V-LAB REPORT FOR FALL 2013

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1. Executive Summary

During the Fall 2013 semester, the V-Lab system has served 337 unique students (70% graduate and 30% undergraduate) in 12 laboratories of 8 courses. More than 388 virtual machines (80% Linux and 20% Windows) are created to allow students to perform experiments for their laboratories in a virtualized environment, and help instructors and teaching assistants evaluate and grade the experiment results.

At the beginning of Fall 2013, the development team of V-Lab incorporated multiple new technologies and designs to the system.

- Migrate to OpenStack cloud operating system
- LDAP identity authentication system
- Web-based VM resource access
- V-Lab web portal
- Git-based version control repository
- High availability cluster architecture
- Ganglia monitoring system

New V-Lab system also adapted and improved features from previous version of the system:

- Certificate-based authentication system
- OpenVPN secure remote connection
- iSCSI SAN-based storage and backup

During the Fall 2013 semester, V-Lab has encountered a few problems as follows.

- Lack of a single sign on (SSO) mechanism
- Computation and memory resources shortage
- Technical support resource shortage.

For the Spring 2014 semester, V-Lab plans to implement and enhance the following new features to provide better services for students and public users:

- Extend more physical resource
- Upgrade to a new version of OpenStack
- Create an IDAM system
- Redesign the web portal of V-Lab System

More details are described in the rest of the report.

2. V-Lab Usage Statistics

This section presents the V-Lab system's usage statistics.

2.1. Supported Courses and Student Counts

There are five major courses use V-Lab system in Fall 2013. One course combines the undergraduate and graduate level classes (468/598), and another course includes three different class type (545). We consider them as different courses to show the student's distribution. During this semester, 337 students use V-Lab system for their homeworks, experiments, and course projects. 70% of students are graduate students (236) and 30% of students are under-graduate (101). Table 2-1 shows the detail information of each course, the number of students and the student's distributions.

Table 2-1: Supported course and student counts

Course	Total Students	Grad Students	Under-graduate Students	% of graduate	% of Under-graduate	Instructor	Course Name
468	52	0	52	0%	100%	Dijiang Huang	Computer Network Security
598	14	14	0	100%	0%	Dijiang Huang	Computer Network Security
545 (in-person)	57	57	0	100%	0%	Stephen Yau	Software Security
545 (online)	9	9	0	100%	0%	Stephen Yau	Software Security
545 (hybrid)	46	46	0	100%	0%	Stephen Yau	Software Security
465	49	0	49	0%	100%	Stephen Yau	Information Assurance
598	46	46	0	100%	0%	Yinong Chen	Distributed Software Development
591	64	64	0	100%	0%	Dijiang Huang	Cloud Computing
Total	**337**	**236**	**101**	**70%**	**30%**		

2.2. Supported Laboratories and Allocated Resource

Table 2-2 shows the information of each supported laboratories and the allocated resources from V-Lab system, which include the number of projects, the number of virtual machines (VMs), the number of virtual CPU (vCPU), the total amount of disk space, and the total amount of memory for each course. During this semester, 155 projects have created in V-Lab system to support students' experiments, and 388 virtual machines (80% Linux and

20% Windows) have allocated for these projects. To support these virtual machines, V-Lab system needs to allocate 410 virtual CPUs, 4884GB disk space (4.77TB), and 336.5GB memory.

Table 2-2: Supported Laboratories and Allocated Resource

Course	Lab Name	# of Projects	# of Linux VMs	# of Window VMs	# of vCPU	Total Disk (GB)	Total Memory (GB)
468/598	1). Packet Filtering Setup 2). Secure Web Service Setup 3). Intrusion Detection and Penetration Testing using Snort, Syslog and OpenVAS 4). Basic Network Setup 5). Advanced Study on Firewall	71	210	0	234	1420	124.5
545 (in-person)	1). Course Project	11	0	11	11	410	22
545 (online)	1). Course Project	8	1	7	8	286	14.5
545 (hybrid)	1). Course Project	8	1	7	8	286	14.5
465	1). OTP-based access control Web application development group project 2). Attribute-based access control Web application development group project	11	22	11	28	662	35
598	1). Web-based Application Development and State Management Lab 2). Service-Oriented Software Development Lab 3). XML and Related Technologies Lab	20	0	20	23	920	46
591	1). Cloud computing research term project	26	74	24	98	900	80
Total		**155**	**308 (80%)**	**80 (20%)**	**410**	**4884 (GB)**	**336.5 (GB)**

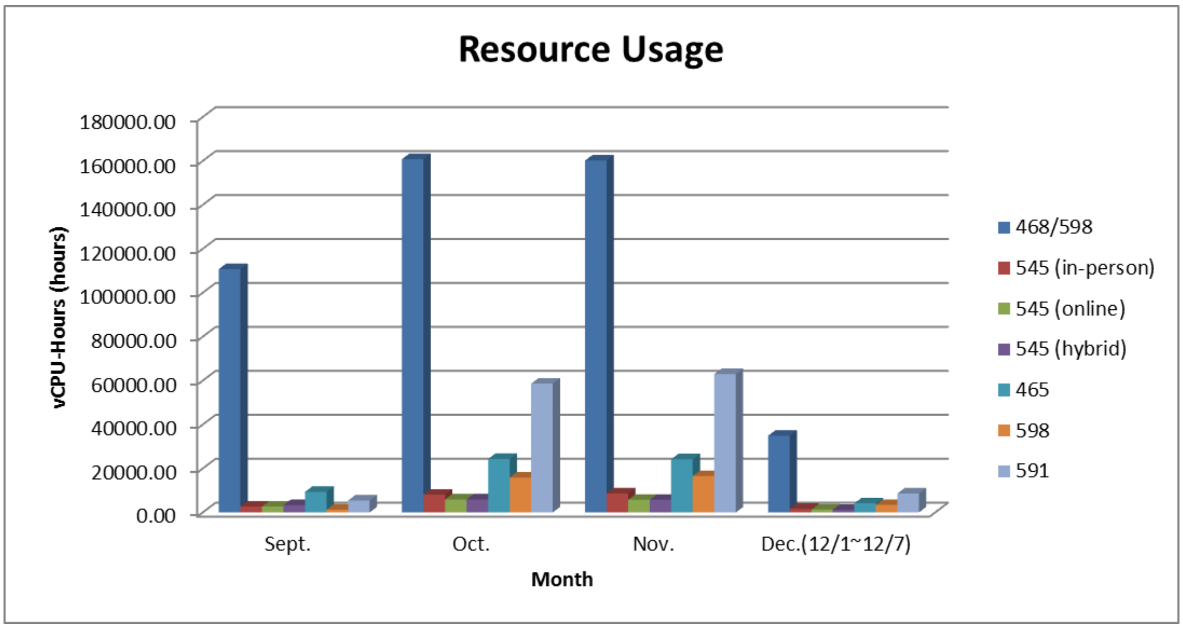
2.3. Resource Usage

Table 2-3 shows the resource usage of each course during this semester from September to early December (12/1~12/7). The resource usage is measured by vCPU-hours that represents the total hours of using assigned vCPU. Figure 2-1 shows the charts of collected data from Table 2-3.

