CloudStack  
Administration Guide

For CloudStack Version 3.0

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**A note to our readers**

This document is a draft of work in progress for a future release of ClouStack. It is not ready for publication. It may have errors, omissions, and descriptions of features that will not appear in the released software. The draft is provided for those who want an early look at work in progress for the next upcoming release of CloudStack, with the understanding that the documentation is subject to change, including major revision or removal. Distribution is not recommended.

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# What's In This Guide

If you have already installed CloudStack or you want to learn more about the ongoing operation and maintenance of a CloudStack-powered cloud, this guide is for you. With the procedures in this Administration Guide, you can start using, configuring, and managing the ongoing operation of your cloud.

# What Is CloudStack?

CloudStack™ is an open source software platform that pools computing resources to build public, private, and hybrid Infrastructure as a Service (IaaS) clouds. CloudStack manages the network, storage, and compute nodes that make up a cloud infrastructure. Use CloudStack to deploy, manage, and configure cloud computing environments.

**Who Should Read This**

If you are new to CloudStack or you want to learn more about concepts before installing and running CloudStack, read this overview.

If you just want to get started, see the Basic Installation Guide.

Typical users are service providers and enterprises. With CloudStack, you can:

* Set up an on-demand, elastic cloud computing service. Service providers can sell self‑service virtual machine instances, storage volumes, and networking configurations over the Internet.
* Set up an on-premise private cloud for use by employees. Rather than managing virtual machines in the same way as physical machines, with CloudStack an enterprise can offer self-service virtual machines to users without involving IT departments.



## What Can CloudStack Do?

**Multiple Hypervisor Support**

CloudStack works with a variety of hypervisors. A single cloud deployment can contain multiple hypervisor implementations. You have the complete freedom to choose the right hypervisor for your workload.

CloudStack is designed to work with open source Xen and KVM hypervisors as well as enterprise-grade hypervisors such as VMware vSphere, and Citrix XenServer.

**Massively Scalable Infrastructure Management**

CloudStack can manage tens of thousands of servers installed in multiple geographically distributed datacenters. The centralized management server scales linearly, eliminating the need for intermediate cluster-level management servers. No single component failure can cause cloud-wide outage. Periodic maintenance of the management server can be performed without affecting the functioning of virtual machines running in the cloud.

**Automatic Configuration Management**

CloudStack automatically configures each guest virtual machine’s networking and storage settings.

CloudStack internally manages a pool of virtual appliances to support the cloud itself. These appliances offer services such as firewalling, routing, DHCP, VPN access, console proxy, storage access, and storage replication. The extensive use of virtual appliances greatly simplifies the installation, configuration, and on-going management of a cloud deployment.

**Graphical User Interface**

CloudStack offers an administrator's Web interface, used for provisioning and managing the cloud, as well as an end-user's Web interface, used for running VMs and managing VM templates. The UI can be customized to reflect the desired service provider or enterprise look and feel.

**API and Extensibility**

CloudStack provides an API that gives programmatic access to all the management features available in the UI. The API is maintained and documented. This API enables the creation of command line tools and new user interfaces to suit particular needs. See the Developer’s Guide and API Reference, both available at <http://docs.cloud.com/CloudStack_Documentation>.

The CloudStack platform pluggable allocation architecture allows the creation of new types of allocators for the selection of storage and hosts. See the Allocator Implementation Guide (<http://docs.cloud.com/CloudStack_Documentation/Allocator_Implementation_Guide>).

**High Availability**

The CloudStack platform has a number of features to increase the availability of the system. The Management Server itself may be deployed in a multi-node installation where the servers are load balanced. MySQL may be configured to use replication to provide for a manual failover in the event of database loss. For the Hosts, the CloudStack platform supports NIC bonding and the use of separate networks for storage as well as iSCSI Multipath.

## Deployment Architecture Overview

A CloudStack installation consists of two parts: the Management Server and the cloud infrastructure that it manages. When you set up and manage a CloudStack cloud, you provision resources such as hosts, storage devices, and IP addresses into the Management Server, and the Management Server manages those resources.

The minimum installation consists of one machine running the CloudStack Management Server and another machine to act as the cloud infrastructure (in this case, a very simple infrastructure consisting of one host running hypervisor software).

Management Server

Hypervisor

Machine 1

Machine 2

Simplified view of a basic deployment

A more full-featured installation consists of a highly-available multi-node Management Server installation and up to thousands of hosts using any of several advanced networking setups. For information about deployment options, see the Advanced Installation Guide.

### Management Server Overview

The Management Server:

* Provides the web user interface for the administrator and a reference user interface for end users.
* Provides the APIs for the CloudStack platform.
* Manages the assignment of guest VMs to particular hosts.
* Manages the assignment of public and private IP addresses to particular accounts.
* Manages the allocation of storage to guests as virtual disks.
* Manages snapshots, templates, and ISO images, possibly replicating them across data centers.
* Provides a single point of configuration for the cloud.

For additional options, including how to set up a multi-node management server installation, see the Advanced Installation Guide.

The cloud infrastructure is organized as follows:

* **Zone**: Typically, a zone is equivalent to a single datacenter. A zone consists of one or more pods and secondary storage. See About Zones on page 17.
* **Pod**: Typically, one rack of hardware that includes a layer-2 switch and one or more clusters. See About Pods on page 19.
* **Cluster**: A cluster consists of one or more hosts and primary storage. See About Clusters on page 19.
* **Host**: A single compute node within a cluster. The hosts are where the actual cloud services run in the form of guest virtual machines. See About Hosts on page 34.
* Primary storage is associated with a cluster, and it stores the disk volumes for all the VMs running on hosts in that cluster. See About Primary Storage on page 54.
* Secondary storage is associated with a zone, and it stores templates, ISO images, and disk volume snapshots. See About Secondary Storage on page 57.

Host

Zone

Pod

Cluster

Secondary Storage

Primary Storage

Nested organization of a zone

### Networking Overview

CloudStack offers two types of networking scenario:

* **Basic.** For AWS-style networking. Provides a single network where guest isolation can be provided through layer-3 means such as security groups (IP address source filtering).
* **Advanced.** For more sophisticated topologies. This network model provides the most flexibility in defining guest networks.

For more on networking, see:

* About Physical Networks on page 20
* Providing Services for Users on page 24
* Network Setup in the Advanced Installation Guide

## User Services Overview

In addition to the physical and logical infrastructure of your cloud, and the CloudStack software and servers, you also need a layer of user services so that people can actually make use of the cloud. This means not just a user UI, but a set of options and resources that users can choose from, such as templates for creating virtual machines, disk storage, and more. If you are running a commercial service, you will be keeping track of what services and resources users are consuming and charging them for that usage. Even if you do not charge anything for people to use your cloud – say, if the users are strictly internal to your organization, or just friends who are sharing your cloud – you can still keep track of what services they use and how much of them.

### Service Offerings, Disk Offerings, Network Offerings, and Templates

A user creating a new instance can make a variety of choices about its characteristics and capabilities. CloudStack provides several ways to present users with choices when creating a new instance:

* Service Offerings, defined by the CloudStack administrator, provide a choice of CPU speed, number of CPUs, RAM size, tags on the root disk, and other choices. See Creating a New Service Offering on page 27.
* Disk Offerings, defined by the CloudStack administrator, provide a choice of disk size for primary data storage. See Creating a New Disk Offering on page 28.
* Network Offerings, defined by the CloudStack administrator, describe the feature set that is available to end users from the virtual router or external networking devices on a given guest network. See Network Offerings on page 26.
* Templates, defined by the CloudStack administrator or by any CloudStack user, are the base OS images that the user can choose from when creating a new instance. For example, the CloudStack platform includes CentOS as a template. See Working with Templates on page 64.

In addition to these choices that are provided for users, there is another type of service offering which is available only to the CloudStack root administrator, and is used for configuring virtual infrastructure resources. For more information, see Upgrading a Virtual Router with System Service Offerings on page 86.

### Accounts, Users, and Domains

An account typically represents a customer of the service provider or a department in a large organization. Multiple users can exist in an account. Users are like aliases in the account. Users in the same account are not isolated from each other, but they are isolated from users in other accounts. Most installations need not surface the notion of users; they just have one user per account.

Accounts are grouped by domains. Domains usually contain accounts that have some logical relationship to each other and a set of delegated administrators with some authority over the domain and its subdomains. For example, a service provider with several resellers could create a domain for each reseller.

Administrators are accounts with special privileges in the system. There may be multiple administrators in the system. Administrators can create or delete other administrators, and change the password for any user in the system. Root administrators have complete access to the system, including managing templates, service offerings, customer care administrators, and domains. Domain administrators can perform administrative operations for users who belong to that domain. Domain administrators do not have visibility into physical servers or other domains.

### Using an LDAP Server for User Authentication

You can use an external LDAP server such as Microsoft Active Directory or ApacheDS to authenticate CloudStack end-users. Just map CloudStack accounts to the corresponding LDAP accounts using a query filter. The query filter is written using the query syntax of the particular LDAP server, and can include special wildcard characters provided by CloudStack for matching common values such as the user’s email address and name. CloudStack will search the external LDAP directory tree starting at a specified base directory and return the distinguished name (DN) and password of the matching user. This information along with the given password is used to authenticate the user.

To set up LDAP authentication in CloudStack, provide the following:

* Hostname or IP address and listening port of the LDAP server and whether SSL is used
* Search user DN credentials, which give CloudStack permission to search on the LDAP server
* Base directory and query filter

For more information about query filter syntax, consult the documentation for your LDAP server. The CloudStack wildcards are:

|  |  |
| --- | --- |
| %u | Account name |
| %e | Email address |
| %n | First and last name |

# Logging In to the CloudStack UI

After the CloudStack Management Server software is installed and running, you can run the CloudStack user interface. This UI is there to help you provision, view, and manage your cloud infrastructure.

Open your favorite Web browser and go to this URL. Substitute the IP address of your own Management Server machine:

http://<management-server-ip-address>:8080/client

The first time you start the UI after a fresh Management Server installation, the Installation Wizard appears. Thereafter, the dashboard of the logged-in user appears. The various links in this screen and the navigation bar on the left provide access to a variety of administrative functions, as well as the ability to run VMs in the cloud and perform other user tasks.

# Provisioning Cloud Infrastructure

After the Management Server is installed and running, you can add the compute resources for it to manage.

To provision the cloud infrastructure, or to scale it up at any time, follow these procedures, all of which are available in the Advanced Installation Guide:

1. Add zones and pods
2. Configure the physical network
3. Add clusters
4. Add hosts
5. Add primary storage
6. Add secondary storage

When you have finished these steps, you will have a deployment with the following basic structure:

Host

Zone

Pod

Cluster

Management Server

Secondary Storage

Primary Storage

MySQL cloud\_db

Conceptual view of a basic deployment

Your actual deployment can have multiple management servers and zones.

## About Zones

A zone is the largest organizational unit within a CloudStack deployment. A zone typically corresponds to a single datacenter, although it is permissible to have multiple zones in a datacenter. The benefit of organizing infrastructure into zones is to provide physical isolation and redundancy. For example, each zone can have its own power supply and network uplink, and the zones can be widely separated geographically (though this is not required).

A zone consists of:

* One or more pods. Each pod contains one or more clusters of hosts and one or more primary storage servers.
* Secondary storage, which is shared by all the pods in the zone.

Host

Zone

Pod

Cluster

Secondary Storage

Primary Storage

A simple zone

Zones are visible to the end user. When a user starts a guest VM, the user must select a zone for their guest. Users might also be required to copy their private templates to additional zones to enable creation of guest VMs in those zones from their templates.

Zones may be public or private. Public zones are visible to all users. This means that any user may create a guest in that zone. Private zones are reserved for a specific domain. Only users in that domain or its subdomains may create guests in that zone.

Hosts in the same zone are directly accessible to each other without having to go through a firewall. Hosts in different zones can access each other through statically configured VPN tunnels.

For each zone, the administrator must decide the following.

* How many pods to place in a zone.
* How many clusters to have per pod.
* How many hosts to place in each cluster.
* How many primary storage servers to place in each cluster and total capacity for the storage servers.
* How much secondary storage to deploy in a zone.

## About Pods

A pod often represents a single rack. Hosts in the same pod are in the same subnet.

A pod is the second-largest organizational unit within a CloudStack deployment. Pods are contained within zones. Each zone can contain one or more pods.

A pod consists of one or more clusters of hosts and one or more primary storage servers.

Host

Pod

Cluster

Primary Storage

A simple pod

Pods are not visible to the end user.

## About Clusters

A cluster provides a way to group hosts. To be precise, a cluster is a XenServer server pool, a set of KVM servers, or a VMware cluster preconfigured in vCenter. The hosts in a cluster all have identical hardware, run the same hypervisor, are on the same subnet, and access the same shared primary storage. Virtual machine instances (VMs) can be live-migrated from one host to another within the same cluster, without interrupting service to the user.

A cluster is the third-largest organizational unit within a CloudStack deployment. Clusters are contained within pods, and pods are contained within zones. Size of the cluster is limited by the underlying hypervisor, although the CloudStack recommends less in most cases; see the Best Practices section in the Installation Guide.

A cluster consists of one or more hosts and one or more primary storage servers.

Host

Cluster

Primary Storage

A simple cluster

CloudStack allows multiple clusters in a cloud deployment.

Every VMware cluster is managed by a vCenter server. Administrator must register the vCenter server with CloudStack. There may be multiple vCenter servers per zone. Each vCenter server may manage multiple VMware clusters.

Even when local storage is used, clusters are still required. There is just one host per cluster.

## About Physical Networks

Part of adding a zone is setting up the physical network. One or (in an advanced zone) more physical networks can be associated with each zone. The network corresponds to a NIC on the hypervisor host. Each physical network can carry one or more types of network traffic. The choices of traffic type for each network vary depending on whether you are creating a zone with basic networking or advanced networking.

### Basic Zone Network Traffic Types

When basic networking is used, there can be only one physical network in the zone. That physical network carries three traffic types:

We strongly recommend the use of separate NICs for management traffic and guest traffic.

* Guest. When end users run VMs, they generate guest traffic. The guest VMs communicate with each other over a network that can be referred to as the guest network. Each pod in a basic zone is a broadcast domain, and therefore each pod has a different IP range for the guest network. The administrator must configure the IP range for each pod.
* Management. When CloudStack’s internal resources communicate with each other, they generate management traffic. This includes communication between hosts, system VMs (VMs used by CloudStack to perform various tasks in the cloud), and any other component that communicates directly with the CloudStack Management Server. You must configure the IP range for the system VMs to use.
* Storage. Traffic between primary and secondary storage servers, such as VM templates and snapshots.

In a basic network, configuring the physical network is fairly straightforward. You only need to configure one guest network to carry traffic that is generated by guest VMs.

### Basic Zone Guest IP Addresses

When basic networking is used, CloudStack will assign IP addresses in the CIDR of the pod to the guests in that pod. The administrator must add a Direct IP range on the pod for this purpose. These IPs are in the same VLAN as the hosts.

If the administrator changes the guest traffic CIDR at any time, the existing VMs continue to use the old CIDR. The new CIDR affects only VMs created from that point forward.

### Advanced Zone Network Traffic Types

When advanced networking is used, there can be multiple physical networks in the zone. Each physical network can carry one or more traffic types, and you need to let CloudStack know which type of network traffic you want each network to carry. The traffic types in an advanced zone are:

* Guest. When end users run VMs, they generate guest traffic. The guest VMs communicate with each other over a network that can be referred to as the guest network. This network can be isolated or shared. In an isolated guest network, the administrator needs to reserve VLAN ranges to provide isolation for each CloudStack account’s network (potentially a large number of VLANs). In a shared guest network, all guest VMs share a single network. In this case, you can provide isolation by using layer-2 networking isolation techniques, such as security groups.
* Management. When CloudStack’s internal resources communicate with each other, they generate management traffic. This includes communication between hosts, system VMs (VMs used by CloudStack to perform various tasks in the cloud), and any other component that communicates directly with the CloudStack Management Server. You must configure the IP range for the system VMs to use.
* Public. Public traffic is generated when VMs in the cloud access the Internet. Publicly accessible IPs must be allocated for this purpose. End users can use the CloudStack UI to acquire these IPs to implement NAT between their guest network and the public network.
* Storage. Traffic between primary and secondary storage servers, such as VM templates and snapshots.

