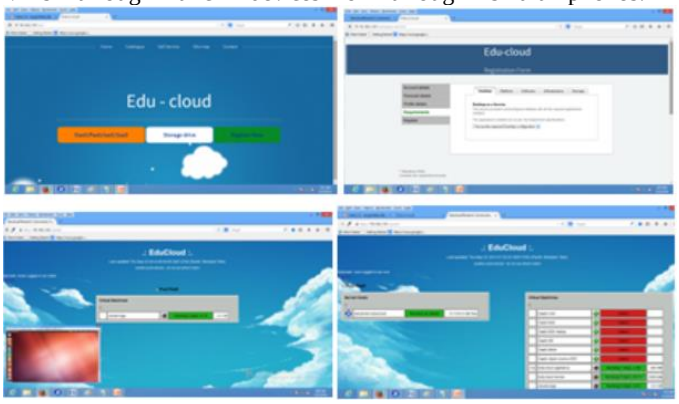

Figure 9. Edu-Cloud home page, Registration Panel, User accessing the VM, Admin panel.

The performance evaluation is done on the provisioning of DaaS to the users in Edu – Cloud. In a manner it is possible to provide and manage numerous virtual machines. In the present Edu – Cloud, The performance evaluation is done with the above specified system specification. Out of 24 GB of RAM the hypervisor, Edu – Cloud Appliance, Edu – Cloud server will consume 1 GB each and the DaaS master-copy VM will consume 1 GB. After conducting all the performance evaluation experiments on the Edu – Cloud with the pre-requisite that no other services are running on Edu – Cloud except DaaS the results shown were, the Edu – Cloud was able to provision the DaaS service to 20 users simultaneously, since the storage is huge many more DaaS client VMs can be created, but due to memory constraints Edu – Cloud can support only 20 users simultaneously with the given system specifications. Table II tells the VM

provisioning time for different IaaS VMs with different configurations.

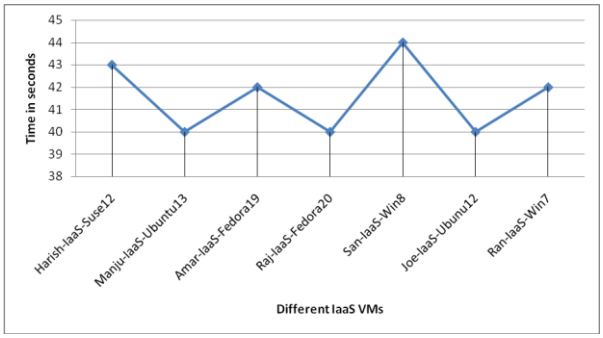

Figure 10. Representation of VM Configurations and provisioning time delay.

Table II VM Configurations and Provisioning time delay

	VM Configuration					VM Provisioning
Sl. No	**VM Name**	**No. of Virtual Processor**	**Storage (GB)**	**RAM**	**Operating System**	**Time in Seconds**
1	Harish-IaaS-Suse12	2	10	2GB	Open Suse 12	**43**
2	Manju-IaaS-Ubuntu13	1	25	1GB	Ubuntu 13.10	**40**
3	Amar-IaaS-Fedora19	2	30	1GB	Fedora 19	**42**
4	Raj-IaaS-Fedora20	1	15	1GB	Fedora 20	**40**
5	San-IaaS-Win8	2	15	2GB	Windows 8	**44**
6	Joe-IaaS-Ubunu12	2	35	1GB	Ubuntu 12.04	**40**
7	Ran-IaaS-Win7	2	40	2GB	Windows 7	**42**

7. CONCLUSION

Edu-Cloud can help educational community as well as nation to transform education level to a higher altitude. An entire world of knowledge can now be made available to all through cloud-based services that can be accessed anytime, anywhere, from any device which is completely dedicated only for academic and research purpose. This work presents a multi-tenant service provisioning framework for four types of service models built on XenServer based cloud, the framework is completely built on open-source software. The multi-tenant architecture for handling the service is the key features of the framework. The enhanced design principles are highlighted, transact a set of experiments and the experiments have met the educational requirements. Our current prototype was able to support 20 users simultaneously, due to time constraints the entire visualized system was not able to realized in all facet, hence giving due room for enhancements.

7.1 Future Work

The system has been developed keeping the enhancement factor in mind and to facilitate further modifications with minimal effort. Some of the possible enhancements can be worked out such as:

- Live migration of VMs, Effective Scheduling algorithms and advanced security system can be implemented.
- New service modules can be implemented such as Data as a Service, Management as a Service, Cluster as a Service, so on.

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