Table 2-3: Resource Usage measured by vCPU-Hours

Course	Course Name	Sept.	Oct.	Nov.	Dec.
468/598	Computer Network Security	110789.50	160813.10	160181.40	34931.88
545 (in-person)	Software Security	2695.44	8102.96	8646.58	1637.24
545 (online)	Software Security	2694.84	5952.00	5760.00	1339.56
545 (hybrid)	Software Security	3371.07	5952.00	5760.00	1190.72
465	Information Assurance	9360.12	24367.50	24247.60	4167.60
598	Distributed Software Development	1269.94	15910.17	16560.00	3423.33
591	Cloud Computing	5444.41	58659.36	62980.23	8632.81
Subtotal		**135625.32**	**279757.09**	**284135.81**	**55323.14**
Total		**754841.36 (Hours)**			

Figure 2-1: Resource usage from each course



3. New Features

This section presents the new features that have been developed and integrated with V-Lab system during the Fall 2013 semester.

3.1. OpenStack Cloud Operating System

V-Lab system has migrated from Xen based virtualization platform to OpenStack cloud operating system. OpenStack provides an easy-to-use web front-end to plan, manage, and use resources in a cloud system. Currently, we only allow system administrator, instructor, TAs, and advanced users accessing the cloud resources from the web front-end [1].

OpenStack cloud operating system consists of five major components, it enables enterprises and service providers to offer on-demand computing resources, by provisioning and managing large networks of virtual machines. Compute resources are accessible via APIs for developers building cloud applications and via web interfaces for administrators and users. The compute architecture is designed to scale horizontally on standard hardware, enabling the cloud economics companies have come to expect.

OpenStack Networking is a pluggable, scalable and API-driven system for managing networks and IP addresses. Like other aspects of the cloud operating system, it can be used by administrators and users to increase the value of existing datacenter assets. OpenStack Networking ensures the network will not be the bottleneck or limiting factor in a cloud deployment and gives users real self service, even over their network configurations.

The *OpenStack dashboard* provides administrators and users a graphical interface to access, provision and automate cloud-based resources. The extensible design makes it easy to plug in and expose third party products and services, such as billing, monitoring and additional management tools. The dashboard is also brandable for service providers and other commercial vendors who want to make use of it.

OpenStack Identity provides a central directory of users mapped to the OpenStack services they can access. It acts as a common authentication system across the cloud operating system and can integrate with existing backend directory services like LDAP. It supports multiple forms of authentication including standard username and password credentials, token-based systems and AWS-style logins.

The *OpenStack Image Service* provides discovery, registration and delivery services for disk and server images. The ability to copy or snapshot a server image and immediately store it away is a powerful capability of the OpenStack cloud operating system. Stored images can be used as a template to get new servers up and running quickly and more consistently if you are provisioning multiple servers than installing a server operating system and individually configuring additional services. It can also be used to store and catalog an unlimited number of backups.

3.2. LDAP Identity Management System

V-Lab system has built a LDAP based identity management system. The Lightweight Directory Access Protocol (LDAP) is a directory service protocol that runs on a layer above the TCP/IP stack. It provides a mechanism used to connect to, search, and modify Internet directories.

The LDAP directory service is based on a client-server model. The function of LDAP is to enable access to an existing directory.

The data model (data and namespace) of LDAP is similar to that of the X.500 OSI directory service, but with lower resource requirements. The associated LDAP API simplifies writing Internet directory service applications.

3.3. Web-based VM Resource Access

V-Lab system has built an approach to access VM resource through a web browser using noVNC technology. Students are able to access to their VM using any HTML5 supported web browser from anywhere. This feature removes many complex client side configuration tasks for users, such as VPN client configuration.

To use this feature, students or users need to login to the web portal of V-Lab system to get the token and access url after passing the authentication. Then, they can access to their VM using any HTML5 supported web browser with the obtained url and token. However, the token is valid only a certain period of time. If users didn't access to their VM using the obtained token during the time, they need to request a new token. The token and url can be requested from OpenStack web-front end or V-Lab system web portal.

noVNC is a browser based VNC client implemented using HTML5 Canvas and WebSockets. In the server side, V-Lab system has configured a VNC proxy for each Nova-compute (VM provisioning server) to tunnel the VNC protocol over WebSockets, so that the noVNC client has a way to talk VNC.

In general, the VNC proxy (1) bridges between the public network, where the clients live, and the private network, where vncservers live, (2) mediates token authentication, and (3) transparently deals with hypervisor-specific connection details to provide a uniform client experience.

3.4. V-Lab Web Portal

At the beginning of Fall 2013 semester, the V-Lab web portal has been transformed into a Drupal based website which provides a web based user interface to V-lab service [2].

Drupal is an open source content management system and web application development framework used and trusted by thousands of organizations for creating websites. Drupal is wildly popular because it provides a powerful, scalable, low cost, high value solution to manage and grow an internet presence.

The web portal provides end users and cloud administrators with interfaces to all other V-lab services, which includes interfaces of services like usage information, cloud virtual machine access, project management, VPN certificate management, file sharing, source code management and application store.

Other than these, this web portal also provides an extra interface for cloud administrators which allow administrators to define service catalog offerings of services, manage projects, administer user accounts and view access to source management in the cloud.

One important thing needs to be mention is that the web portal is currently using a centralized MobiCloud identity management system which been set to work with ASU's CVS authentication server to provide authentication service to currently enrolled ASU students and allow them to access resources of V-Lab.

The system has been used during the Fall semester of 2013 and very few issues have been reported by students.

3.5. Git-based Version Control Repository

As an extension of the MobiCloud research project, a self-developed Git-based version control repository called MobiCloud Source Forge [3] has integrated into the V-Lab system at the beginning of Fall 2013 semester.

A Version Control Repository keeps track of all work and all changes in a set of source code, and allows members of a software development team to work together on the same set of code. By using our version control repository in V-Lab, students can upload their team software project's source code into our system anytime they've made a change, then they are able to keep the track of changes to the codes. The system will provide a single point of access so that all source codes are available from one location by all the students and instructors. It also allows roll back function so that users can get old versions of codes or other files any time. Git, which is the backbone of this system, is a free open source distributed version control repository initially designed for Linux kernel development in 2005. It is distributed under the term of the GNU General Public License.

A Web UI for the version control repository is also introduced into the system. This web interface provides various options like user account management and access control, project wiki site with tutorials, source code viewing and downloads, etc. Compare to the traditional command line based interface, this UI not only provides students with a more user-friendly environment but also makes the management of source code much easier and clearer. The system is currently being used by all the student team of CSE 591 Cloud Computing Class, which includes about 20 teams.