These traffic types can each be on a separate physical network, or they can be combined with certain restrictions. When you use the Add Zone wizard in the UI to create a new zone, you are guided into making only valid choices.

### Advanced Zone Guest IP Addresses

When advanced networking is used, the administrator can create additional networks for use by the guests. These networks can span the zone and be available to all accounts, or they can be scoped to a single account, in which case only the named account may create guests that attach to these networks. The networks are defined by a VLAN ID, IP range, and gateway. The administrator may provision thousands of these networks if desired.

If the administrator changes the guest traffic CIDR at any time, the existing VMs continue to use the old CIDR. The new CIDR affects only guest networks and VMs created from that point forward.

### Advanced Zone Public IP Addresses

CloudStack provisions one public IP address per account for use as the source NAT IP address. If a Juniper SRX firewall is used, CloudStack can instead use a single public IP address as an interface NAT IP for all accounts, reducing the number of IP addresses consumed. Users may request additional public IP addresses. The administrator must configure one or more ranges of public IP addresses for use by CloudStack. These IP addresses could be RFC1918 addresses in private clouds.

### System Reserved IP Addresses

In each zone, you need to configure a range of reserved IP addresses for the management network. This network carries communication between the CloudStack Management Server and various system VMs, such as Secondary Storage VMs, Console Proxy VMs, and DHCP.

The reserved IP addresses must be unique across the cloud. You cannot, for example, have a host in one zone which has the same private IP address as a host in another zone.

The hosts in a pod are assigned private IP addresses. These are typically RFC1918 addresses. The Console Proxy and Secondary Storage system VMs are also allocated private IP addresses in the CIDR of the pod that they are created in.

The management network IP addresses are in the same subnet as the compute nodes where hypervisors and the Management Server run. You therefore need to make sure computing servers and Management Servers use IP addresses outside of the System Reserved IP range. For example, suppose the System Reserved IP range starts at 192.168.154.2 and ends at 192.168.154.7. CloudStack can use .2 to .7 for System VMs. This leaves the rest of the pod CIDR, from .8 to .254, for the Management Server and hypervisor hosts.

###### In all zones

Provide private IPs for the system in each pod and provision them in CloudStack.

For KVM and XenServer, the recommended number of private IPs per pod is one per host. If you expect a pod to grow, add enough private IPs now to accommodate the growth.

###### In a zone that uses advanced networking

For vSphere with advanced networking, we recommend provisioning enough private IPs for your total number of customers, plus enough for the required CloudStack System VMs. Typically, about 10 additional IPs are required for the System VMs. For more information about System VMs, see Working with System Virtual Machines in the Administrator's Guide.

When advanced networking is being used, the number of private IP addresses available in each pod varies depending on which hypervisor is running on the nodes in that pod. Citrix XenServer and KVM use link-local addresses, which in theory provide more than 65,000 private IP addresses within the address block. As the pod grows over time, this should be more than enough for any reasonable number of hosts as well as IP addresses for guest virtual routers. VMWare ESXi, by contrast uses any administrator-specified subnetting scheme, and the typical administrator provides only 255 IPs per pod. Since these are shared by physical machines, the guest virtual router, and other entities, it is possible to run out of private IPs when scaling up a pod whose nodes are running ESXi.

To ensure adequate headroom to scale private IP space in an ESXi pod that uses advanced networking, use one or more of the following techniques:

* Specify a larger CIDR block for the subnet. A subnet mask with a /20 suffix will provide more than 4,000 IP addresses.
* Create multiple pods, each with its own subnet. For example, if you create 10 pods and each pod has 255 IPs, this will provide 2,550 IP addresses.

# Providing Services for Users

People using cloud infrastructure have a variety of needs and preferences when it comes to the networking services provided by the cloud. As a CloudStack administrator, you can do the following things to set up networking for your users:

* Set up physical networks in zones (see the Advanced Installation Guide)
* Set up several different providers for the same service on a single physical network (for example, both Cisco and Juniper firewalls)
* Bundle different types of network services into network offerings, so users can choose the desired network services for any given virtual machine (see Network Offerings on page 26)
* Add new network offerings as time goes on so end users can upgrade to a better class of service on their network
* Provide more ways for a network to be accessed by a user, such as through a project of which the user is a member (see Using Projects to Organize Users and Resources on page 33)

## About Physical Networks

A physical network is the actual network hardware and wiring in a zone. A zone can have multiple physical networks. An administrator can:

* Add/Remove/Update physical networks in a zone
* Configure VLANs on the physical network
* Configure a name so the network can be recognized by hypervisors
* Configure the service providers (firewalls, load balancers, etc.) available on a physical network
* Configure the IP addresses trunked to a physical network
* Specify what type of traffic is carried on the physical network, as well as other properties like network speed

### Configurable Characteristics of Physical Networks

CloudStack provides configuration settings you can use to set up a physical network in a zone, including:

* What type of network traffic it carries (guest, public, management, storage)
* VLANs
* Unique name that the hypervisor can use to find that particular network
* Enabled or disabled. When a network is first set up, it is disabled – not in use yet. The administrator sets the physical network to enabled, and it begins to be used. The administrator can later disable the network again, which prevents any new virtual networks from being created on that physical network; the existing network traffic continues even though the state is disabled.
* Speed
* Tags, so network offerings can be matched to physical networks
* Isolation method

## About Virtual Networks

A virtual network is a logical construct that enables multi-tenancy on a single physical network. In CloudStack, a virtual network can be shared or isolated.

### Isolated Networks

An isolated network can be accessed only by virtual machines of a single account. Isolated networks have the following properties.

* Resources such as VLAN are allocated and garage collected dynamically.
* There is one network offering for the entire network.
* The network offering can be upgraded or downgraded but it is for the entire network.

### Shared Networks

A shared network can be accessed by virtual machines that belong to many different accounts. Network Isolation on shared networks is accomplished using techniques such as security groups.

* Shared Networks are created by the administrator
* Shared Networks can be designated to a certain domain
* Shared Network resources such as VLAN and physical network that it maps to are designated by the administrator
* Shared Networks can have multiple network offerings, allowing an end user to choose the network offering to deploy their virtual machine with
* Shared Networks are isolated by security groups
* Public Network is a shared network that is not shown to the end users.

### Runtime Allocation of Virtual Network Resources

When you define a new virtual network, all your settings for that network are stored in CloudStack. The actual network resources are activated only when the first virtual machine starts in the network. When all virtual machines have left the virtual network, the network resources are garbage collected so they can be allocated again. This helps to conserve network resources.

## Network Service Providers

A service provider (also called a network element) is hardware or virtual appliance that makes a network service possible; for example, a firewall appliance can be installed in the cloud to provide firewall service. On a single network, multiple providers can provide the same network service. For example, a firewall service may be provided by Cisco or Juniper devices in the same physical network.

You can have multiple instances of the same service provider in a network (say, more than one Juniper SRX device).

If different providers are set up to provide the same service on the network, the administrator can create *network offerings* so users can specify which network service provider they prefer (along with the other choices offered in network offerings). Otherwise, CloudStack will choose which provider to use whenever the service is called for.

### Supported Network Service Providers

For the most up-to-date list of which network service providers CloudStack supports, see the CloudStack UI or call listNetworkServiceProviders.

CloudStack ships with an internal list of the supported service providers, and you’ll choose from this list when creating a network offering.

## Network Offerings

A network offering is a named set of network services, such as:

For the most up-to-date list of which network services CloudStack supports, see the CloudStack UI or call listNetworkServices.

* DHCP
* Source NAT
* Gateway
* Load Balancing
* Firewall
* VPN
* Port Forwarding
* (Optional) Name one of several available providers to use for a given service, such as Juniper for the firewall
* (Optional) Network tag to specify which physical network to use

When creating a new VM, the user chooses one of the available network offerings, and that determines which network services the VM can use.

The CloudStack administrator can create any number of custom network offerings, in addition to the default network offerings provided by CloudStack. By creating multiple custom network offerings, you can set up your cloud to offer different classes of service on a single multi-tenant physical network. For example, while the underlying physical wiring may be the same for two tenants, tenant A may only need simple firewall protection for their website, while tenant B may be running a web server farm and require a scalable firewall solution, load balancing solution, and alternate networks for accessing the database backend.

When creating a new virtual network, the CloudStack administrator chooses which network offering to enable for that network. Each virtual network is associated with one network offering. A virtual network can be upgraded or downgraded by changing its associated network offering. If you do this, be sure to reprogram the physical network to match.

CloudStack also has internal network offerings for use by CloudStack system VMs. These network offerings are not visible to users but can be modified by administrators.

## Defining Service Offerings and Disk Offerings for Users

A service offering is a set of virtual hardware features such as CPU core count and speed, memory, and disk size. The CloudStack administrator can set up various offerings, and then end users choose from the available offerings when they create a new VM.

A service offering includes the following elements:

* CPU, memory, and network resource guarantees.
* How resources are metered.
* How the resource usage is charged.
* How often the charges are generated.

For example, one service offering might allow users to create a virtual machine instance that is equivalent to a 1 GHz Intel® Core™ 2 CPU, with 1 GB memory at $0.20/hour, with network traffic metered at $0.10/GB. Based on the user’s selected offering, CloudStack emits usage records that can be integrated with billing systems.

CloudStack separates service offerings into computing service offerings and disk service offerings. The computing service offering specifies:

* Guest CPU
* Guest RAM
* Guest Networking type (virtual or direct)
* Tags on the root disk

The disk offering specifies:

* Disk size (optional). An offering without a disk size will allow users to pick their own.
* Tags on the data disk

### Creating a New Service Offering

1. Log in with admin privileges to the CloudStack UI.
2. In the Add Service Offering dialog, make the following choices:

* **Name**. Any desired name for the service offering.
* **Display text**. A short description of the offering.
* **Storage type**. The type of disk that should be allocated to the guest. Local allocates from storage attached to XenServer directly. Shared allocates from storage accessible via NFS.
* **# of CPU cores**. The number of cores which should be allocated to an instance with this offering.
* **CPU (in MHz)**. The CPU speed of the cores that the instance is allocated. For example, “2000” would provide for a 2 GHz clock.
* **Memory (in MB)**. The amount of memory in megabytes that the instance should be allocated. For example, “2048” would provide for a 2 GB RAM allocation.
* **Offer HA**. If yes, the user will be able to choose a VM to be monitored and as highly available as possible.
* **Tags**. The tags that should be associated with the primary storage for this root disk.
* **CPU cap**. Whether to cap users at their purchased level of CPU usage even if spare capacity is available
* **Public**. Should the service offering be available all domains or only some domains. Chooes Yes to make it available to all domains. Choose No to limit the scope to a subdomain; CloudStack will then prompt for the subdomain's name.

1. Click Add.

### Modifying or Deleting a Service Offering

Service offerings cannot be changed once created.

A service offering can be deleted. If it is no longer in use, it is deleted immediately and permanently. If the service offering is still in use, it will remain in the database until all the virtual machines referencing it have been deleted. After deletion by the administrator, a service offering will not be available to end users that are creating new instances.

### Creating a New Disk Offering

1. Log in with admin privileges to the CloudStack UI.
2. In the Add Disk Offering dialog, make the following choices:

* Name and description
* Disk size (optional). An offering without a disk size will allow users to pick their own.
* Tags on the data disk
* Public or private

1. Click Add.

# Working With Virtual Machines

CloudStack provides administrators with complete control over the lifecycle of all guest VMs executing in the cloud.

The CloudStack platform provides several guest management operations for end users and administrators. VMs may be stopped, started, rebooted, and destroyed.

Guests have a name and group. Guest names and groups are opaque to the CloudStack platform and are available for end users to organize their VMs. Each VM can have three names for use in different contexts. Only two of these names can be controlled by the user:

* Instance name – a unique, immutable ID that is generated by CloudStack and can not be modified by the user. This name conforms to the requirements in IETF RFC 1123.
* Display name – the name displayed in the CloudStack web UI. Can be set by the user. Defaults to instance name.
* Name – host name that the DHCP server assigns to the VM. Can be set by the user. Defaults to instance name.

Guests can be configured to be Highly Available (HA). An HA-enabled guest is monitored by the system. If the system detects that the guest is down, it will attempt to restart the guest, possibly on a different Host.

The CloudStack platform cannot distinguish a guest VM that was shut down by the user (E.g. Via the “shutdown” command in Linux) from a VM that exited unexpectedly. If an HA-enabled guest is shut down inside the VM, the CloudStack platform will restart it. The user must go through the CloudStack UI or API to shut down an HA-enabled guest.

## VM Lifecycle

Virtual machines can be in the following states:

Start

Stop

Reboot

Destroy

Start

Fail

Once a virtual machine is destroyed, it cannot be recovered. All the resources used by the virtual machine will be reclaimed by the system. This includes the virtual machine’s IP address.

A stop will attempt to gracefully shut down the operating system, which typically involves terminating all the running applications. If the operation system cannot be stopped, it will be forcefully terminated. This has the same effect as pulling the power cord to a physical machine.

A reboot is a stop followed by a start.

Unlike Amazon EC2, the system preserves the state of the virtual machine hard disk until the machine is destroyed.

A running virtual machine may fail because of hardware or network issues. A failed virtual machine is in the down state.

The system places the virtual machine into the down state if it does not receive the heartbeat from the hypervisor for three minutes.

The hard disk image is preserved when a virtual machine enters the down state.

The user can manually restart the virtual machine from the down state.

The system will start the virtual machine from the down state automatically if the virtual machine is marked as HA-enabled.

## Creating VMs

Virtual machines are usually created from a template. Users can also create blank virtual machines. A blank virtual machine is a virtual machine without an OS template. Users can attach an ISO file and install the OS from the CD/DVD-ROM.

To create a VM from a template:

1. Log in to the CloudStack UI as an administrator or user.
2. Click Add Instance.
3. Select a template, then follow the steps in the wizard. (For more information about how the templates came to be in this list, see Working with Templates on page 64.)
4. Be sure that the hardware you have allows starting the selected service offering.
5. Click Submit and your VM will be created and started.

To create a VM from an ISO:

1. Log in to the CloudStack UI as an administrator or user.
2. Click Add Instance.
3. Select ISO Boot, and follow the steps in the wizard.
4. Click Submit and your VM will be created and started.
5. (Oracle VM only) After ISO installation, the installer reboots into the operating system. Due to a known issue in OVM, the reboot will place the VM in the Stopped state. In the CloudStack UI, detach the ISO from the VM (so that the VM will not boot from the ISO again), then click the Start button to restart the VM.

## Stopping and Starting VMs

Once a VM instance is created (see Creating VMs on page 31) you can stop, restart, or delete it as needed. In the CloudStack UI, click Instances, select the VM, and use the Stop, Start, Reboot, and Destroy links.

## Moving VMs Between Hosts (Manual Live Migration)

(Not available for bare metal hosts)

The CloudStack administrator can move a running VM from one host to another without interrupting service to users or going into maintenance mode. This is called manual live migration, and can be done under the following conditions:

* The root administrator is logged in. Domain admins and users can not perform manual live migration of VMs.
* The VM is running. Stopped VMs can not be live migrated.
* The destination host must be in the same cluster as the original host.
* The VM must not be using local disk storage.
* The destination host must have enough available capacity. If not, the VM will remain in the "migrating" state until memory becomes available.

To manually live migrate a virtual machine:

1. Log in to the CloudStack UI as the CloudStack root administrator.
2. Go to Instances.
3. Choose the VM that you want to migrate.
4. Choose Migrate Instance.
5. From the list of hosts, choose the one to which you want to move the VM.
6. Click OK.

## Deleting VMs

Users can delete their own virtual machines. A running virtual machine will be abruptly stopped before it is deleted.

Administrators can delete any virtual machines.

## Remote Access to VMs

The user is able to access virtual machine console through the web management UI.

Administrators can access the virtual machine consoles that belong to any users for the purpose of support and troubleshooting. The adminisintrators will be subject to providing the root (or other) password for the guest.

# Using Projects to Organize Users and Resources

CloudStack users can group themselves into projects so they can collaborate and share virtual resources. CloudStack tracks usage per project as well as per user, so the usage can be billed to either a user account or a project. For example, a private cloud within a software company might have all members of the QA department assigned to one project, so the company can track the resources used in testing while the project members can more easily isolate their efforts from other users of the same cloud.

You can configure CloudStack to allow any user to create a new project, or you can restrict that ability to just CloudStack administrators. Once you have created a project, you become that project’s administrator, and you can add others within your domain to the project. CloudStack can be set up either so that you can add people directly to a project, or so that you have to send an invitation which the recipient must accept. Project members can view and manage all virtual resources created by anyone in the project (for example, share VMs). A user can be a member of any number of projects and can switch views in the CloudStack UI to show only project-related information, such as project VMs, fellow project members, project-related alerts, and so on.

The project administrator can pass on the role to another project member. The project administrator can also invite more users, remove users from the project, set new resource limits (as long as they are below the global defaults set by the CloudStack administrator), and delete the project. When the administrator removes a user from the project, resources created by that user, such as VM instances, remain with the project. This brings us to the subject of resource ownership and which resources can be used by a project.

Resources created within a project are owned by the project, not by any particular CloudStack account, and they can be used only within the project. A user who belongs to one or more projects can still create resources outside of those projects, and those resources belong to the user’s account; they will not be counted against the project’s usage or resource limits. You can create project-level networks to isolate traffic within the project and provide network services such as port forwarding, load balancing, VPN, and static NAT. A project can also make use of certain types of resources from outside the project, if those resources are shared. For example, a shared network or public template is available to any project in the domain. A project can get access to a private template if the template’s owner will grant permission. A project can use any service offering or disk offering available in its domain; however, you can not create private service and disk offerings at the project level.

# Working with Hosts

This section gives concepts and technical details about hosts in CloudStack. For information about how to install and configure hosts through the CloudStack UI, see the Advanced Installation Guide.

## About Hosts

A host is a single computer. Hosts provide the computing resources that run the guest virtual machines. Each host has hypervisor software installed on it to manage the guest VMs. For example, a Linux KVM-enabled server, a Citrix XenServer server, and an ESXi server are hosts.

The host is the smallest organizational unit within a CloudStack deployment. Hosts are contained within clusters, clusters are contained within pods, and pods are contained within zones.

Hosts in a CloudStack deployment:

* Provide the CPU, memory, storage, and networking resources needed to host the virtual machines
* Interconnect using a high bandwidth TCP/IP network and connect to the Internet
* May reside in multiple data centers across different geographic locations
* May have different capacities (different CPU speeds, different amounts of RAM, etc.), although the hosts within a cluster must all be homogeneous

Additional hosts can be added at any time to provide more capacity for guest VMs.

CloudStack automatically detects the amount of CPU and memory resources provided by the Hosts.

Hosts are not visible to the end user. An end user cannot determine which host their guest has been assigned to.

For a host to function in CloudStack, you must do the following:

* Install hypervisor software on the host
* Assign an IP address to the host
* Ensure the host is connected to the CloudStack Management Server

## Scheduled Maintenance and Maintenance Mode for Hosts

You can place a host into maintenance mode. When maintenance mode is activated, the host is first removed from the pool of hosts available to receive new guest VMs. Then, the guest VMs currently running on the host are seamlessly migrated to another host not in maintenance mode. This migration uses live migration technology and does not interrupt the execution of the guest.

### vCenter and Maintenance Mode

To enter maintenance mode on a vCenter host, both vCenter and CloudStack must be used in concert. CloudStack and vCenter have separate maintenance modes that work closely together.

1. Place the host into CloudStack's "scheduled maintenance" mode. This does not invoke the vCenter maintenance mode, but only causes VMs to be migrated off the host.

When the CloudStack maintenance mode is requested, the host first moves into the Prepare for Maintenance state. In this state it cannot be the target of new guest VM starts. Then all VMs will be migrated off the server. Live migration will be used to move VMs off the host. This allows the guests to be migrated to other hosts with no disruption to the guests. After this migration is completed, the host will enter the Ready for Maintenance mode.

1. Wait for the "Ready for Maintenance" indicator to appear in the UI.
2. Now use vCenter to perform whatever actions are necessary to maintain the host. During this time, the host cannot be the target of new VM allocations.
3. When the maintenance tasks are complete, take the host out of maintenance mode as follows:
4. First use vCenter to exit the vCenter maintenance mode.

This makes the host ready for CloudStack to reactivate it.

1. Then use CloudStack's administrator UI to cancel the CloudStack maintenance mode.

When the host comes back online, the VMs that were migrated off of it are migrated back to it and new VMs can be added.

### XenServer and Maintenance Mode

Some host in the cluster must be up in order for a host to be put into maintenance mode. With XenServer, maintenance mode ejects the host from the XenServer pool. If no hosts are up then the command to eject the host cannot be processed by any XenServer, and maintenance mode will fail.

The administrator should use XenServer to confirm that the host has been ejected from the pool when the host has entered maintenance mode. To check this, on the removed host:

# xe host-list

If this returns more than one host, manually eject the host that is in maintenance mode:

# xe pool-eject uuid={uuid of this host}

## Disabling and Enabling Zones, Pods, and Clusters

You can enable or disable a zone, pod, or cluster without permanently removing it from the cloud. This is useful for maintenance or when there are problems that make a portion of the cloud infrastructure unreliable. No new allocations will be made to a disabled zone, pod, or cluster until its state is returned to Enabled. When a zone, pod, or cluster is first added to the cloud, it is Disabled by default.

## Removing Hosts

Hosts can be removed from the cloud as needed. The procedure to remove a host depends on the hypervisor type.

### Removing XenServer and KVM Hosts

A node cannot be removed from a cluster until it has been placed in maintenance mode. This will ensure that all of the VMs on it have been migrated to other Hosts. To remove a Host from the cloud:

1. Place the node in maintenance mode (see Scheduled Maintenance and Maintenance Mode for Hosts on page 34).
2. For KVM, stop the cloud-agent service.
3. Use the UI option to remove the node.

Then you may power down the Host, re-use its IP address, re-install it, etc.

### Removing vSphere Hosts

To remove this type of host, first place it in maintenance mode, as described in Scheduled Maintenance and Maintenance Mode for Hosts on page 34. Then use CloudStack to remove the host. CloudStack will not direct commands to a host that has been removed using CloudStack. However, the host may still exist in the vCenter cluster.

## Re-Installing Hosts

You can re-install a host after placing it in maintenance mode and then removing it. If a host is down and cannot be placed in maintenance mode, it should still be removed before the re-install. See Removing Hosts on page 34.

## Changing Host Password

The password for a XenServer Node, KVM Node, or vSphere Node may be changed in the database. Note that all Nodes in a Cluster must have the same password. To change a Node's password:

1. Identify all hosts in the cluster.
2. Change the password on all hosts in the cluster. Now the password for the host and the password known to CloudStack will not match. Operations on the cluster will fail until the two passwords match.
3. Get the list of host IDs for the host in the cluster where you are changing the password. You will need to access the database to determine these host IDs. For each hostname "h" (or vSphere cluster) that you are changing the password for, execute:
4. mysql> select id from cloud.host where name like '%h%';
5. This should return a single ID. Record the set of such IDs for these hosts.
6. Update the passwords for the host in the database. In this example, we change the passwords for hosts with IDs 5, 10, and 12 to "password".

mysql> update cloud.host set password='password' where id=5 or id=10 or id=12;

## Host Allocation

The system automatically picks the most appropriate host to run each virtual machine. End users may specify the zone in which the virtual machine will be created. End users do not have control over which host will run the virtual machine instance.

CloudStack administrators can specify that certain hosts should have a preference for particular types of guest instances. For example, an administrator could state that a host should have a preference to run Windows guests. The default host allocator will attempt to place guests of that OS type on such hosts first. If no such host is available, the allocator will place the instance wherever there is sufficient physical capacity.

### Over-Provisioning and Service Offering Limits

The CloudStack platform performs CPU over-provisioning based on an over-provisioning ratio configured by the administrator. This is defined by the cpu.overprovisioning.factor global configuration variable.

CPU over-provisioning allows the sum total of the gigahertz of CPU speed allocated to guests to exceed the physically available gigahertz. For example, if a Host had 2 cores at 2 GHz each, it would have 4 GHz total. With a CPU over provisioning factor of 1.5, the CloudStack would allocate VMs up to 6 GHz total on the Host.

Service offerings limits (e.g. 1 GHz, 1 core) are strictly enforced for core count. For example, a guest with a service offering of one core will have only one core available to it regardless of other activity on the Host.

Service offering limits for gigahertz are enforced only in the presence of contention for CPU resources. For example, suppose that a guest was created with a service offering of 1 GHz on a Host that has 2 GHz cores, and that guest is the only guest running on the Host. The guest will have the full 2 GHz available to it. When multiple guests are attempting to use the CPU a weighting factor is used to schedule CPU resources. The weight is based on the clock speed in the service offering. Guests receive a CPU allocation that is proportionate to the GHz in the service offering. For example, a guest created from a 2 GHz service offering will receive twice the CPU allocation as a guest created from a 1 GHz service offering.

The CloudStack platform does not perform memory over-provisioning.

## VLAN Provisioning

CloudStack automatically creates and destroys interfaces bridged to VLANs on the hosts. In general the administrator does not need to manage this process.

CloudStack manages VLANs differently based on hypervisor type. For XenServer or KVM, the VLANs are created on only the hosts where they will be used and then they are destroyed when all guests that require them have been terminated or moved to another host.

For vSphere the VLANs are provisioned on all hosts in the cluster even if there is no guest running on a particular Host that requires the VLAN. This allows the administrator to perform live migration and other functions in vCenter without having to create the VLAN on the destination Host. Additionally, the VLANs are not removed from the Hosts when they are no longer needed.

# Managing Networks and Traffic

In a CloudStack cloud, guest VMs can communicate with each other using shared infrastructure with the security and user perception that the guests have a private LAN.

The CloudStack virtual router is the main component providing networking features for guest traffic.

## Guest Traffic

A network can carry guest traffic only between VMs within one zone. Virtual machines in different zones cannot communicate with each other using their IP addresses; they must communicate with each other by routing through a public IP address.

Figure 1 illustrates a typical guest traffic setup.

Routing Domain

Account 1 Guest 1

Account 1 Guest 2

Account 1 Guest 3

Account 1 Guest 4

Internet

Public Traffic (65.37.\*.\*)

Guest Traffic 10.0.0.0/8

Gateway address 10.1.1.1

NAT  
Load Balancing

65.37.141.24  
65.37.141.27

65.37.\*.\*

10.1.1.2

10.1.1.3

10.1.1.4

10.1.1.5

Link-Local Network (169.254.\*.\*)

Figure Guest Traffic Setup

The Management Server automatically creates a virtual router for each network. A virtual router is a special virtual machine that runs on the hosts. Each virtual router has three network interfaces. Its eth0 interface serves as the gateway for the guest traffic and has the IP address of 10.1.1.1. Its eth1 interface is used by the system to configure the virtual router. Its eth2 interface is assigned a public IP address for public traffic.

The virtual router provides DHCP and will automatically assign an IP address for each guest VM within the IP range assigned for the network. The user can manually reconfigure guest VMs to assume different IP addresses.

Source NAT is automatically configured in the virtual router to forward outbound traffic for all guest VMs.

## Networking in a Pod

Figure 2 illustrates network setup within a single pod. The hosts are connected to a pod-level switch. At a minimum, the hosts should have one physical uplink to each switch. Bonded NICs are supported as well. The pod-level switch is a pair of redundant gigabit switches with 10 G uplinks.

Pod-Level Switch (layer-2 switch)

Host 3

Host 1

Storage Device 1

Host 2

Host 4

Host 5

Storage Device 2

Host 6

Public Traffic (65.37.\*.\*)

Management Traffic (192.168.\*.\*)



Guest Traffic (10.\*.\*.\*)

Figure Network Setup within a Single Pod – Logical View

Servers are connected as follows:

* Storage devices are connected to only the network that carries management traffic.
* Hosts are connected to networks for both management traffic and public traffic.
* Hosts are also connected to one or more networks carrying guest traffic.

We recommend the use of multiple physical Ethernet cards to implement each network interface as well as redundant switch fabric in order to maximize throughput and improve reliability.

## Networking in a Zone

Figure 3 illustrates the network setup within a single zone.



Layer-2 switch



Internet

Layer-3 switch w/ firewall modules

Pod 2

Pod 1

Primary storage servers



Management Server farm with MySQL



Hosts



Secondary storage servers



Figure Network setup in a zone

A firewall for management traffic operates in the NAT mode. The network typically is assigned IP addresses in the 192.168.0.0/16 Class B private address space. Each pod is assigned IP addresses in the 192.168.\*.0/24 Class C private address space.

Each zone has its own set of public IP addresses. Public IP addresses from different zones do not overlap.

## Basic Zone Physical Network Configuration

In a basic network, configuring the physical network is fairly straightforward. You only need to configure one guest network to carry traffic that is generated by guest VMs. When you first add a zone to CloudStack, you set up the guest network through the Add Zone screens (see the Advanced Installation Guide).

### About Guest IP Addresses in a Basic Zone

When basic networking is used, CloudStack will assign IP addresses in the CIDR of the pod to the guests in that pod. The administrator must add a Direct IP range on the pod for this purpose. These IPs are in the same VLAN as the hosts.

## Advanced Zone Physical Network Configuration

Within a zone that uses advanced networking, you need to tell the Management Server how the physical network is set up to carry different kinds of traffic in isolation.

### Configure Guest Traffic in an Advanced Zone

In a zone that uses advanced networking, you need to configure at least one guest network to carry traffic that is generated by guest VMs.

#### About Guest IP Addresses in an Advanced Zone

When advanced networking is used, the administrator can create additional networks for use by the guests. These networks can span the zone and be available to all accounts, or they can be scoped to a single account, in which case only the named account may create guests that attach to these networks. The networks are defined by a VLAN ID, IP range, and gateway. The administrator may provision thousands of these networks if desired.

#### Configuring Guest Traffic in an Advanced Zone

These steps assume you have already logged in to the CloudStack UI (see page 16). To configure the base guest network:

1. In the left navigation, choose System. On Zones, click View More, then click the zone to which you want to add a network.
2. Click the Network tab.
3. Click Add network.
4. Provide the following information:

* **Name**. The name of the network. This will be user-visible.
* **Description**: The description of the network. This will be user-visible.
* **VLAN ID**: Enter an administrator-configured VLAN ID so you can create different networks for use by different VM users in the zone.
* **Access**: Choose account-specific or domain-specific if you would like to make the network accessible to only a single account or domain. Choose zone-wide if all accounts with access to the zone should be able to access the network.
* **Domain/Account**: If Scope is account-specific, enter the domain and account name for the account.
* **Network offering: If the administrator has configured multiple network offerings, select the one you want to use for this network.**
* **Gateway**: The gateway that the guests should use.
* **Netmask**: The netmask in use on the subnet the guests will use.
* **Start IP/End IP**: Enter the first and last IP addresses that define a range that CloudStack can assign to guests. If one NIC is used, these IPs should be in the same CIDR as the pod CIDR. If multiple NICs are used, they may be in a different subnet.
* **Network Domain**: (Optional) If you want to assign a special domain name to this network, specify the DNS suffix.

1. Click OK.

### Configure Public Traffic in an Advanced Zone

In a zone that uses advanced networking, you need to configure at least one range of IP addresses for Internet traffic.

#### About Public IP Addresses

CloudStack provisions one public IP address per account for use as the source NAT IP address. If a Juniper SRX firewall is used, CloudStack can instead use a single public IP address as an interface NAT IP for all accounts, reducing the number of IP addresses consumed. Users may request additional public IP addresses. The administrator must configure one or more ranges of public IP addresses for use by CloudStack. These IP addresses could be RFC1918 addresses in private clouds.

#### Adding IP Addresses for the Public Network

These steps assume you have already logged in to the CloudStack UI (see page 16).

1. In the left navigation, choose System. In Zones, click View More, then click the desired zone
2. Click the Network tab.
3. In the Public node of the diagram, click Configure.
4. Click the IP Ranges tab.
5. Enter the following details.

* **Gateway**. The gateway in use for these IP addresses.
* **Netmask**. The netmask associated with this IP range.
* **VLAN**. The VLAN that will be used for public traffic.
* **Start IP/End IP**. A range of IP addresses that are assumed to be accessible from the Internet and will be allocated for access to guest networks.

1. Click Add.

## Using Multiple Guest Networks

In zones that use advanced networking, additional networks for guest traffic may be added at any time after the initial installation. You can also customize the domain name associated with the network by specifying a DNS suffix for each network.