3.6. High Availability Cluster Architecture

A crucial aspect of high availability is the elimination of single points of failure (SPOFs). In order to eliminate SPOFs, check that mechanisms exist for redundancy of (1) network components, such as switches and routers, (2) applications and automatic service migration, and (3) storage components.

V-Lab system has built a high availability (HA) architecture by clustering major components in OpenStack to provide non-SPOF services in Fall 2013 semester. The HA architecture of the V-Lab system is implemented with Active/Passive mode to clustering MySQL and RabbitMQ in the cloud controller and quantum service in the network controller.

OpenStack infrastructure high availability relies on the Pacemaker [4] cluster stack, the state-of-the-art high availability and load balancing stack for the Linux platform. Pacemaker is storage- and application-agnostic, and is in no way specific to OpenStack.

Pacemaker in turn relies on the Corosync messaging layer [5] for reliable cluster communications. Corosync implements the Totem single-ring ordering and membership protocol and provides UDP and InfiniBand based messaging, quorum, and cluster membership to Pacemaker.

3.7. Ganglia Monitoring System

In order to monitor the overall performance of V-Lab system and health status of each server in the cloud architecture, V-Lab system has built a real-time online monitoring system using Ganglia. Administrators are able to check many system performance metrics online [6] , such as CPU load average, disk usage, various parts of memory utilization, byte-level and packet-level traffic statistics, and system information from each sever.

Ganglia [7] is a scalable distributed monitoring system for high-performance computing systems such as clusters and Grids. It is based on a hierarchical design targeted at federations of clusters. It leverages widely used technologies such as XML for data representation, XDR for compact, portable data transport, and RRDtool for data storage and visualization. It uses carefully engineered data structures and algorithms to achieve very low per-node overheads and high concurrency. The implementation is robust, has been ported to an extensive set of operating systems and processor architectures, and is currently in use on thousands of clusters around the world. It has been used to link clusters across university campuses and around the world and can scale to handle clusters with 2000 nodes.

4. Improved Features

This section presents improved features migrating from the previous version of the V-Lab system.

4.1. Certificate-based User Authentication System

At the beginning of Fall 2012 semester, the V-Lab system was integrated with a self-developed certificate management system, which was an extension to the MobiCloud research project. The system can work with ASU's LDAP authentication server to issue certificates to currently enrolled ASU students and allow them to access internal resources of V-Lab.

The certificates include information for both user Identity and access control. The accesses to internal services of V-Lab such as OpenVPN and SSH can be issued as tickets with expiration timestamp. The default expiration time for tickets is one semester.

To allow students to create and manage their certificates, V-Lab system provides a web-GUI that incorporates with ASU's LDAP-based authentication system. The web-GUI allows only currently enrolled ASU students to login and create their own certificates. After that, students can download the certificates and use them to provide single sign-on (SSO) for accessing all kinds of internal services of V-Lab system based on the user's privilege.

The system has been adapted to the new version of the V-Lab system in the beginning of Fall 2013 semester and integrated with the OpenVPN feature to authenticate the user's identity for accessing cloud resources through a VPN connection.

4.2. OpenVPN-based Secure Remote Connection

V-Lab system has been migrated from an IPTABLEs-based port forwarding solution to an OpenVPN-based remote access solution at the beginning of Fall 2012. The OpenVPN allows users to establish a secure channel from an OpenVPN client to a cloud server for accessing their VM, regardless of the networking protocol used on the application layer. This ensures the security over the communication channels.

The new V-Lab system in Fall 2013 also adapts the OpenVPN-based remote connection solution as an alternative approach to access users' VM in addition to the web-based access. The new OpenVPN architecture is implemented on one of the servers in the OpenStack, and integrated into the quantum component of the system.

4.3. iSCSI SAN-based Storage and Backup

V-Lab system has been migrated from NFS-based storage solution to iSCSI-based storage and backup system at the beginning of Fall 2012. iSCSI is in many ways dependent on the operating system, it allows for multi-path to be configured, effectively using multiple datalinks as individual paths that data may take to reach the target. By using iSCSI, the overall V-Lab system performance has been improved.

During the Fall 2013 semester, V-Lab system has installed and configured iSCSI SAN-based storage and backup system with two Dell PowerVault MD3600i iSCSCI SAN Storage Array to support the storage for VMs, images, snapshots, and backups. The current storage space is around 24 terabytes and can be extended by installing additional hard drive.

5. V-Lab System Capacity

5.1. Overview

The current V-Lab system consists of 12 servers and 2 iSCSI SAN-based storage array with four major hardware models:

1. Dell PowerEdge 410 1U Rack Server
   CPU: Dual Quad-core Intel Xeon processor E5640@2.66GHz
   Total 8 cores & 16 threads
   Memory: 32G
2. Dell PowerEdge 620 1U Rack Server
   CPU: Dual Six-core Intel Xeon processor E5-2640@2.50GHz
   Total 12 cores & 24 threads
   Memory: 64G
3. Dell PowerVault MD3600i iSCSCI SAN Storage Array
4. Dell Old Server (unknown model)
   CPU: Dual core Intel Pentium 4 @3.00GHZ

5.2. Computation and Storage Resources

The computation and storage resources are two important components of a cloud system. Table 5-1 shows the physical servers providing the resource to support these two services in the V-Lab system.

Table 5-1: The list of physical servers for computation and storage resources

Role	Hostname	Model	Cores	Disk	RAM	Purpose
Nova	node2	R410	16	2T	32G	VM provisioning
Nova	node3	R410	16	2T	32G	VM provisioning
Nova	node4	R410	16	2T	32G	VM provisioning
Nova	node5	R410	16	4T	32G	VM provisioning
Nova	node13	R620	24	0.5T	64G	VM provisioning, VPN server
Nova	node14	R620	24	0.5T	64G	VM provisioning
storage1		md3600i		12.6T		iscsi-storage
storage2		md3600i		10.8T		iscsi-storage
Total allocatable physical resources			112	34.4T	256G	
Virtual resource allocation ratio			1:16		1:1.5	
Total allocatable virtual resources			**1792**		**384G**	

The number of CPU cores and the amount of memory space are two major elements to determine the capacity of the V-Lab system. In the Fall 2013 semester, the V-Lab system supports 112 physical CPU cores and 256G physical RAM in total. Based on the default allocation ratio from OpenStack (CPU allocation ratio 1:16 and RAM allocation ratio 1:1.5), the V-Lab system is able to support at most **384 VMs with 1G RAM**.

5.3. Controller and Network Resources

In addition to the computation and storage resources, V-Lab system also needs servers to support control function for the system administrator and network services for users. Table 5-2 shows the list of physical servers have installed in the V-Lab system at the beginning of Fall 2013 semester.

Table 5-2: The list of physical servers for cloud control and network services.