A VM's networks are defined at VM creation time. A VM cannot add or remove networks after it has been created, although the user can go into the guest and remove the IP address from the NIC on a particular network.

Each VM has just one default network. The virtual router's DHCP reply will set the guest's default gateway as that for the default network. Multiple non-default networks may be added to a guest in addition to the single, required default network. The administrator controls which networks are available as the default network.

Additional networks can either be available to all accounts or be assigned to a specific account. Networks that are available to all accounts are zone-wide. Any user with access to the zone can create a VM with access to that network. These zone-wide networks provide little or no isolation between guests. Networks that are assigned to a specific account provide strong isolation.

### Adding an Additional Guest Network

These steps assume you have already logged in to the CloudStack UI (see page 16).

1. In the left navigation, choose System. On Zones, click View More, then click the zone you want to work with.
2. Select the physical network where you want to add a guest virtual network.
3. In the Guest node of the network diagram, click Configure.



1. Click the Network tab.
2. Click Add network.

* Provide the following information:
* **Name**. The name of the network. This will be user-visible.
* **Description**: The description of the network. This will be user-visible.
* **Network offering: If the administrator has configured multiple network offerings, select the one you want to use for this network.**
* **Pod**: The name of the pod this network applies to. Each pod in a basic zone is a broadcast domain, and therefore each pod has a different IP range for the guest network. The administrator must configure the IP range for each pod.
* **VLAN ID**: The VLAN tag for this network.
* **Gateway**: The gateway that the guests should use.
* **Netmask**: The netmask in use on the subnet the guests will use.
* **Start IP/End IP**: Enter the first and last IP addresses that define a range that CloudStack can assign to guests.
* We strongly recommend the use of multiple NICs. If multiple NICs are used, they may be in a different subnet.
* If one NIC is used, these IPs should be in the same CIDR as the pod CIDR.

1. Click Create.

## Security Groups

### About Security Groups

In a zone that uses basic networking, there is a single guest network for all guest VMs. Security groups can be used to control network traffic to and from the VMs. A security group is a group of VMs that filter their incoming and outgoing traffic according to a set of rules, called ingress and egress rules. These rules filter network traffic according to the IP address that is attempting to communicate with the VM.

In a zone that uses advanced networking, you can instead define multiple guest networks to isolate traffic to VMs.

Each CloudStack account comes with a default security group that denies all inbound traffic and allows all outbound traffic. The default security group can be modified so that all new VMs inherit some other desired set of rules.

Any CloudStack user can set up any number of additional security groups. When a new VM is launched, it is assigned to the default security group unless another user-defined security group is specified. A VM can be a member of any number of security groups. Once a VM is assigned to a security group, it remains in that group for its entire lifetime; you can not move a running VM from one security group to another.

You can modify a security group by deleting or adding any number of ingress and egress rules. When you do, the new rules apply to all VMs in the group, whether running or stopped.

If no ingress rules are specified, then no traffic will be allowed in, except for responses to any traffic that has been allowed out through an egress rule.

In order for security groups to function in a zone, the security groups feature must first be enabled for the zone. The administrator can do this when creating a new zone, by selecting a network offering that includes security groups. The procedure is described in Adding a Zone in the Advanced Installation Guide.

### Adding a Security Group

These steps assume you have already logged in to the CloudStack UI (see page 26).

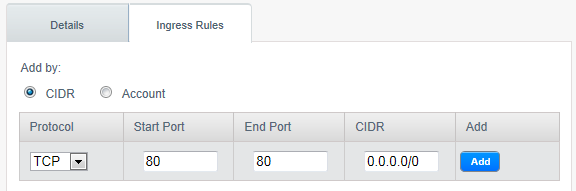
1. In the left navigation, choose Network.
2. In Select view, choose Security Groups.
3. Click Add Security Group.
4. Provide a name and description.
5. Click OK.
6. The new security group appears in the Security Groups Details tab.
7. To make the security group useful, continue to Adding Ingress and Egress Rules to a Security Group on page 46.

### Adding Ingress and Egress Rules to a Security Group

1. In the left navigation, choose Network.
2. In Select view, choose Security Groups, then click the security group you want to work with.
3. To add an ingress rule, click the Ingress Rules tab and fill out the following fields to specify what network traffic is allowed into VM instances in this security group. If no ingress rules are specified, then no traffic will be allowed in, except for responses to any traffic that has been allowed out through an egress rule.

* Add by CIDR/Account. Indicate whether the source of the traffic will be defined by IP address (CIDR) or an existing security group in a CloudStack account (Account). Choose Account if you want to allow incoming traffic from all VMs in another security group.
* Protocol. The networking protocol that sources will use to send traffic to the security group. TCP and UDP are typically used for data exchange and end-user communications. ICMP is typically used to send error messages or network monitoring data.
* Start Port, End Port. (TCP, UDP only) A range of listening ports that are the destination for the incoming traffic. If you are opening a single port, use the same number in both fields.
* ICMP Type, ICMP Code. (ICMP only) The type of message and error code that will be accepted.
* CIDR. (Add by CIDR only) To accept only traffic from IP addresses within a particular address block, enter a CIDR or a comma-separated list of CIDRs. The CIDR is the base IP address of the incoming traffic. For example, 192.168.0.0/22. To allow all CIDRs, set to 0.0.0.0/0.
* Account, Security Group. (Add by Account only) To accept only traffic from another security group, enter the CloudStack account and name of a security group that has already been defined in that account. To allow traffic between VMs within the security group you are editing now, enter the same name you used in step 7.

The following example allows inbound HTTP access from anywhere.



1. To add an egress rule, click the Egress Rules tab and fill out the following fields to specify what type of traffic is allowed to be sent out of VM instances in this security group. If no egress rules are specified, then all traffic will be allowed out. Once egress rules are specified, the following types of traffic are allowed out: traffic specified in egress rules; queries to DNS and DHCP servers; and responses to any traffic that has been allowed in through an ingress rule.

* Add by CIDR/Account. Indicate whether the destination of the traffic will be defined by IP address (CIDR) or an existing security group in a CloudStack account (Account). Choose Account if you want to allow outgoing traffic to all VMs in another security group.
* Protocol. The networking protocol that VMs will use to send outgoing traffic. TCP and UDP are typically used for data exchange and end-user communications. ICMP is typically used to send error messages or network monitoring data.
* Start Port, End Port. (TCP, UDP only) A range of listening ports that are the destination for the outgoing traffic. If you are opening a single port, use the same number in both fields.
* ICMP Type, ICMP Code. (ICMP only) The type of message and error code that will be sent.
* CIDR. (Add by CIDR only) To send traffic only to IP addresses within a particular address block, enter a CIDR or a comma-separated list of CIDRs. The CIDR is the base IP address of the destination. For example, 192.168.0.0/22. To allow all CIDRs, set to 0.0.0.0/0.
* Account, Security Group. (Add by Account only) To allow traffic to be sent to another security group, enter the CloudStack account and name of a security group that has already been defined in that account. To allow traffic between VMs within the security group you are editing now, enter its name

1. Click Add.

## External Firewalls and Load Balancers

CloudStack is capable of replacing its Virtual Router with an external Juniper SRX device and an optional external NetScaler or F5 load balancer for gateway and load balancing services. In this case, the VMs use the SRX as their gateway.

For information about how to add external firewalls and load balancers to CloudStack, see the Advanced Installation Guide.

### About Using a NetScaler Load Balancer

Citrix NetScaler is supported as an external network element for load balancing in zones that use advanced networking (also called advanced zones). Set up an external load balancer when you want to provide load balancing through means other than CloudStack’s provided virtual router.

The NetScaler can be set up in either in-line (behind the firewall) or direct (outside the firewall) mode. It must be added before any load balancing rules are deployed on guest VMs in the zone.

The functional behavior of the NetScaler with CloudStack is the same as described in the CloudStack documentation for using an F5 external load balancer. The only exception is that the F5 supports routing domains, and NetScaler does not; however, the same effect can be achieved by using the NetScaler in-line with a Juniper SRX firewall. NetScaler can not yet be used as a firewall.

The Citrix NetScaler comes in three varieties. The following table summarizes how these variants are treated in CloudStack.

|  |  |  |
| --- | --- | --- |
| **NetScaler ADC Type** | **Description of Capabilities** | **CloudStack 3.0 Supported Features** |
| MPX | Physical appliance. Capable of deep packet inspection. Can act as application firewall and load balancer. | In advanced zones, load balancer functionality fully supported without limitation. In basic zones, static NAT, elastic IP (EIP), and elastic load balancing (ELB) are also provided. |
| VPX | Virtual appliance. Can run as VM on XenServer, ESXi, and Hyper-V hypervisors. Same functionality as MPX. | Supported only on ESXi. Same functional support as for MPX. CloudStack will treat VPX and MPX as the same device type. |
| SDX | Physical appliance. Can create multiple fully isolated VPX instances on a single appliance to support multi-tenant usage. | Cloudstack will dynamically provision, configure, and manage the lifecycle of VPX instances on the SDX. Provisioned instances are added into CloudStack automatically – no manual configuration by the administrator is required. Once a VPX instance is added into CloudStack, it is treated the same as a VPX on an ESXi host. |

### Initial Setup of External Firewalls and Load Balancers

When the first VM is created for a new account, CloudStack programs the external firewall and load balancer to work with the VM. The following objects are created on the firewall:

* A new logical interface to connect to the account's private VLAN. The interface IP is always the first IP of the account's private subnet (e.g. 10.1.1.1).
* A source NAT rule that forwards all outgoing traffic from the account's private VLAN to the public Internet, using the account's public IP address as the source address.
* A firewall filter counter that measures the number of bytes of outgoing traffic for the account.

The following objects are created on the load balancer:

* A new VLAN that matches the account's provisioned Zone VLAN.
* A self IP for the VLAN. This is always the second IP of the account's private subnet (e.g. 10.1.1.2).

### Ongoing Configuration of External Firewalls and Load Balancers

Additional user actions (e.g. setting a port forward) will cause further programming of the firewall and load balancer. A user may request additional public IP addresses and forward traffic received at these IPs to specific VMs. This is accomplished by enabling static NAT for a public IP address, assigning the IP to a VM, and specifying a set of protocols and port ranges to open. When a static NAT rule is created, CloudStack programs the zone's external firewall with the following objects:

* A static NAT rule that maps the public IP address to the private IP address of a VM.
* A security policy that allows traffic within the set of protocols and port ranges that are specified.
* A firewall filter counter that measures the number of bytes of incoming traffic to the public IP.

The number of incoming and outgoing bytes through source NAT, static NAT, and load balancing rules is measured and saved on each external element. This data is collected on a regular basis and stored in the CloudStack database.

### Load Balancer Rules

A user may also create load balancing rules that balance traffic received at a public IP to one or more VMs. When a user creates a rule, specifies an algorithm, and assigns the rule to a set of VMs, CloudStack programs the zone's external load balancer with the following objects:

* A virtual server that listens for traffic at the specified public IP and measures the number of incoming and outgoing bytes.
* A load balancing pool that redirects traffic to VMs with the specified algorithm.
* Pool members and nodes for each VM that the rule is assigned to.

#### Sticky Session Policies for External Load Balancer Rules

CloudStack supports sticky session policies for NetScaler and F5 external load balancers.

Sticky sessions are used in Web-based applications to ensure continued availability of information across the multiple requests in a user's session. For example, if a shopper is filling a cart, you need to remember what has been purchased so far. The concept of “stickiness” is also referred to as persistence, or maintaining state.

Citrix NetScaler supports sticky sessions by allowing you to direct all requests from a single user session to the same backend server, where the user’s persistent session data is stored. This overrides the typical load balancer behavior, which would assign each new request to any available server that best balances the load, without regard to which user made the request.

Any load balancer rule defined in CloudStack can have a stickiness policy. The policy consists of a name, stickiness method, and parameters. The parameters are name-value pairs or flags, which are defined by the load balancer vendor. The stickiness method could be load balancer-generated cookie, application-generated cookie, or source-based. In the source-based method, the source IP address is used to identify the user and locate the user’s stored data. In the other methods, cookies are used. The cookie generated by the load balancer or application is included in request and response URLs to create persistence. The cookie name can be specified by the administrator or automatically generated. A variety of options are provided to control the exact behavior of cookies, such as how they are generated and whether they are cached.

For the most up to date list of available stickiness methods, see the CloudStack UI or call listNetworks and check the SupportedStickinessMethods capability.

## Guest IP Ranges

The IP ranges for guest network traffic are set on a per-account basis by the user. This allows the users to configure their network in a fashion that will enable VPN linking between their guest network and their clients.

## IP Forwarding and Firewalling

By default, all incoming traffic to the public IP address is rejected. All outgoing traffic from the guests is translated via NAT to the public IP address and is allowed.

To allow incoming traffic, users may set up firewall rules and/or port forwarding rules. For example, you can use a firewall rule to open a range of ports on the public IP address, such as 33 through 44. Then use port forwarding rules to direct traffic from individual ports within that range to specific ports on user VMs. For example, one port forwarding rule could route incoming traffic on the public IP's port 33 to port 100 on one user VM's private IP.

For the steps to implement these rules, see Firewall Rules on page 51 and Port Forwarding on page 52.

### Firewall Rules

By default, all incoming traffic to the public IP address is rejected by the firewall. To allow external traffic, you can open firewall ports by specifying firewall rules. You can optionally specify one or more CIDRs to filter the source IPs. This is useful when you want to allow only incoming requests from certain IP addresses.

Firewall rules can be created using the Firewall tab in the Management Server UI. This tab is not displayed by default when CloudStack is installed. To display the Firewall tab, set the global configuration parameter firewall.rule.ui.enabled to "true."

To create a firewall rule:

1. If you have not already done so, add a firewall to your CloudStack deployment. See Advanced Networking: Adding an External Firewall in the Installation Guide.
2. If you have not already done so, add a public IP address range to a zone in CloudStack. See Adding a Zone and Pod in the Installation Guide.
3. Log in to the CloudStack UI and display the Firewall screen for an IP address within a network.

Fill in the following values:

* **Source CIDR.** (Optional) To accept only traffic from IP addresses within a particular address block, enter a CIDR or a comma-separated list of CIDRs. Example: 192.168.0.0/22. Leave empty to allow all CIDRs.
* **Protocol.** The communication protocol in use on the opened port(s).
* **Start Port** and **End Port**. The port(s) you want to open on the firewall. If you are opening a single port, use the same number in both fields.
* **ICMP Type** and **ICMP Code.** Used only if Protocol is set to ICMP. Provide the type and code required by the ICMP protocol to fill out the ICMP header. Refer to ICMP documentation for more details if you are not sure what to enter.

1. Click Add.

### Port Forwarding

A port forward service is a set of port forwarding rules that define a policy. A port forward service is then applied to one or more guest VMs. The guest VM then has its inbound network access managed according to the policy defined by the port forwarding service. You can optionally specify one or more CIDRs to filter the source IPs. This is useful when you want to allow only incoming requests from certain IP addresses to be forwarded.

A guest VM can be in any number of port forward services. Port forward services can be defined but have no members.

To set up port forwarding:

1. Log in to the CloudStack UI.
2. If you have not already done so, add a firewall to your CloudStack deployment. See Advanced Networking: Adding an External Firewall in the Installation Guide.
3. If you have not already done so, add a public IP address range to a zone in CloudStack. See Adding a Zone and Pod in the Installation Guide.
4. Add one or more VM instances to CloudStack.
5. Choose an existing IP address or acquire a new IP address.
6. In the Port Forwarding screen, fill in the following for each instance:

* **CIDR.** (Optional) Filter the incoming requests so that only those from IP addresses within a particular address block are forwarded. Enter a CIDR or a comma-separated list of CIDRs. Example: 192.168.0.0/22.
* Public Port. The port to which public traffic will be addressed on the IP address you acquired in the previous step.
* Private Port. The port on which the instance is listening for forwarded public traffic.
* Protocol. The communication protocol in use between the two ports.
* Instance. Choose the name of the instance to which this rule applies.

1. Test by opening an ssh session to the instance.

## IP Load Balancing

The user may choose to associate the same public IP for multiple guests. The system implements a TCP-level load balancer with the following policies.

* Round-robin
* Least connection
* Source IP

This is similar to port forwarding but the destination may be multiple IP addresses.

## DNS and DHCP

The Virtual Router provides DNS and DHCP services to the guests. It proxies DNS requests to the DNS server configured on the Availability Zone.

## VPN

CloudStack provides a L2TP-based VPN service to guest virtual networks. Clients native to Windows and Mac OS X may be used to connect to the guest network. The user is responsible for creating and managing users for their VPN. CloudStack does not allow its authentication database to be used for this purpose.

Users need to make sure that not all traffic goes through the VPN. That is, the route installed by the VPN should be only for the guest network and not for all traffic.

### Mac OS X

In Mac OS X, in Connect Menu -> Options the user should make sure that the checkbox "Send all traffic over VPN connection" is not checked.

### Windows

The procedure to effect this varies by Windows version. Generally the user will need to edit the VPN properties and make sure that the default route is not the VPN.

# Working With Storage

CloudStack defines two types of storage: primary and secondary. Primary storage can be accessed by either iSCSI or NFS. Additionally, direct attached storage may be used for primary storage. Secondary storage is always accessed using NFS.

There is no ephemeral storage in CloudStack. All volumes on all nodes are persistent.

## Primary Storage

This section gives concepts and technical details about CloudStack primary storage. For information about how to install and configure primary storage through the CloudStack UI, see the Advanced Installation Guide.

### About Primary Storage

Primary storage is associated with a cluster, and it stores the disk volumes for all the VMs running on hosts in that cluster. You can add multiple primary storage servers to a cluster. At least one is required. It is typically located close to the hosts for increased performance.

The CloudStack platform is designed to work with all standards-compliant iSCSI and NFS servers that are supported by the underlying hypervisor, including, for example:

* Dell EqualLogic™ for iSCSI
* Network Appliances filers for NFS and iSCSI
* Scale Computing for NFS

CloudStack manages the allocation of guest virtual disks to particular primary storage devices.

If you intend to use only local disk for your installation, you can skip this section.

### System Requirements for Primary Storage

Hardware requirements:

* Any standards-compliant iSCSI or NFS server that is supported by the underlying hypervisor.
* The storage server should be a machine with a large number of disks. The disks should ideally be managed by a hardware RAID controller.
* Minimum required capacity depends on your needs.

When setting up primary storage, follow these restrictions:

* **Primary storage cannot be added until a host has been added to the cluster.**
* **If you do not provision shared storage for primary storage, you will not be able to create additional volumes.**
* **If you do not provision shared primary storage, you must set the global configuration parameter system.vm.local.storage.required to true, or else you will not be able to start VMs.**

### Best Practices for Primary Storage

The speed of primary storage will impact guest performance. If possible, choose smaller, higher RPM drives for primary storage.

### Runtime Behavior of Primary Storage

Root volumes are created automatically when a virtual machine is created. Root volumes are deleted when the VM is destroyed. Data volumes can be created and dynamically attached to VMs (although, when the Oracle VM hypervisor is used, the VM must be stopped before an additional volume can be attached). Data volumes are not deleted when VMs are destroyed.

Administrators should monitor the capacity of primary storage devices and add additional primary storage as needed. See the Advanced Installation Guide.

Administrators add primary storage to the system by creating a CloudStack storage pool. Each storage pool is associated with a cluster.

### Hypervisor Support for Primary Storage

The following table discusses storage options and parameters for different hypervisors.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **VMware vSphere** | **Citrix XenServer** | **KVM** | **Oracle VM** |
| **Format for Disks, Templates, and Snapshots** | VMDK | VHD | QCOW2 | RAW |
| **iSCSI support** | VMFS | Clustered LVM | Yes, via Shared Mountpoint | Yes, via OCFS2 |
| **Fiber Channel support** | VMFS | Yes, via Existing SR | Yes, via Shared Mountpoint | No |
| **NFS support** | Y | Y | Y | Y |
| **Local storage support** | Y | Y | Y | N |
| **Storage over-provisioning** | NFS and iSCSI | NFS | NFS | No |

XenServer uses a clustered LVM system to store VM images on iSCSI and Fiber Channel volumes and does not support over-provisioning in the hypervisor. The storage server itself, however, can support thin-provisioning. As a result the CloudStack can still support storage over-provisioning by running on thin-provisioned storage volumes.

KVM supports "Shared Mountpoint" storage. A shared mountpoint is a file system path local to each server in a given cluster. The path must be the same across all Hosts in the cluster, for example /mnt/primary1. This shared mountpoint is assumed to be a clustered filesystem such as OCFS2. In this case the CloudStack does not attempt to mount or unmount the storage as is done with NFS. The CloudStack requires that the administrator insure that the storage is available.

Oracle VM supports both iSCSI and NFS storage. When iSCSI is used with OVM, the CloudStack administrator is responsible for setting up iSCSI on the host, including re-mounting the storage after the host recovers from a failure such as a network outage. With other hypervisors, CloudStack takes care of mounting the iSCSI target on the host whenever it discovers a connection with an iSCSI server and unmounting the target when it discovers the connection is down.

With NFS storage, CloudStack manages the overprovisioning. In this case the global configuration parameter storage.overprovisioning.factor controls the degree of overprovisioning. This is independent of hypervisor type.

Local storage is an option for primary storage for vSphere, XenServer, Oracle VM, and KVM. When the local disk option is enabled, a local disk storage pool is automatically created on each host. To use local storage for the System Virtual Machines (such as the Virtual Router), set system.vm.use.local.storage to true in global configuration.

CloudStack supports multiple primary storage pools in a Cluster. For example, you could provision 2 NFS servers in primary storage. Or you could provision 1 iSCSI LUN initially and then add a second iSCSI LUN when the first approaches capacity.

### Storage Tags

Storage may be "tagged". A tag is a text string attribute associated with primary storage, a Disk Offering, or a Service Offering. Tags allow administrators to provide additional information about the storage. For example, that is a "SSD" or it is "slow". Tags are not interpreted by CloudStack. They are matched against tags placed on service and disk offerings. CloudStack requires all tags on service and disk offerings to exist on the primary storage before it allocates root or data disks on the primary storage. Service and disk offering tags are used to identify the requirements of the storage that those offerings have. For example, the high end service offering may require "fast" for its root disk volume.

The interaction between tags, allocation, and volume copying across clusters and pods can be complex. To simplify the situation, use the same set of tags on the primary storage for all clusters in a pod. Even if different devices are used to present those tags, the set of exposed tags can be the same.

### Maintenance Mode for Primary Storage

Primary storage may be placed into maintenance mode. This is useful, for example, to replace faulty RAM in a storage device. Maintenance mode for a storage device will first stop any new guests from being provisioned on the storage device. Then it will stop all guests that have any volume on that storage device. When all such guests are stopped the storage device is in maintenance mode and may be shut down. When the storage device is online again you may cancel maintenance mode for the device. The CloudStack will bring the device back online and attempt to start all guests that were running at the time of the entry into maintenance mode.

## Secondary Storage

This section gives concepts and technical details about CloudStack secondary storage. For information about how to install and configure secondary storage through the CloudStack UI, see the Advanced Installation Guide.

### About Secondary Storage

Secondary storage is associated with a zone, and it stores the following:

* Templates – OS images that can be used to boot VMs and can include additional configuration information, such as installed applications
* ISO images – disc images containing data or bootable media for operating systems
* Disk volume snapshots – saved copies of VM data which can be used for data recovery or to create new templates

The items in secondary storage are available to all hosts in the zone.

### System Requirements for Secondary Storage

* NFS storage appliance or Linux NFS server
* (Optional) OpenStack Object Storage (Swift) (see http://swift.openstack.org)
* 100GB minimum capacity
* A secondary storage device must be located in the same zone as the guest VMs it serves.
* Each secondary storage server must be available to all hosts in the zone.

### Best Practices for Secondary Storage

Each Zone can have one or more secondary storage servers. Multiple secondary storage servers provide increased scalability to the system.

Secondary storage has a high read:write ratio and is expected to consist of larger drives with lower IOPS than primary storage.

### Secondary Storage VM

In addition to the hosts, CloudStack’s Secondary Storage VM mounts and writes to secondary storage.

Submissions to secondary storage go through the Secondary Storage VM. The Secondary Storage VM can retrieve templates and ISO images from URLs using a variety of protocols.

When copying and pasting a command, be sure the command has pasted as a single line before executing. Some document viewers may introduce unwanted line breaks in copied text.

### Changing the Secondary Storage IP Address

You can change the secondary storage IP address after it has been provisioned. After changing the IP address on the host, log in to your management server and execute the following commands. Replace HOSTID below with your own value, and change the URL to use the appropriate IP address and path for your server.

# mysql

mysql> use cloud;

mysql> select id from host where type = 'SecondaryStorage';

mysql> update host\_details set value = 'nfs://192.168.160.20/export/mike-ss1'

where host\_id = HOSTID and name = 'orig.url';

mysql> update host set name = 'nfs://192.168.160.20/export/mike-ss1' where type

= 'SecondaryStorage';

mysql> update host set url = 'nfs://192.168.160.20/export/mike-ss1' where type

= 'SecondaryStorage';

mysql> update host set guid = 'nfs://192.168.160.20/export/mike-ss1' where type

= 'SecondaryStorage';

Then log in to the cloud console UI and stop and start (not reboot) the Secondary Storage VM for that Zone.

### Changing Secondary Storage Servers

You can change the secondary storage NFS mount. Perform the following steps to do so:

1. Stop all running Management Servers.
2. Wait 30 minutes. This allows any writes to secondary storage to complete.
3. Copy all files from the old secondary storage mount to the new.
4. Use the procedure above to change the IP address for secondary storage if required.
5. Start the Management Server(s).

## About Volumes

A volume provides storage to a guest VM. The volume can provide for a root disk or an additional data disk. The CloudStack platform supports additional volumes for guest VMs.

Volumes are created for a specific hypervisor type. A volume that has been attached to guest using one hypervisor type (e.g, XenServer) may not be attached to a guest that is using another hypervisor type (e.g. vSphere, Oracle VM, KVM). This is because the different hypervisors use different disk image formats.

The CloudStack platform defines a volume as a unit of storage available to a guest VM. Volumes are either root disks or data disks. The root disk has “/” in the file system and is usually the boot device. Data disks provide for additional storage (e.g. As “/opt” or “D:”). Every guest VM has a root disk and a data disk. End users can mount multiple data disks to guest VMs. Users choose data disks from the disk offerings created by administrators. The user can create a template from a volume as well; this is the standard procedure for private template creation. Volumes are hypervisor-specific: a volume from one hypervisor type may not be used on a guest of another hypervisor type.

### Creating a New Volume

You can add more data disk volumes to a guest VM at any time, up to the limits of your storage capacity. Both CloudStack administrators and users can add volumes to VM instances. When you create a new volume, it is stored as an entity in CloudStack, but the actual storage resources are not allocated on the physical storage device until you attach the volume. This optimization allows the CloudStack to provision the volume nearest to the guest that will use it when the first attachment is made.

1. Log in to the CloudStack UI as an administrator or user.
2. In the left navigation bar, click Storage.
3. In Select View, choose Volumes.
4. To create a new volume, click Add Volume, provide the following details, and click OK:

* **Name.** Give the volume a unique name so you can find it later.
* **Availability Zone.** Where do you want the storage to reside? This should be close to the VM that will use the volume.
* **Disk Offering.** Choose the characteristics of the storage.

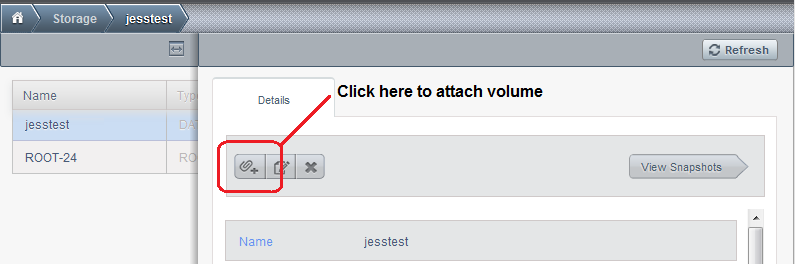
The new volume appears in the list of volumes with the state “Allocated.” The volume data is stored in CloudStack, but the volume is not yet ready for use.

1. To start using the volume, continue to Attaching a Volume on page 60.

### Attaching a Volume

You can attach a volume to a guest VM to provide extra disk storage. Attach a volume when you first create a new volume, when you are moving an existing volume from one VM to another, or after you have migrated a volume from one storage pool to another.

1. Log in to the CloudStack UI as an administrator or user.
2. In the left navigation bar, click Storage.
3. In Select View, choose Volumes.
4. Click the volume name in the Volumes list, then click the Attach Disk button.



1. In the Instance popup, choose the VM to which you want to attach the volume. You will only see instances to which you are allowed to attach volumes; for example, a user will see only instances created by that user, but the administrator will have more choices.

If the VM is running in the OVM hypervisor, the VM must be stopped before a new volume can be attached to it.

1. When the volume has been attached, you should be able to see it by clicking Instances, the instance name, and View Volumes.

### Detaching and Moving Volumes

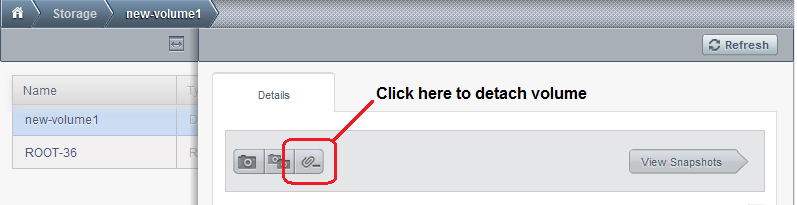
A volume can be detached from a guest VM and attached to another guest. Both CloudStack administrators and users can detach volumes from VMs and move them to other VMs.

This procedure is different from moving disk volumes from one storage pool to another. See VM Storage Migration on page 61.

If the two VMs are in different clusters, and the volume is large, it may take several minutes for the volume to be moved to the new VM.

If the destination VM is running in the OVM hypervisor, the VM must be stopped before a new volume can be attached to it.

1. Log in to the CloudStack UI as an administrator or user.
2. In the left navigation bar, click Storage, and choose Volumes in Select View. Alternatively, if you know which VM the volume is attached to, you can click Instances, click the VM name, and click View Volumes.
3. Click the name of the volume you want to detach, then click the Detach Disk button.



When the operation is complete, the Detach Disk button is replaced by the Attach Disk button. AttachVolumeButton

1. To move the volume to another VM, follow the steps in Attaching a Volume on page 60.

### VM Storage Migration

Supported in XenServer, KVM, and VMware.

This procedure is different from moving disk volumes from one VM to another. See Detaching and Moving Volumes on page 60.

You can migrate a virtual machine’s root disk volume or any additional data disk volume from one storage pool to another in the same zone. Administrators can migrate both types of volumes, but users can migrate only data volumes.

You can use the storage migration feature to achieve some commonly desired administration goals, such as balancing the load on storage pools and increasing the reliability of virtual machines by moving them away from any storage pool that is experiencing issues.

#### Migrating a Data Disk Volume to a New Storage Pool

1. Log in to the CloudStack UI as an administrator or user.
2. Detach the data disk from the VM. See Detaching and Moving Volumes on page 60 (but skip the “reattach” step at the end. You will do that after migrating to new storage.)
3. Call the CloudStack API command migrateVolume and pass in the volume ID and the ID of any storage pool in the zone.
4. Watch for the volume status to change to Migrating, then back to Ready.
5. Attach the volume to any desired VM running in the same cluster as the new storage server. See Attaching a Volume on page 60.

#### Migrating a VM Root Volume to a New Storage Pool

When migrating the root disk volume, the VM must first be stopped, and users can not access the VM. After migration is complete, the VM can be restarted.

1. Log in to the CloudStack UI as administrator.
2. Detach any data disks from the VM. See Detaching and Moving Volumes on page 60.
3. Stop the VM.
4. Call the CloudStack API command migrateVirtualMachine with the ID of the VM to migrate and the IDs of a destination host and destination storage pool in the same zone.
5. Watch for the VM status to change to Migrating, then back to Stopped.
6. Restart the VM.