Role	Hostname	Model	Cores	Disk	RAM	Purpose
Quantum	node6	R620	24	0.5T	64G	Networking
Quantum-bak	node7	R620	24	0.5T	64G	Networking
Controller	node8	R620	24	0.5T	64G	Controller
Controller-bak	node9	R620	24	0.5T	64G	Controller
Webserver	node10	Old server	2	500G	8G	vlab web portal
Monitoring and Log Server	node12	Old server	2	500G	8G	Monitor/Auditing

5.4. VM Templates and Resource Allocation Flavor

Each laboratory in V-Lab system consists of one or multiple virtual machines (VMs). The VMs are built based on pre-configured templates. Current system configures templates with qcow2 format (OpenStack default image format) that are available to be created for laboratories:

- Ubuntu 12.04 64-bit: 512MB Memory and 6GB Storage
- Ubuntu 13.10 64-bit: 1G Memory and 8GB Storage
- Windows 7 Professional SP1 64-bit: 1GB Memory and 40GB Storage
- Windows 2008 Server R2SP1 64-bit: 2GB Memory and 40GB Storage
- Windows Server 2012 64-bit: 2GB Memory and 4GB Storage

In addition to the VM templates, the virtual CPU, disk storage, and RAM also need to be assigned by selecting the flavor in the V-Lab system. Current system defines the following flavors for allocating resources to users:

- Ubuntu-small, 1 vCPU, 512MB RAM, 6G Disk
- Ubuntu-medium, 1 vCPU, 1G RAM, 8G Disk
- Ubuntu-large, 1 vCPU, 2G RAM, 10G Disk
- Ubuntu-xlarge, 2 vCPU, 4G RAM, 10G Disk
- Windows_64bits, 1 vCPU, 2G RAM, 40G Disk

5.5. Estimated Capacity for Resource Allocation

Based on the information from previous sections, the current capacity of V-Lab system is determined by the amount of RAM requested by users. The total amount of RAM in the current system is 384G. If we take 20% of RAM resources for the operating system control and administrative purpose, the total allocatable RAM is around 310G. Based on this capacity of free RAM, the current V-Lab system can only support at most 310 VMs with Ubuntu-medium requirement, or at most 155 VMs with Windows_64bits environment requirement to install various types of Windows OS.

6. Computation Resource Performance Analysis

During the Fall 2013 semester, the V-Lab system has installed Ganglia Cluster Monitoring System [6][7] to collect and monitor the resource utilization on each monitored server. This section presents the utilization and health status of each nova-compute servers which provide the VM provisioning and computation services for students during the Fall 2013 semester. This section also discusses the performance analysis based on the information from the monitoring system.

Since the monitoring system collects metrics from each server between during Oct.14.2013~Dec.7.2013, which covers 8 weeks of operation from week 42 to week 49, the following figures show various resource utilization on the following servers during this period of time:

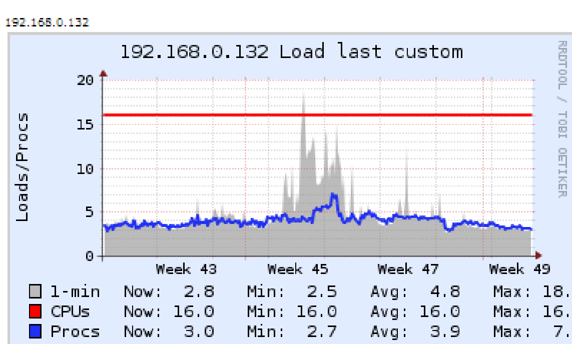
- Nova-1 cluster (which contains four nova-compute servers)
    - node2, IP address: 192.168.0.132
    - node3, IP address: 192.168.0.133
    - node4, IP address: 192.168.0.134
    - node5, IP address: 192.168.0.135
- Nova-2 cluster (which contains two nova-compute servers)
    - node13, IP address: 192.168.0.143
    - node14, IP address: 192.168.0.144

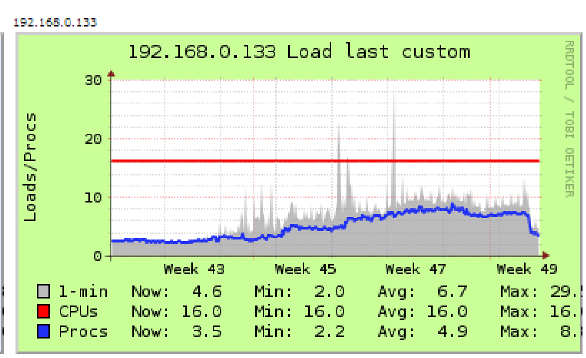
6.1. System Load Average

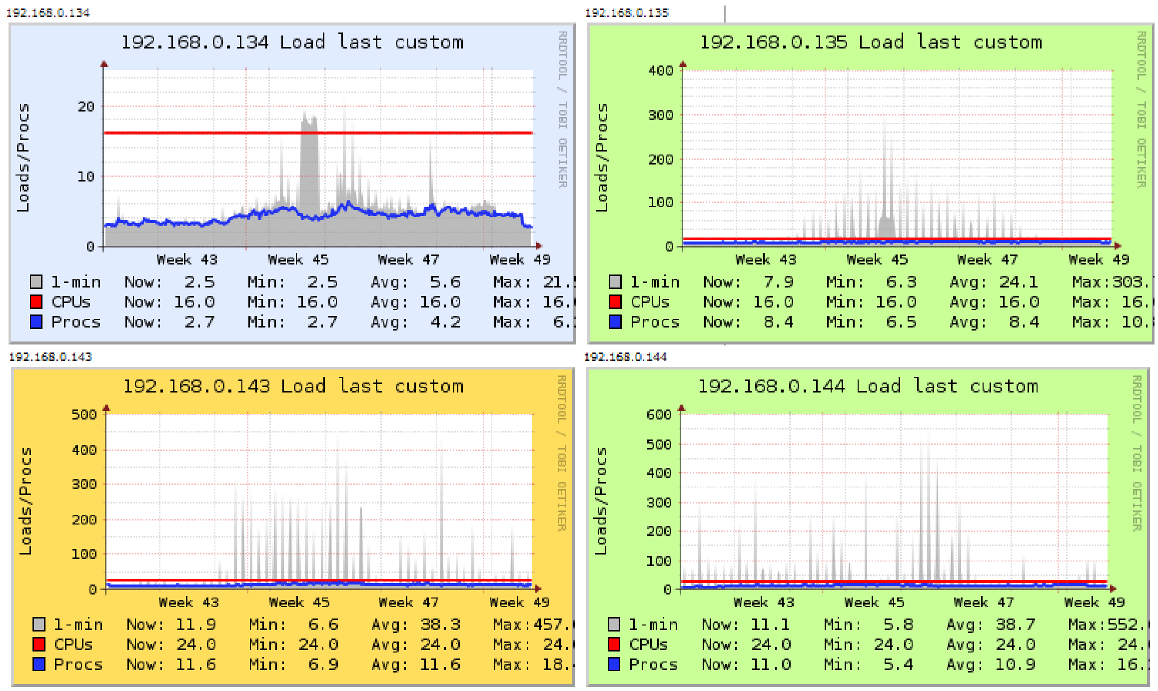
The system load average represents the average system load over a period of time. It conventionally appears in the form of three numbers which represent the system load during the last one-, five-, and fifteen-minute periods. Technically speaking, the load average represents the average number of processes that have to wait for CPU time during the last 1, 5 or 15 minutes.