### Resizing Volumes

CloudStack does not provide the ability to resize root disks or data disks; the disk size is fixed based on the template used to create the VM. However, the tool [VHD Resizer](http://vmtoolkit.com/files/folders/converters/entry87.aspx) (<http://vmtoolkit.com/files/folders/converters/entry87.aspx>), while not officially supported by Cloud.com or Citrix, might provide a workaround. To increase disk size with VHD Resizer:

1. Get the VHD from the secondary storage.
2. Import it into VHD Resizer.
3. Resize the VHD.
4. Upload the new VHD.
5. Create a new VM.
6. On a Linux guest, extend the file system to reflect the new disk size. Manually resize your partitions using the operating system's utilities. For example, use resize2fs or use LVM utilities to add partition space.
7. Take a snapshot, then create a new template from that snapshot.

For more information, see [How to Resize a Provisioning Server 5 Virtual Disk](http://support.citrix.com/article/CTX118608) at the Citrix Knowledge Center (<http://support.citrix.com/article/CTX118608>).

### Volume Deletion and Garbage Collection

The deletion of a volume does not delete the snapshots that have been created from the volume.

When a VM is destroyed, data disk volumes that are attached to the VM are not deleted.

Volumes are permanently destroyed using a garbage collection process. The global configuration variables expunge.delay and expunge.interval determine when the physical deletion of volumes will occur.

* expunge.delay: determines how old the volume must be before it is destroyed, in seconds
* expunge.interval: determines how often to run the garbage collection check

Administrators should adjust these values depending on site policies around data retention.

## Working with ISOs

The CloudStack platform supports ISOs and their attachment to guest VMs. An ISO is a read-only file that has an ISO/CD-ROM style file system. Users can upload their own ISOs and mount them on their guest VMs.

ISOs are uploaded based on a URL. HTTP is the supported protocol. Once the ISO is available via HTTP specify an upload URL such as http://my.web.server/filename.iso.

ISOs may be public or private, like templates.

ISOs are not hypervisor-specific. That is, a guest on vSphere can mount the exact same image that a guest on KVM can mount.

ISO images may be stored in the system and made available with a privacy level similar to templates. ISO images are classified as either bootable or not bootable. A bootable ISO image is one that contains an OS image (E.g. An Ubuntu 10.04 installation CD). The CloudStack platform allows a user to boot a guest VM off of an ISO image. Users can also attach ISO images to guest VMs. For example, this enables installing PV drivers into Windows. ISO images are not hypervisor-specific.

### Adding an ISO

To make additional operating system or other software available in CloudStack, you can add an ISO. The ISO is typically thought of as an operating system image, but you can also add ISOs for other types of software, such as desktop applications that you want to be installed as part of a template.

1. In the Add ISO screen, provide the following:

* **Name**. Short name for the ISO image. (E.g. CentOS 5.5 64 bit)
* **Display** **Text**. Description of the ISO image. (E.g. CentOS 5.5 64 bit)
* **URL**. The URL that hosts the ISO image. The Management Server must be able to access this location via HTTP. If needed you can place the ISO image directly on the Management Server.
* **Zone.** Choose the zone where you want the ISO to be available, or All Zones to make it available throughout CloudStack.
* **OS Type.** This helps the CloudStack platform and hypervisor perform certain operations and make assumptions that improve the performance of the guest. Select one of the following:
* If the operating system of your desired ISO image is listed, choose it.
* If the OS Type of the ISO is not listed or if the ISO is not bootable, choose Other.
* (XenServer only) If you want to boot from this ISO in PV mode, choose Other PV (32-bit) or Other PV (64-bit). This choice is not valid for Ubuntu. To create an Ubuntu PV template, see Creating an Ubuntu 10.04 LTS Template for XenServer on page 50.

**Note: Generally you should not choose an older version of the OS** than the version in the image**. For example, choosing CentOS 5.3 to support a CentOS 5.4 image will in general not work. In those cases you should choose Other.**

* **Bootable.** Whether or not a guest could boot off this ISO image. For example, a CentOS ISO is bootable, a Microsoft Office ISO is not bootable.
* **Public.** Choose Yes if this ISO should be available to other users.
* **Featured.** Choose Yes if you would like this ISO to be more prominent for users to select. The ISO will appear in the Featured ISOs list. Only an administrator can make an ISO Featured.

1. Click Create.

The Management Server will download the ISO. Depending on the size of the ISO, this may take a long time. The ISO status column will display Ready once it has been successfully downloaded into secondary storage. Clicking Refresh updates the download percentage.

1. **Important: Wait for the ISO to finish downloading. If you move on to the next task and try to use the ISO right away, it will appear to fail. The entire ISO must be available before CloudStack can work with it.**

## Working with Templates

A template is a reusable configuration for virtual machines. When users launch VMs, they can choose from a list of templates in CloudStack.

Specifically, a template is a virtual disk image that includes one of a variety of operating systems, optional additional software such as office applications, and settings such as access control to determine who can use the template. Each template is associated with a particular type of hypervisor, which is specified when the template is added to CloudStack.

CloudStack ships with a default template. In order to present more choices to users, CloudStack administrators and users can create templates and add them to CloudStack.

### Creating Templates: Overview

CloudStack ships with a default template for the CentOS operating system. There are a variety of ways to add more templates. Administrators and end users can add templates. The typical sequence of events is:

1. Launch a VM instance that has the operating system you want. Make any other desired configuration changes to the VM.
2. Stop the VM.
3. Convert the volume into a template.

There are other ways to add templates to CloudStack. For example, you can take a snapshot of the VM's volume and create a template from the snapshot, or import a VHD from another system into CloudStack.

The various techniques for creating templates are described in the next few sections.

### Requirements for Templates

* For XenServer, install PV drivers / Xen tools on each template that you create. This will enable live migration and clean guest shutdown.
* For vSphere, install VMware Tools on each template that you create. This will enable console view to work properly.

### Best Practices for Templates

If you plan to use large templates (100 GB or larger), be sure you have a 10-gigabit network to support the large templates. A slower network can lead to timeouts and other errors when large templates are used.

### The Default Template

The CloudStack platform includes a CentOS template. This template is downloaded by the Secondary Storage VM after the primary and secondary storage are configured. You can use this template in your production deployment or you can delete it and use custom templates.

The root password for the default template is "password".

A default template is provided for each of XenServer, KVM, and vSphere. The templates that are downloaded depend on the hypervisor type that is available in your cloud. Each template is approximately 2.5 GB physical size.

The default template includes the standard iptables rules, which will block most access to the template excluding ssh.

# iptables --list

Chain INPUT (policy ACCEPT)

target prot opt source destination

RH-Firewall-1-INPUT all -- anywhere anywhere

Chain FORWARD (policy ACCEPT)

target prot opt source destination

RH-Firewall-1-INPUT all -- anywhere anywhere

Chain OUTPUT (policy ACCEPT)

target prot opt source destination

Chain RH-Firewall-1-INPUT (2 references)

target prot opt source destination

ACCEPT all -- anywhere anywhere

ACCEPT icmp -- anywhere anywhere icmp any

ACCEPT esp -- anywhere anywhere

ACCEPT ah -- anywhere anywhere

ACCEPT udp -- anywhere 224.0.0.251 udp dpt:mdns

ACCEPT udp -- anywhere anywhere udp dpt:ipp

ACCEPT tcp -- anywhere anywhere tcp dpt:ipp

ACCEPT all -- anywhere anywhere state RELATED,ESTABLISHED

ACCEPT tcp -- anywhere anywhere state NEW tcp dpt:ssh

REJECT all -- anywhere anywhere reject-with icmp-host-prohibited

### Private and Public Templates

When a user creates a template, it can be designated private or public.

Private templates are only available to the user who created them. By default, an uploaded template is private.

When a user marks a template as “public,” the template becomes available to all users in all accounts in the user's domain, as well as users in any other domains that have access to the Zone where the template is stored. This depends on whether the Zone, in turn, was defined as private or public. A private Zone is assigned to a single domain, and a public Zone is accessible to any domain. If a public template is created in a private Zone, it is available only to users in the domain assigned to that Zone. If a public template is created in a public Zone, it is available to all users in all domains.

### Creating a Template from an Existing Virtual Machine

Once you have at least one VM set up in the way you want, you can use it as the prototype for other VMs.

1. Create and start a virtual machine using any of the techniques in Creating VMs on page 31.
2. Make any desired configuration changes on the running VM, then click Stop.
3. Wait for the VM to stop. When the status shows Stopped, go to the next step.
4. Click Create Template and provide the following:

* **Name and Display Text.** These will be shown in the UI, so choose something descriptive.
* **OS Type.** This helps the CloudStack platform and hypervisor perform certain operations and make assumptions that improve the performance of the guest. Select one of the following:
* If the operating system of the stopped VM is listed, choose it.
* If the OS type of the stopped VM is not listed, choose Other.
* If you want to boot from this template in PV mode, choose Other PV (32-bit) or Other PV (64-bit). This choice is available only for XenServer.

**Note: Generally you should not choose an older version of the** OS than the version in the image**. For example, choosing CentOS 5.3 to support a CentOS 5.4 image will in general not work. In those cases you should choose Other.**

* **Public.** Choose Yes to make this template accessible to all users of this CloudStack installation. The template will appear in the Community Templates list. See Private and Public Templates on page 66.
* **Password Enabled.** Choose Yes if your template has the CloudStack platform password change script installed. See Adding Password Management to Your Templates on page 79.

1. Click Add.

The new template will be visible in the Templates section when the template creation process has been completed. The template is then available when creating a new VM.

### Creating a Template From a Snapshot

(Not supported by Oracle VM)

If you do not want to stop the VM in order to use the Create Template menu item (as described in Creating a Template from an Existing Virtual Machine on page 66), you can create a template directly from any snapshot through the CloudStack UI.

### Uploading Templates

Templates are uploaded based on a URL. HTTP is the supported access protocol. Templates are frequently large files. You can optionally gzip them to decrease upload times.

To upload a template:

1. In the Add Template screen, provide the following:

* **Name and Display Text.** These will be shown in the UI, so choose something descriptive.
* **URL.** The Management Server will download the file from the specified URL, such as <http://my.web.server/filename.vhd.gz>.

**Warning:** If you are uploading a template that was created using vSphere Client, be sure the OVA file does not contain an ISO. If it does, the deployment of VMs from the template will fail.

* **Zone.** Choose the zone where you want the template to be available, or All Zones to make it available throughout CloudStack.
* **OS Type**: This helps the CloudStack platform and hypervisor perform certain operations and make assumptions that improve the performance of the guest. Select one of the following:
* If the operating system of the stopped VM is listed, choose it.
* If the OS type of the stopped VM is not listed, choose Other.
* If you want to use Ubuntu in PV mode, choose Other PV (32-bit) or Other PV (64-bit). This choice is available only for XenServer.

**Note: Generally you should not choose an older version of the OS** than the version in the image**. For example, choosing CentOS 5.3 to support a CentOS 5.4 image will in general not work. In those cases you should choose Other.**

* Hypervisor.
* **Format.** The format of the template upload file, such as VHD or OVA.
* **Password Enabled.** Choose Yes if your template has the CloudStack platform password change script installed. See Adding Password Management to Your Templates on page 79.
* **Public.** Choose Yes to make this template accessible to all users of this CloudStack installation. The template will appear in the Community Templates list. See Private and Public Templates on page 66.
* **Featured.** Choose Yes if you would like this template to be more prominent for users to select. The template will appear in the Featured Templates list. Only an administrator can make a template Featured.

### Exporting Templates

End users and Administrators may export templates from the CloudStack. Navigate to the template in the UI and choose the Download function from the Actions menu.

### Creating a Windows Template

Windows templates must be prepared with Sysprep before they can be provisioned on multiple machines. Sysprep allows you to create a generic Windows template and avoid any possible SID conflicts.

An overview of the procedure is as follows:

1. Upload your Windows ISO. (If you need help, see Adding an ISO on page 63.)
2. Create a VM Instance with this ISO. (If you need help, see Creating VMs on page 31.)
3. Follow the steps in Sysprep for Windows Server 2008 R2 (below) or Sysprep for Windows Server 2003 R2 on page 72, depending on your version of Windows Server.
4. The preparation steps are complete. Now you can actually create the template as described in Creating the Windows Template on page 73.

#### Sysprep for Windows Server 2008 R2

For Windows 2008 R2, you run Windows System Image Manager to create a custom sysprep response XML file. Windows System Image Manager is installed as part of the Windows Automated Installation Kit (AIK). Windows AIK can be downloaded from the Microsoft Download Center at the following location:

<http://www.microsoft.com/downloads/details.aspx?FamilyID=94bb6e34-d890-4932-81a5-5b50c657de08&DisplayLang=en>

Use the following steps to run sysprep for Windows 2008 R2.[[1]](#footnote-1)

1. Download and install the Windows AIK.

**Note: Windows AIK should not be installed on the Windows 2008 R2 VM you just created. Windows AIK should not be part of the template you create. It is only used to create the sysprep answer file.**

1. Copy the install.wim file in the \sources directory of the Windows 2008 R2 installation DVD to the hard disk. This is a very large file and may take a long time to copy. Windows AIK requires the WIM file to be writable.
2. Start the Windows System Image Manager, which is part of the Windows AIK.
3. In the Windows Image pane, right click “Select a Windows image or catalog file” to load the install.wim file you just copied.
4. Select the Windows 2008 R2 Edition.

You may be prompted with a warning that the catalog file cannot be opened. Click Yes to create a new catalog file.

1. In the Answer File pane, right click to create a new answer file.
2. Generate the answer file from the Windows System Image Manager using the following steps.
3. The first page you need to automate is the Language and Country or Region Selection page. To automate this, expand Components in your Windows Image pane, right-click and add the Microsoft-Windows-International-Core setting to Pass 7 oobeSystem. In your Answer File pane, configure the InputLocale, SystemLocale, UILanguage, and UserLocale with the appropriate settings for your language and country or region. Should you have a question about any of these settings, you can right-click on the specific setting and select Help. This will open the appropriate CHM help file with more information, including examples on the setting you are attempting to configure.



1. You need to automate the Software License Terms Selection page, otherwise known as the End-User License Agreement (EULA). To do this, expand the Microsoft-Windows-Shell-Setup component. High-light the OOBE setting, and add the setting to the Pass 7 oobeSystem . Under Settings, select the drop down next to HideEULAPage and select true.



1. Make sure the license key is properly set. If you use MAK key, you can just enter the MAK key on the Windows 2008 R2 VM. You need not input the MAK into the Windows System Image Manager. If you use KMS host for activation you need not enter the Product Key. Details of Windows Volume Activation can be found here: <http://technet.microsoft.com/en-us/library/bb892849.aspx>
2. You need to automate is the Change Administrator Password page. Expand the Microsoft-Windows-Shell-Setup component (if it is not still expanded), expand UserAccounts, right-click on AdministratorPassword, and add the setting to the Pass 7 oobeSystem configuration pass of your answer file. Under Settings, specify a password next to Value.



You may read the AIK documentation and set many more options that suit your deployment. The steps above are the minimum needed to make Windows unattended setup work.

1. Save the answer file as unattend.xml. You can ignore the warning messages that appear in the validation window.
2. Copy the unattend.xml file into the c:\windows\system32\sysprep directory of the Windows 2008 R2 Virtual Machine.
3. Once you place the unattend.xml file in c:\windows\system32\sysprep directory, you run the sysprep tool as follows:

cd c:\Windows\System32\sysprep

sysprep.exe /oobe /generalize /shutdown

The Windows 2008 R2 VM will automatically shut down after sysprep is complete

#### Sysprep for Windows Server 2003 R2

Earlier versions of Windows have a different sysprep tool. Follow these steps for Windows Server 2003 R2.

1. Extract the content of \support\tools\deploy.cab on the Windows installation CD into a directory called c:\sysprep on the Windows 2003 R2 VM.
2. Run c:\sysprep\setupmgr.exe to create the sysprep.inf file.
3. Select Create New to create a new Answer File.
4. Enter “Sysprep setup” for the Type of Setup.
5. Select the appropriate OS version and edition.
6. On the License Agreement screen, select “Yes fully automate the installation”.
7. Provide your name and organization.
8. Leave display settings at default.
9. Set the appropriate time zone.
10. Provide your product key.
11. Select an appropriate license mode for your deployment.
12. Select “Automatically generate computer name”.
13. Type a default administrator password. If you enable the password reset feature, the users will not actually use this password. This password will be reset by the instance manager after the guest boots up.
14. Leave Network Components at “Typical Settings”.
15. Select the “WORKGROUP” option.
16. Leave Telephony options at default.
17. Select appropriate Regional Settings.
18. Select appropriate language settings.
19. Do not install printers.
20. Do not specify “Run Once commands”.
21. You need not specify an identification string.
22. Save the Answer File as c:\sysprep\sysprep.inf.
23. Run the following command to sysprep the image:
24. c:\sysprep\sysprep.exe -reseal -mini -activated
25. After this step the machine will automatically shut down.

#### Creating the Windows Template

Once your VM has shut down, you can create a template.

1. Click on Instances and find your VM. Click on it.
2. Find the root disk under Volumes.
3. Click Create Template.

### Importing AMIs

The following procedures describe how to import an Amazon Machine Image (AMI) into the CloudStack platform when using the XenServer hypervisor.

Assume you have an AMI file and this file is called CentOS\_5.4\_x64. Assume further that you are working on a CentOS host. If the AMI is a Fedora image, you need to be working on a Fedora host initially.

When copying and pasting a command, be sure the command has pasted as a single line before executing. Some document viewers may introduce unwanted line breaks in copied text.

**Note: You need to have a XenServer host with a file-based storage repository (either a local ext3 SR or an NFS SR) to convert to a VHD once the image file has been customized on the Centos/Fedora host.**

1. Set up loopback on image file:

# mkdir -p /mnt/loop/centos54

# mount -o loop CentOS\_5.4\_x64 /mnt/loop/centos54

1. Install the kernel-xen package into the image. This downloads the PV kernel and ramdisk to the image.

# yum -c /mnt/loop/centos54/etc/yum.conf --installroot=/mnt/loop/centos54/ -y install kernel-xen

1. Create a grub entry in /boot/grub/grub.conf.

# mkdir -p /mnt/loop/centos54/boot/grub

# touch /mnt/loop/centos54/boot/grub/grub.conf

# echo "" > /mnt/loop/centos54/boot/grub/grub.conf

1. Determine the name of the PV kernel that has been installed into the image

# cd /mnt/loop/centos54

# ls lib/modules/

2.6.16.33-xenU 2.6.16-xenU 2.6.18-164.15.1.el5xen 2.6.18-164.6.1.el5.centos.plus 2.6.18-xenU-ec2-v1.0 2.6.21.7-2.fc8xen 2.6.31-302-ec2

# ls boot/initrd\*

boot/initrd-2.6.18-164.6.1.el5.centos.plus.img boot/initrd-2.6.18-164.15.1.el5xen.img

# ls boot/vmlinuz\*

boot/vmlinuz-2.6.18-164.15.1.el5xen boot/vmlinuz-2.6.18-164.6.1.el5.centos.plus boot/vmlinuz-2.6.18-xenU-ec2-v1.0 boot/vmlinuz-2.6.21-2952.fc8xen

Xen kernels/ramdisk always end with "xen". For the kernel version you choose, there has to be an entry for that version under lib/modules, there has to be an initrd and vmlinuz corresponding to that. Above, the only kernel that satisfies this condition is 2.6.18-164.15.1.el5xen

1. Based on your findings, create an entry in the grub.conf file. Below is an example entry.

default=0

timeout=5

hiddenmenu

title CentOS (2.6.18-164.15.1.el5xen)

        root (hd0,0)

        kernel /boot/vmlinuz-2.6.18-164.15.1.el5xen ro root=/dev/xvda

        initrd /boot/initrd-2.6.18-164.15.1.el5xen.img

1. Edit etc/fstab, changing “sda1” to “xvda” and changing “sdb” to “xvdb”.

# cat etc/fstab

/dev/xvda / ext3 defaults 1 1

/dev/xvdb /mnt ext3 defaults 0 0

none /dev/pts devpts gid=5,mode=620 0 0

none /proc proc defaults 0 0

none /sys sysfs defaults 0 0

1. Enable login via the console. The default console device in a XenServer system is xvc0. Ensure that etc/inittab and etc/securetty have the following lines respectively:

# grep xvc0 etc/inittab

co:2345:respawn:/sbin/agetty xvc0 9600 vt100-nav

# grep xvc0 etc/securetty

xvc0

1. Ensure the ramdisk supports PV disk and PV network. Customize this for the kernel version you have determined above.

# chroot /mnt/loop/centos54

# cd /boot/

# mv initrd-2.6.18-164.15.1.el5xen.img initrd-2.6.18-164.15.1.el5xen.img.bak

# mkinitrd -f /boot/initrd-2.6.18-164.15.1.el5xen.img --with=xennet --preload=xenblk --omit-scsi-modules 2.6.18-164.15.1.el5xen

1. Change the password.

 # passwd

Changing password for user root.

New UNIX password:

Retype new UNIX password:

passwd: all authentication tokens updated successfully.

1. Exit out of chroot.

# exit

1. Check etc/ssh/sshd\_config for lines allowing ssh login using a password.

# egrep "PermitRootLogin|PasswordAuthentication" /mnt/loop/centos54/etc/ssh/sshd\_config

PermitRootLogin yes

PasswordAuthentication yes

1. If you need the template to be enabled to reset passwords from the CloudStack UI or API, install the password change script into the image at this point. See Adding Password Management to Your Templates on page 79.
2. Unmount and delete loopback mount.

# umount /mnt/loop/centos54

# losetup -d /dev/loop0

1. Copy the image file to your XenServer host's file-based storage repository. In the example below, the Xenserver is "xenhost". This XenServer has an NFS repository whose uuid is a9c5b8c8-536b-a193-a6dc-51af3e5ff799.

# scp CentOS\_5.4\_x64 xenhost:/var/run/sr-mount/a9c5b8c8-536b-a193-a6dc-51af3e5ff799/

1. Log in to the Xenserver and create a VDI the same size as the image.

[root@xenhost ~]# cd /var/run/sr-mount/a9c5b8c8-536b-a193-a6dc-51af3e5ff799

[root@xenhost a9c5b8c8-536b-a193-a6dc-51af3e5ff799]# ls -lh CentOS\_5.4\_x64

-rw-r--r-- 1 root root 10G Mar 16 16:49 CentOS\_5.4\_x64

[root@xenhost a9c5b8c8-536b-a193-a6dc-51af3e5ff799]# xe vdi-create virtual-size=10GiB sr-uuid=a9c5b8c8-536b-a193-a6dc-51af3e5ff799 type=user name-label="Centos 5.4 x86\_64"

cad7317c-258b-4ef7-b207-cdf0283a7923

1. Import the image file into the VDI. This may take 10–20 minutes.

[root@xenhost a9c5b8c8-536b-a193-a6dc-51af3e5ff799]# xe vdi-import filename=CentOS\_5.4\_x64 uuid=cad7317c-258b-4ef7-b207-cdf0283a7923

1. Locate a the VHD file. This is the file with the VDI’s UUID as its name. Compress it and upload it to your web server.

[root@xenhost a9c5b8c8-536b-a193-a6dc-51af3e5ff799]# bzip2 -c cad7317c-258b-4ef7-b207-cdf0283a7923.vhd > CentOS\_5.4\_x64.vhd.bz2

[root@xenhost a9c5b8c8-536b-a193-a6dc-51af3e5ff799]# scp CentOS\_5.4\_x64.vhd.bz2 webserver:/var/www/html/templates/

### Creating a Bare Metal Template

Before you can create a bare metal template, you must have performed several other installation and setup steps to create a bare metal cluster and environment. See Bare Metal Installation in the Installation Guide. It is assumed you already have a directory named "win7\_64bit" on your CIFS server, containing the image for the bare metal instance. This directory and image are set up as part of the Bare Metal Installation procedure.

1. Log into the UI as either an end user or administrator.
2. In the UI, click Add Template.
3. In the dialog box, enter the following values.

* **Name.** Short name for the template.
* **Display Text.** Description of the template.
* **URL.** The directory name which contains image file on your CIFS server. For example, win7\_64bit.
* **Zone.** All Zones.
* **OS Type.** Select the OS type of the ISO image. Choose other if the OS Type of the ISO is not listed or if the ISO is not bootable.
* **Hypervisor.** BareMetal.
* **Format.** BareMetal.
* Password Enabled. No.
* Public. No.
* **Featured.** Choose Yes if you would like this ISO to be more prominent for users to select. Only administrators may make ISOs featured.

### Creating an Ubuntu 10.04 LTS Template for XenServer

This section tells how to create an Ubuntu 10.04 LTS template so that you can create Ubuntu VM instances on the XenServer hypervisor.

1. In XenServer, create a running Ubuntu 10.04 VM by following these steps. (Copied from [Installing Ubuntu 10.04 LTS](http://community.citrix.com/display/xs/Installing+Ubuntu+Server+10.04+%2832bit+and+64bit%29+LTS) on the Citrix Developer Network. Check the website for the most up-to-date information: http://community.citrix.com/display/xs/Installing+Ubuntu+Server+10.04+%2832bit+and+64bit%29+LTS.)
2. Copy makeubuntu.sh script to the Pool Master (download the script from the Citrix Developer Network link above).
3. Execute makeubuntu.sh script to create Ubuntu Templates.
4. Create an Ubuntu VM with the new templates.
5. Perform install and reboot.
6. Perform the following tests.
   1. Make sure the VM is booted with one NIC (eth0).
   2. Open the file /etc/network/interfaces and be sure that eth0 is set to use DHCP.
7. Stop the Ubuntu VM.

In the next few steps, you will copy the virtual machine's virtual hard disk (VHD) to a web server.

1. From the XenServer command line, list the VMs with the following command. Note the UUID of your Ubuntu VM.

# xe vm-list

1. List the virtual block devices (VBDs) with the following command, passing in the VM UUID you discovered in the previous step. Note the VDI UUID for the VBD.

# xe vbd-list <your Ubuntu VM UUID>

1. Navigate to the mount point for primary storage to find the VHD file. The name of the VHD file is the VDI UUID you discovered in the previous step.
2. Copy the VHD file to a webserver.
3. In the CloudStack UI, click Add Template.
4. Select the URL of the VHD file on the web server as the location.
5. For the guest OS type, select Ubuntu if you are running XenServer 5.6 FP1 or greater (for earlier XenServer versions, select CentOS 5.4 x64). Alternatively, if you want Ubuntu to boot in PV mode, select Other PV (64-bit).
6. Start a new VM from the template.
7. Make sure the VM was able to get an IP address. If not, follow these troubleshooting steps:
8. Start a CentOS 5.3 x64 VM.
9. On the CentOS VM, run this command to find the location of the DHCP client script.

# which dhclient

The location returned should be /sbin/modified-dhclient/dhclient.

1. On the Ubuntu VM, create a new folder.

# mkdir /sbin/modified-dhclient

1. Copy the dhclient script from the CentOS VM to the Ubuntu VM at /sbin/modified-dhclient/dhclient.
2. Add the new folder to the front of your VM's path.
3. Log out of the VM and log in again.

### Converting a Hyper-V VM to a Template

To convert a Hyper-V VM to a XenServer-compatible CloudStack template, you will need a standalone XenServer host with an attached NFS VHD SR. Use whatever XenServer version you are using with CloudStack, but use XenCenter 5.6 FP1 or SP2 (it is backwards compatible to 5.6). Additionally, it may help to have an attached NFS ISO SR.

For Linux VMs, you may need to do some preparation in Hyper-V before trying to get the VM to work in XenServer. Clone the VM and work on the clone if you still want to use the VM in Hyper-V. Uninstall Hyper-V Integration Components and check for any references to device names in /etc/fstab:

1. From the linux\_ic/drivers/dist directory, run make uninstall (where "linux\_ic" is the path to the copied Hyper-V Integration Components files).
2. Restore the original initrd from backup in /boot/ (the backup is named \*.backup0).
3. Remove the "hdX=noprobe" entries from /boot/grub/menu.lst.
4. Check /etc/fstab for any partitions mounted by device name. Change those entries (if any) to mount by LABEL or UUID (get that information with the "blkid" command).

The next step is make sure the VM is not running in Hyper-V, then get the VHD into XenServer. There are two options for doing this.

Option one:

1. Import the VHD using XenCenter. In XenCenter, go to Tools > Virtual Appliance Tools > Disk Image Import.
2. Choose the VHD, then click Next.
3. Name the VM, choose the NFS VHD SR under Storage, enable "Run Operating System Fixups" and choose the NFS ISO SR.
4. Click Next, then Finish. A VM should be created.

Option two:

1. Run XenConvert, under From choose VHD, under To choose XenServer. Click Next.
2. Choose the VHD, then click Next.
3. Input the XenServer host info, then click Next.
4. Name the VM, then click Next, then Convert. A VM should be created.

Once you have a VM created from the Hyper-V VHD, prepare it using the following steps.

1. Boot the VM, uninstall Hyper-V Integration Services, and reboot.
2. Install XenServer Tools, then reboot.
3. Prepare the VM as desired. For example, run sysprep on Windows VMs (see Creating a Windows Template on page 68).

Either option above will create a VM in HVM mode. This is fine for Windows VMs, but Linux VMs may not perform optimally. Converting a Linux VM to PV mode will require additional steps and will vary by distribution.

1. Shut down the VM and copy the VHD from the NFS storage to a web server; for example, mount the NFS share on the web server and copy it, or from the XenServer host use sftp or scp to upload it to the web server.
2. In CloudStack, create a new template using the following values:

* **URL.** Give the URL for the VHD
* **OS Type.** Use the appropriate OS. For PV mode on CentOS, choose Other PV (32-bit) or Other PV (64-bit). This choice is available only for XenServer.
* **Hypervisor.** XenServer.
* Format. VHD.

The template will be created and you can create instances from it.

### Adding Password Management to Your Templates

The CloudStack platform provides an optional password reset feature that allows users to set a temporary admin or root password as well as reset the existing admin or root password from the CloudStack UI.

To enable the Reset Password feature, you will need to download an additional script to patch your template. When you later upload the template into the CloudStack platform, you can specify whether reset admin/root password feature should be enabled for this template.

The password management feature works always resets the account password on instance boot. The script does an HTTP call to the virtual router to retrieve the account password that should be set. As long as the virtual router is accessible the guest will have access to the account password that should be used. When the user requests a password reset the management server generates and sends a new password to the virtual router for the account. Thus an instance reboot is necessary to effect any password changes.

If the script is unable to contact the virtual router during instance boot it will not set the password but boot will continue normally.

#### Window OS Installation

Download the installer, CloudInstanceManager.msi, from [<http://cloudstack.org/download.html>](http://open.cloud.com) and run the installer in the newly created Windows VM.

#### Linux OS Installation

Use the following steps to begin the Linux OS installation.

1. Download the script file cloud-set-guest-password from the CloudStack community on the Web:

* Linux:  
  <http://cloudstack.org/dl/cloud-set-guest-password>
* Windows:   
  <http://sourceforge.net/projects/cloudstack/files/Password%20Management%20Scripts/CloudInstanceManager.msi/download>

1. Copy this file to /etc/init.d. (On some Linux distributions, copy the file to /etc/rc.d/init.d.)
2. Run the following command to make the script executable.

chmod +x /etc/init.d/cloud-set-guest-password

1. Depending on the Linux distribution, continue with the appropriate step.
2. **Fedora, CentOS/RHEL, and Debian**. Run “chkconfig --add cloud-set-guest-password”.
3. **Ubuntu**. If you are using Ubuntu 11.04, start by creating a directory called /var/lib/dhcp3 on your Ubuntu machine (works around a known issue with this version of Ubuntu). On all Ubuntu versions: Run “sudo update-rc.d cloud-set-guest-password defaults 98”. To test, run "mkpasswd" and check that it is generating a new password. If the “mkpasswd” command does not exist, run "sudo apt-get install whois" (or sudo apt-get install mkpasswd, depending on your Ubuntu version) and repeat.

### Deleting Templates

Templates may be deleted. In general, when a template spans multiple Zones, only the copy that is selected for deletion will be deleted; the same template in other Zones will not be deleted. The provided CentOS template is an exception to this. If the provided CentOS template is deleted, it will be deleted from all Zones.

When templates are deleted, the VMs instantiated from them will continue to run. However, new VMs cannot be created based on the deleted template.

## Working with Snapshots

(Supported for the following hypervisors: XenServer, VMware vSphere, and KVM)

The CloudStack platform supports snapshots of disk volumes. Snapshots are a point-in-time capture of virtual machine disks. Memory and CPU states are not captured. If you are using the Oracle VM hypervisor, you can not take snapshots, since OVM does not support them.