Figure 6-1 shows the last one-min system load average of each nova-compute server during the monitoring time. Higher numbers represent an overloaded machine, and the load should not exceed the number of cores available on the system (the red line in the figure).

Figure 6-1: One-min Process Load Average







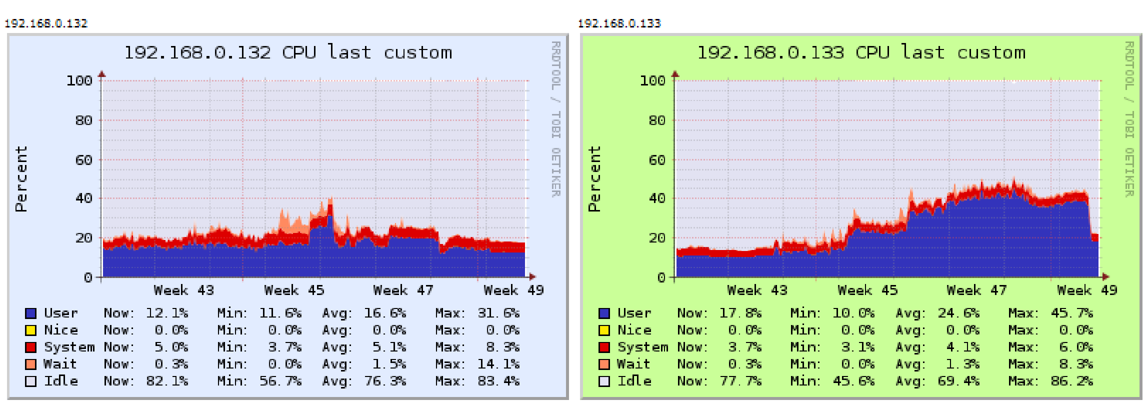
Based on the information from figure 6-1, we know 3 servers were overloaded:

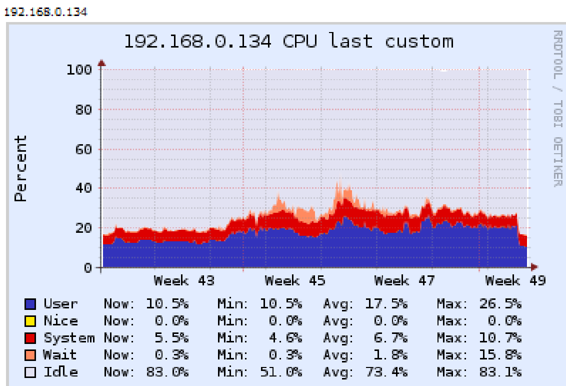
- Node 5 (192.168.0.135) has only 16 vCPU, but the average 1-min load is 24.1 and the max 1-min load is more than 303.
- Node 13 (192.168.0.143) has 24 vCPU, but the average 1-min load is 38.3 and the max 1-min load is more than 457.
- Node 14 (192.168.0.144) has 24 vCPU, but the average 1-min load is 38.7 and the max 1-min load is more than 552.

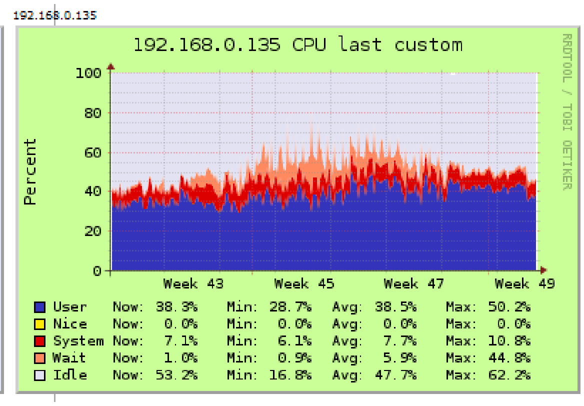
6.2. CPU Utilization

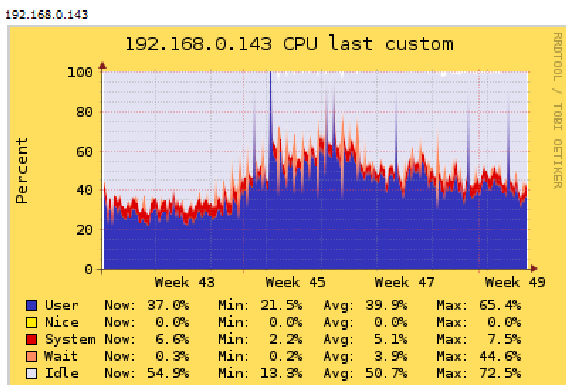
CPU utilization monitoring shows the workload of a given physical processor for real machines or of virtual processors for virtual machines. Figure 6-2 shows the CPU utilization of each nova-compute server during the monitoring time.

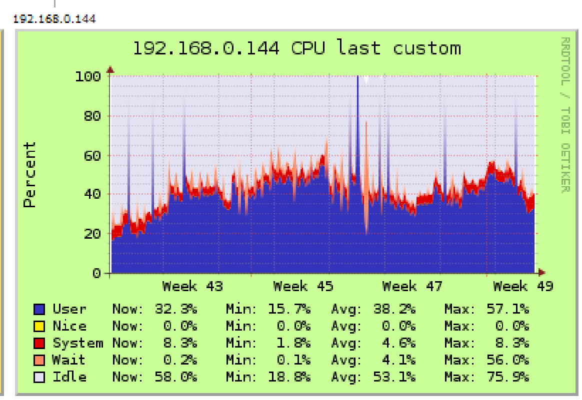
Figure 6-2: CPU Utilization









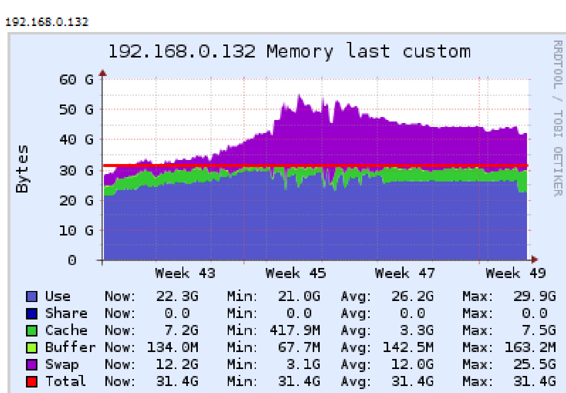


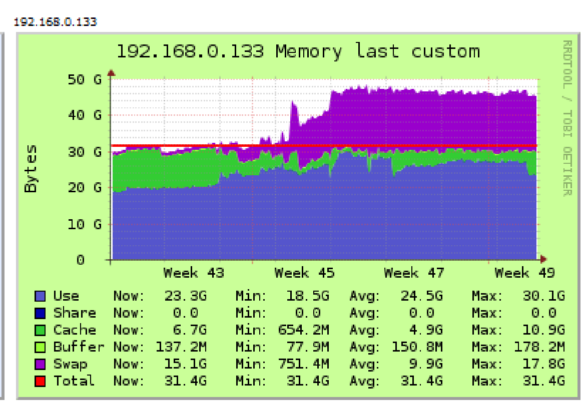
Based on the information from figure 6-2, we know Nova-1 cluster has better CPU utilization than the Nova-2 cluster. The CPU utilization of node 5 (192.168.0.135) was a little bit higher than other servers in the Nova-2 cluster, but still in a good shape. The CPU utilization of two servers in Nova-2 cluster still under the threshold (70%) on average, however, some sparse events make the utilization reaching to 100%.

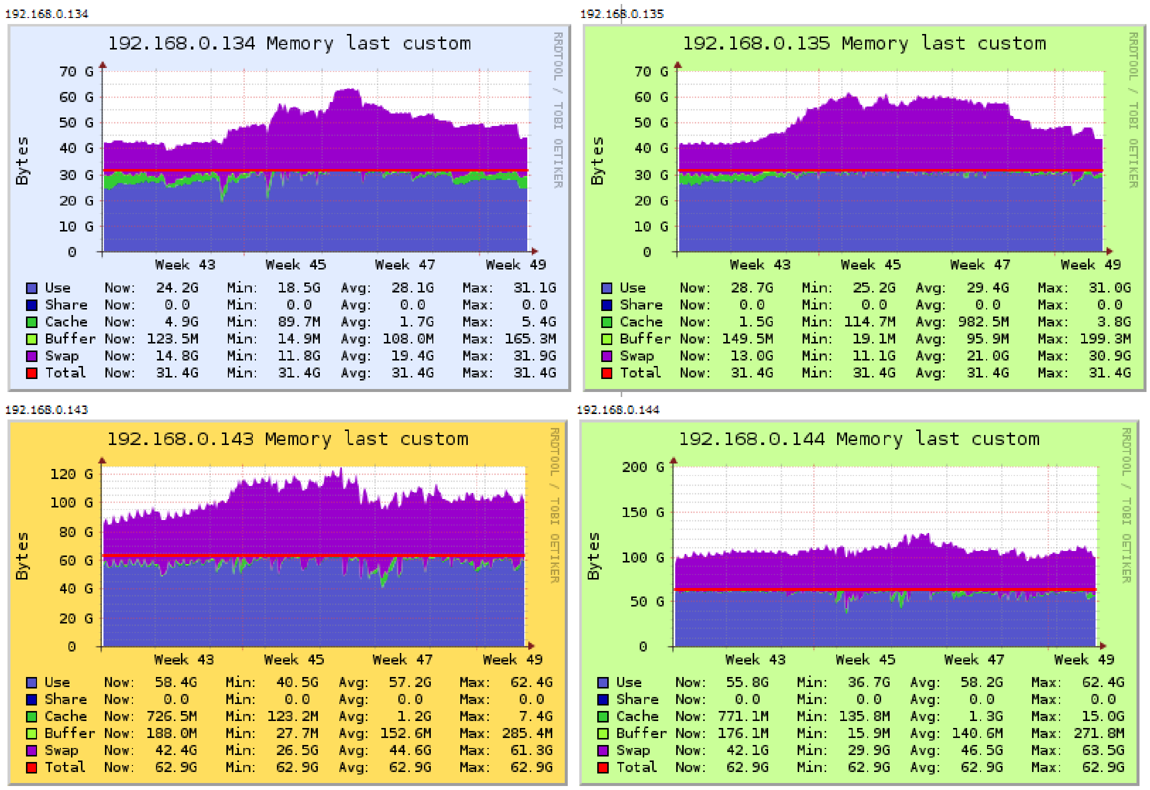
6.3. Memory Uage

Memory usage shows how users' processes use system memory. Figure 6-3 shows the memory usage on each nova-compute server during the monitoring time. The red line in each figure represents the total memory size on the server.

Figure 6-3: Memory Usage





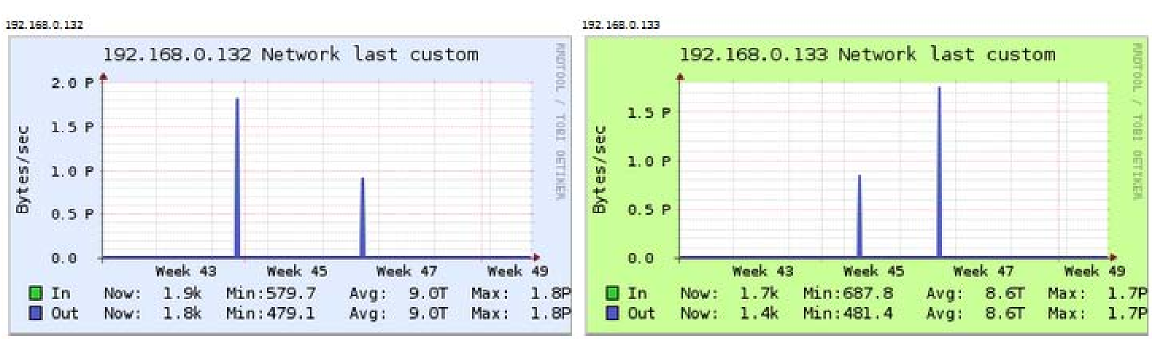


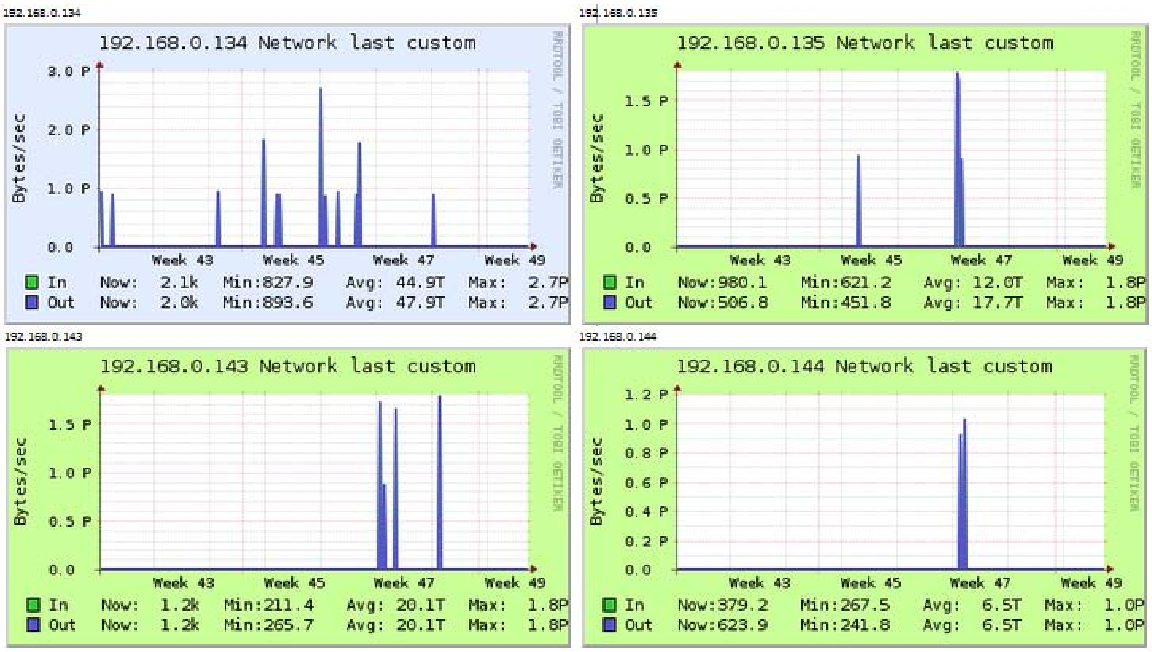
Based on the information from figure 6-2, we know that all servers suffer from the memory shortage problem because there is a big portion of swap memory usage of each server. This is the performance bottleneck in both Nova clusters since the swapping causes the disk I/O and the CPU process delay, which in turn causes more processes waiting for the CPU processing time in the queue and the higher system load average.

6.4. Network Usage

Network usage shows the inbound and outbound flow (bytes/second) passing through all interfaces (which include physical network interfaces and virtual network interfaces) on each server. Figure 6-4 shows the network usage of each nova-compute server during the monitoring time.

Figure 6-4: Network Usage





Although the average flow shown in each figure is a terabyte-level and the maximum flow reaches to a petabyte-level, the color shown in each figure still in gray or green which means the network utilization is below 50%, i.e., the network usage on each Nova compute server is normal.

Since Nova-compute node will create a lot of virtual interfaces for VMs and Ganglia's network usage will accumulate the traffic flow from all interfaces (both physical and virtual interfaces) on a server, therefore, we cannot tell the network throughput for a certain physical interface only. In order to monitor the interface-level network usage information, V-Lab system needs to use other monitoring tools especially for network analysis, for example, sFlow, NetFlow, or commercial tools.

7. Issues and Discussions

This section presents the issues found in V-Lab system with discussions.

7.1. Lack of Single Sign On mechanism

Currently the V-Lab system provides user management on the Web-GUI and OpenVPN. But it lacks user management for each virtual machine. By default, each virtual machine is created based on a template, and thus they all have same login credentials. This could be a security issue when the default password may be used to login newly created virtual machines. To solve the problem, V-Lab system needs to extend the authentication and authorization mechanism to certificate-based and Kerberos token-based solutions, which allows single sign on (SSO) from a portal and requests the credentials or tokens to access the authorized resources or services based on users' privilege without checking the username and password everywhere.

7.2. Computation and memory resource shortage

During the Fall 2013 semester, the V-Lab system has supported 337 students in 5 major courses, and accepted more than 388 VMs. From the capacity analysis for V-Lab system in previous sections, we know the memory (RAM) is a bottleneck to support a good quality of computation service. The current V-Lab system only equips with 384G RAM in total. However, the actual total allocated free RAM is around 310G after removing 20% of RAM resources for the operating system control and administrative purpose. Roughly speaking, the system can only support at most 310 Linux VMs, or at most 155 Windows VMs. In order to support more VMs and better computation service, V-Lab system needs to extend the memory (RAM) capacity.

7.4. Technical support resource shortage

CS department only assigned 10 hours/week for a TA to maintain the V-Lab system and provide technical support for students. In addition to the routine tasks for system maintenance and tuning, V-Lab TA also needs to answer the problems from 377 students and fix the technical issues for more than 380 VMs with more than 5 different configurations. During the Fall 2013 semester, V-Lab TA spent more than 10hours/week to maintain the system and fix the issues from students. Due to the support resource shortage, students' problem cannot be solved immediately, which in turn cause late submission of their project assignment.

To provide a better service and reduce the complaints from users, more technical support resources or V-Lab TA hours are needed.

8. Development and Enhancements of V-Lab In Spring 2014

This section presents the new features of V-Lab system for the future courses. Especially for the coming Spring 2014 semester, the development and enhancements described as follows.

8.1. Extend More Physical Resource

Since the students' VM demands are increasing, more and more resources are required to host student experiments. The V-Lab system is scalable and more servers can be added to extend the resource pool. There are several scaling methods.

First, the compute resource can be easily extended by adding more Nova Compute nodes to the V-Lab. The Nova Compute nodes will increase the VM pool. The more Nova Compute nodes, the more VMs the V-Lab can allocates. To add Nova Compute nodes, we only need to install and configure the new added servers using the same configuration as current Nova Compute configurations.

Second, besides more Nova Compute nodes, more network nodes could be added to the V-Lab to increase the user experience. The more Quantum nodes, the more wider network traffic the V-Lab system can handle, as well as wider bandwidth the system can provide, which means the users will experience fast connection and less responding time. To add more network nodes, similar to adding more compute nodes, we can simply install and configure the servers with the configuration of the currently used network nodes.

Before the Spring 2014 semester, V-Lab system will extend more than 10 physical servers for Nova Compute nodes and setup an additional OpenStack cluster which includes new cloud controller, new network controller, and more Nova Compute nodes to serve the increasing cloud resource requirement.

8.2 Upgrade To A New Version of OpenStack

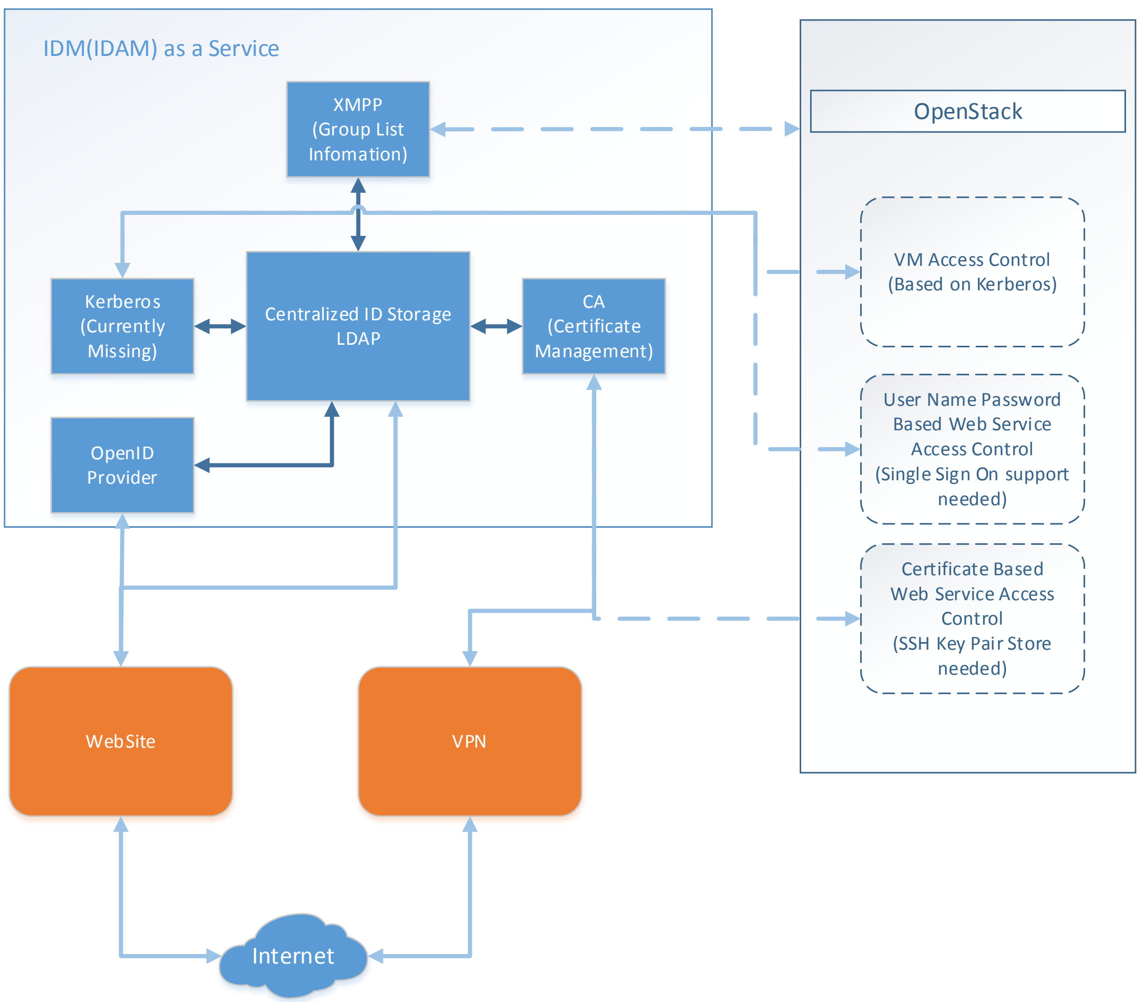
Since the OpenStack is rapidly developing, the new version of OpenStack is available now. The new version includes two new modules that are Telemetry and Orchestration. The OpenStack Telemetry service aggregates usage and performance data across the services deployed in an OpenStack cloud. This powerful capability provides visibility and insight into the usage of the cloud across dozens of data points and allows cloud operators to view metrics globally or by individual deployed resources. OpenStack Orchestration is a template-driven engine that allows application developers to describe and automate the deployment of infrastructure. The flexible template language can specify compute, storage and networking configurations as well as detailed post-deployment activity to automate the full provisioning of infrastructure as well as services and applications. Through integration with the Telemetry service, the Orchestration engine can also perform auto-scaling of certain infrastructure elements.

To upgrade to the new version, a fresh installation is required. The system configuration in the current version could be used as the reference in the new installation. The difference will be the configuration of the two new components. The trial and tests are necessary to make sure the new modules are working properly.

8.3. Create an IDAM system

Identity management system plays an important role in the V-Lab system. The current IDM system we're using is loosely connected to each component in the V-Lab system and each component manages authorization themselves. This makes it hard and inefficient for V-Lab administrator to manage the access and authorization of the entire system. Figure 8-1 shows a new IDAM system we proposed for V-Lab system.

Figure 8-1: IDAM Architecture



As shown in Figure 8-1, we plan to provide IDAM as a Service to V-Lab users as an important feature of the V-Lab system. The main component of the IDAM system is LDAP (Lightweight Directory Access Protocol) server, which act as a centralized ID storage where all the user information including ID, password, certificate, access right of another component, etc. Another XMPP (Extensible Messaging and Presence Protocol) server will be connected to the LDAP server and store users' friend list and group information to other services in the V-Lab system. Keberos and CA service are used to provide an extra identity related services to end user, like single sign-on service, certificate generation and management service, etc.

By adopting the new IDAM system into V-Lab system, we'll have a centralized place to manage all the identity related information about each user. The system can be easily combined with current and future components and services of V-Lab to provide secure and multi-functional identity management service.

8.4. Redesign the Web Portal of V-Lab System

The existing V-Lab Web-GUI has a self-developed PHP-based Web Portal that can be used for students to multiple services and resources provided by V-Lab. The portal was developed without native support for Web 2.0, and thus lacks the Ajax features for dynamic pulling and updating mechanism. As a result, the current web portal is not user-friendly and sometimes confusing for end users.

Our plan is to redesign the Web Protal from the sketch. The new Web Protal will be developed based on an open-source Drupal project and fully adopt the Web 2.0 standard, which comes with come with community support. The portal can work closely with the backend Web service and databases to provide a user-friendly Web-GUI to future V-Lab users. The redesign and development are in process.

9. Estimated Resource Requirement for Spring 2014

Table 9-1 shows the possible courses and estimated number of students will use V-Lab system in Spring 2014. It also shows the estimated resource, which includes the number of VMs, the number of vCPU, the amount of disk space, and the amount of RAM, to support these courses.

Table 9-1: Estimated Resource for Spring 2014

Course	Total Students	# of VMs	# of vCPU	Disk Space (GB)	Memory (GB)	Instructor	Course Name
468	23	75	75	450	75	Staff	Computer Network Security
548	70	>70	>70	>1024	>100	Dijiang Huang	Adv Computer Network Security
543 (not sure)	57	57	57	>2048	>120	Stephen Yau	Information Assurance
445/598	64	>15	>15	>600	>30	Yinong Chen	Distributed Software Development
598 (online) (hybrid)	45	< 45	< 45	< 1820	< 90	Yinong Chen	Distributed Software Development
Total	**259**	**262**	**262**	**6042**	**415**		

The estimated RAM requirement for Spring 2014 is 415G, which is more than the allocatable RAM resource (310G) in the current V-Lab system, therefore, the system needs to extend the capacity of memory at least 100G more. Based on the standard specs of Dell R720 server which with 64G RAM, V-Lab system needs install at least **two more compute servers** to satisfy the estimated requirement for Spring 2014.

10. References

[1] OpenStack Web-front end in V-Lab system, http://openstack.mobicloud.asu.edu/horizon.
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[3] MobiCloud Source Forge, http://mcsf.vlab.asu.edu/
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[5] Corosync, http://en.wikipedia.org/wiki/Corosync_(project)
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[7] Ganglia Monitoring System, http://ganglia.sourceforge.net/.