Users can create snapshots manually, or by setting up automatic recurring snapshot policies. Users can also create disk volumes from snapshots, which may be attached to a VM as any other disk volume. Snapshots of both root disks and data disks is supported. However, the software does not currently support booting of a VM from a recovered root disk. A disk recovered from snapshot of a root disk is treated as a regular data disk; the data on recovered disk can be accessed by attaching the disk to a VM.

Snapshots may be taken for volumes, including both root and data disks (except when the Oracle VM hypervisor is used, which does not support snapshots). The administrator places a limit on the number of stored snapshots per user. Users can create new volumes from the snapshot for recovery of particular files and they can create templates from snapshots to boot from a restored disk. Snapshots may be set to occur on a recurring schedule. A completed snapshot is copied from primary storage to secondary storage, where it is stored until deleted or purged by newer snapshots.

### Automatic Snapshot Creation and Retention

(Supported for the following hypervisors: XenServer, VMware vSphere, and KVM.)

Users can set up a recurring snapshot policy to automatically create multiple snapshots of a disk at regular intervals. Snapshots can be created on an hourly, daily, weekly, or monthly intervals. One snapshot policy can be set up per disk volume. For example, a user can set up a daily snapshot at 02:30.

With each snapshot schedule, users can also specify the number of snapshots to be retained. Older snapshots that exceed the retention limit are automatically deleted.

### Incremental Snapshots and Backup

Snapshots are created on primary storage where a disk resides. After a snapshot is created, it is immediately backed up to secondary storage and removed from primary storage for optimal utilization of space on primary storage.

CloudStack does incremental backups for some hypervisors. When incremental backups are supported, every N backup is a full backup.

|  |  |  |  |
| --- | --- | --- | --- |
|  | VMware vSphere | Citrix XenServer | KVM |
| Support incremental backup | N | Y | N |

### Volume Status

When a snapshot operation is triggered by means of a recurring snapshot policy, a snapshot is skipped if a volume has remained inactive since its last snapshot was taken. A volume is considered to be inactive if it is either detached or attached to a VM that is not running. The CloudStack platform ensures that at least one snapshot is taken since the volume last became inactive.

When a snapshot is taken manually, a snapshot is always created regardless of whether a volume has been active or not.

### Snapshot Restore

There are two paths to restoring snapshots. Users can create volumes from the snapshot. The volume can then be mounted to a VM and files recovered as needed. A template may be created from the snapshot of a root disk. The user can then boot a VM from this template to effect recovery of the enter root disk.

### Performance Considerations

Snapshots not only consume space in secondary storage, but can take up significant CPU cycles and network bandwidth as the snapshots are moved between primary and secondary storage. This is something to be factored in for capacity planning and end-user pricing of snapshot operations.

# Working with System Virtual Machines

The CloudStack platform uses several types of system virtual machines to perform tasks in the cloud. In general the CloudStack platform manages these system VMs and creates, starts, and stops them as needed based on scale and immediate needs. However, the administrator should be aware of them and their roles to assist in debugging issues.

## The System VM Template

The System VMs come from a single template. The System VM has the following characteristics:

* Debian 6.0 ("Squeeze"), 2.6.32 kernel with the latest security patches from the Debian security APT repository
* Has a minimal set of packages installed thereby reducing the attack surface
* 32-bit for enhanced performance on Xen/VMWare
* pvops kernel with Xen PV drivers, KVM virtio drivers, and VMware tools for optimum performance on all hypervisors
* Xen tools inclusion allows performance monitoring
* Latest versions of haproxy, iptables, ipsec, apache from debian repository ensures improved security and speed
* Latest version of JRE from Sun/Oracle ensures improved security and speed

## Multiple System VM Support for VMware

Every CloudStack zone has single System VM for template processing tasks such as downloading templates, uploading templates, and uploading ISOs. In a zone where VMware is being used, additional System VMs can be launched to process VMware-specific tasks such as taking snapshots and creating private templates. The CloudStack management server launches additional System VMs for VMware-specific tasks as the load increases. The management server monitors and weights all commands sent to these System VMs and performs dynamic load balancing and scaling-up of more System VMs.

## Console Proxy

The Console Proxy is a type of System Virtual Machine that has a role in presenting a console view via the web UI. It connects the user’s browser to the VNC port made available via the hypervisor for the console of the guest. Both the administrator and end user web UIs offer a console connection.

Clicking on a console icon brings up a new window. The AJAX code downloaded into that window refers to the public IP address of a console proxy VM. There is exactly one public IP address allocated per console proxy VM. The AJAX application connects to this IP. The console proxy then proxies the connection to the VNC port for the requested VM on the Host hosting the guest.

**Note: The hypervisors will have many ports assigned to VNC usage so that multiple VNC sessions can occur simultaneously.**

There is never any traffic to the guest virtual IP, and there is no need to enable VNC within the guest.

The console proxy VM will periodically report its active session count to the Management Server. The default reporting interval is five seconds. This can be changed through standard Management Server configuration with the parameter consoleproxy.loadscan.interval.

Assignment of guest VM to console proxy is determined by first determining if the guest VM has a previous session associated with a console proxy. If it does, the Management Server will assign the guest VM to the target Console Proxy VM regardless of the load on the proxy VM. Failing that, the first available running Console Proxy VM that has the capacity to handle new sessions is used.

Console proxies can be restarted by administrators but this will interrupt existing console sessions for users.

The console viewing functionality uses a dynamic DNS service under the domain name realhostip.com to assist in providing SSL security to console sessions. The console proxy is assigned a public IP address. In order to avoid browser warnings for mismatched SSL certificates, the URL for the new console window is set to the form of https://aaa-bbb-ccc-ddd.realhostip.com. Customers will see this URL during console session creation. CloudStack includes the realhostip.com SSL certificate in the console proxy VM. Of course, CloudStack cannot know about DNS A records for our customers' public IPs prior to shipping the software. CloudStack therefore runs a dynamic DNS server that is authoritative for the realhostip.com domain. It maps the aaa-bbb-ccc-ddd part of the DNS name to the IP address aaa.bbb.ccc.ddd on lookups. This allows the browser to correctly connect to the console proxy's public IP, where it then expects and receives a SSL certificate for realhostip.com, and SSL is set up without browser warnings.

### Changing the Console Proxy SSL Certificate and Domain

If the administrator prefers, it is possible for the URL of the customer's console session to show a domain other than realhostip.com. The administrator can customize the displayed domain by selecting a different domain and uploading a new SSL certificate and private key. The domain must run a DNS service that is capable of resolving queries for addresses of the form   
aaa-bbb-ccc-ddd.your.domain to an IPv4 IP address in the form aaa.bbb.ccc.ddd, for example, 202.8.44.1.

To change the console proxy domain, SSL certificate, and private key:

1. Set up dynamic name resolution or populate all possible DNS names in your public IP range into your existing DNS server with the format aaa-bbb-ccc-ddd.company.com -> aaa.bbb.ccc.ddd.
2. Generate the private key and certificate signing request (CSR). When you are using openssl to generate private/public key pairs and CSRs, for the private key that you are going to paste into the CloudStack UI, be sure to convert it into PKCS#8 format.
3. Generate a new 2048-bit private key.

openssl genrsa -des3 -out yourprivate.key 2048

1. Generate a new certificate CSR.

openssl req -new -key yourprivate.key -out yourcertificate.csr

1. Head to the website of your favorite trusted Certificate Authority, purchase an SSL certificate, and submit the CSR. You should receive a valid certificate in return.
2. Convert your private key format into PKCS#8 encrypted format.

openssl pkcs8 -topk8 -in yourprivate.key -out yourprivate.pkcs8.encryped.key

1. Convert your PKCS#8 encrypted private key into the PKCS#8 format that is compliant with CloudStack.

openssl pkcs8 -in yourprivate.pkcs8.encrypted.key -out yourprivate.pkcs8.key

1. In the Update SSL Certificate screen of the CloudStack UI, paste the following:

* Certificate from step 1(c).
* Private key from step 1(e).
* The desired new domain name; for example, company.com.

1. Click Add to put the changes into effect.

This stops all currently running console proxy VMs, then restarts them with the new certificate and key. Users might notice a brief interruption in console availability.

The Management Server will generate URLs of the form "aaa-bbb-ccc-ddd.company.com" after this change is made. New console requests will be served with the new DNS domain name, certificate, and key.

## Virtual Router

The virtual router is a type of System Virtual Machine. The virtual router is one of the most frequently used service providers in CloudStack. The end user has no direct access to the virtual router. Users can ping the virtual router and take actions that affect it (such as setting up port forwarding), but users do not have SSH access into the virtual router.

There is no mechanism for the administrator to log in to the virtual router. Virtual routers can be restarted by administrators, but this will interrupt public network access and other services for end users.

A basic test in debugging networking issues is to attempt to ping the virtual router from a guest VM.

Some of the characteristics of the virtual router are determined by its associated system service offering.

### Configuring the Virtual Router

You can set the following:

* IP range
* Supported network services
* Default domain name for the network serviced by the virtual router
* Gateway IP address

### Upgrading a Virtual Router with System Service Offerings

When CloudStack creates a virtual router, it uses default settings. You can upgrade the capabilities of the virtual router by creating and applying a custom system service offering.

System service offerings, defined by the CloudStack administrator, provide a choice of CPU speed, number of CPUs, tags, and RAM size, just as other service offerings do. But rather than being used for virtual machine instances and exposed to users, system service offerings are used to change the default properties of virtual routers and are visible only to the CloudStack root administrator.

To view or change the system service offering associated with an existing virtual router:

1. Log in as root to the Administration UI.
2. Select the router you want to work with.
3. If the router is running, stop the router.
4. When the router is stopped, choose Change Service.
5. Select the service offering you want, then click OK. The offerings available in this dropdown are defined by the administrator.

## Secondary Storage VM

The secondary storage VM provides a background task that takes care of a variety of secondary storage activities: downloading a new template to a Zone, copying templates between Zones, and snapshot backups.

The administrator can log in to the secondary storage VM if needed. The procedure for this is documented in the Troubleshooting section of the Installation Guide.

# System Reliability and HA

## Management Server

The CloudStack Management Server should be deployed in a multi-node configuration such that it is not susceptible to individual server failures. The Management Server itself (as distinct from the MySQL database) is stateless and may be placed behind a load balancer.

Normal operation of Hosts is not impacted by an outage of all Management Serves. All guest VMs will continue to work.

When the Management Server is down, no new VMs can be created, and the end user and admin UI, API, dynamic load distribution, and HA will cease to work.

## Host

When Hosts are down, the CloudStack platform will restart impacted HA-enabled VMs automatically, assuming that other Hosts have sufficient resources available. When the Host comes back online it will be marked as available and newly started VMs may be allocated to it. VMs previously migrated from it will not be migrated back. VMs that were running on it but did not have HA enabled will not be started automatically.

The user will not lose the virtual machine disk image during a Host outage. However, the guest OS may perceive its disk image as corrupt (and needing fsck or equivalent) on restart.

## Primary Storage Outage and Data Loss

When a primary storage outage occurs the hypervisor immediately stops all VMs stored on that storage device. Guests that are marked for HA will be restarted as soon as practical when the primary storage comes back on line. With NFS, the hypervisor may allow the virtual machines to continue running depending on the nature of the issue. For example, an NFS hang will cause the guest VMs to be suspended until storage connectivity is restored.

Primary storage is not designed to be backed up. Individual volumes in primary storage can be backed up using snapshots.

## Secondary Storage Outage and Data Loss

For a Zone that has only one secondary storage server, a secondary storage outage will have feature level impact to the system but will not impact running guest VMs. It may become impossible to create a VM with the selected template for a user. A user may also not be able to save snapshots or examine/restore saved snapshots. These features will automatically be available when the secondary storage comes back online.

Secondary storage data loss will impact recently added user data including templates, snapshots, and ISO images. Secondary storage should be backed up periodically.

Multiple secondary storage servers can be provisioned within each zone to increase the scalability of the system.

## HA-Enabled VM

The user can specify a virtual machine as HA-enabled. All virtual router VMs and system VMs are automatically configured as HA-enabled. When an HA-enabled VM crashes, CloudStack detects the crash and restarts the VM automatically within the same Availability Zone. HA is never performed across different Availability Zones. The CloudStack platform has a conservative policy towards restarting VMs and ensures that there will never be two instances of the same VM running at the same time. The Management Server attempts to start the VM on another Host in the same cluster.

HA features work with iSCSI or NFS primary storage. HA with local storage is not supported.

# Managing the Cloud

## Changing the Database Configuration

The CloudStack Management Server stores database configuration information (e.g., hostname, port, credentials) in the file /etc/cloud/management/db.properties. To effect a change, edit this file on each Management Server, then restart the Management Server.

## PV Drivers

For XenServer, Windows VMs require PV drivers to be added in either the template or after install for the CloudStack platform management functions to work properly. The PV drivers allow functions such as mounting additional volumes and ISO images, live migration, and graceful shutdown.

## Administrator Alerts

The system provides alerts and events to help with the management of the cloud. Alerts are notices to an administrator, generally delivered by e-mail, notifying the administrator that an error has occurred in the cloud. Alert behavior is configurable.

Events track all of the user and administrator actions in the cloud. For example, every guest VM start creates an associated event. Events are stored in the Management Server’s database.

Emails will be sent to administrators under the following circumstances:

* The Management Server cluster runs low on CPU, memory, or storage resources
* The Management Server loses heartbeat from a Host for more than 3 minutes
* The Host cluster runs low on CPU, memory, or storage resources

## Limits

The CloudStack platform provides several administrator control points for capping resource usage by users. Some of these limits are global configuration parameters. Others are applied at the ROOT domain and may be overridden on a per-account basis.

Aggregate limits may be set on a per-domain basis. For example, you may limit a domain and all subdomains to the creation of 100 VMs.

### Configuration Limits

On a Zone the guest virtual network has a 24 bit CIDR by default. This limits the guest virtual network to 254 running instances. It can be adjusted as needed, but this must be done before any instances are created in the Zone. For example, 10.1.1.0/22 would provide for ~1000 addresses.

The following table lists limits set in the Global Configuration.

|  |  |
| --- | --- |
| **Parameter Name** | **Definition** |
| max.account.public.ips | Number of public IP addresses that can be owned by an account |
| max.account.snapshots | Number of snapshots that can exist for an account |
| max.account.templates | Number of templates that can exist for an account |
| max.account.user.vms | Number of virtual machine instances that can exist for an account |
| max.account.volumes | Number of disk volumes that can exist for an account |
| max.template.iso.size | Maximum size for a downloaded template or ISO in GB |
| max.volume.size.gb | Maximum size for a volume in GB |
| network.throttling.rate | Default data transfer rate in megabits per second allowed per user (supported on XenServer) |
| snapshot.max.hourly | Maximum hourly snapshots for a volume |
| snapshot.max.daily | Maximum daily snapshots for a volume |
| snapshot.max.weekly | Maximum weekly snapshots for a volume |
| snapshot.max.monthly | Maximum monthly snapshots for a volume |

To modify global configuration parameters, use the global configuration screen in the CloudStack UI.

### Default Account Resource Limits

You can limit resource use by accounts. The default limits are set using global configuration parameters, and they affect all accounts within a cloud. The relevant parameters are those beginning with max.account (max.account.snapshots, etc.).

To override a default limit for a particular account, set a per-account resource limit. Log in to the administrator web UI at http://management-server-ip-address:8080/client. In the left navigation tree, click Accounts, then All Accounts. Select the account you want to modify, then select Resource limits from the Actions dropdown at the upper right of the account detail display.

### Per-Domain Limits

CloudStack allows the configuration of limits on a domain basis. With a domain limit in place, all users still have their account limits. They are additionally limited, as a group, to not exceed the resource limits set on their domain. Domain limits aggregate the usage of all accounts in the domain as well as all accounts in all subdomains of that domain. Limits set at the root domain level apply to the sum of resource usage by the accounts in all domains and sub-domains below that root domain.

To set a domain limit, go to Domains in the CloudStack UI, choose the domain, and click Edit. A value of -1 shows that there is no limit in place.

## Customizing the Network Domain Name

The root administrator can optionally assign a custom DNS suffix at the level of a network, account, domain, zone, or entire CloudStack installation, and a domain administrator can do so within their own domain. To specify a custom domain name and put it into effect, follow these steps.

1. Set the DNS suffix at the desired scope:

* At the network level, the DNS suffix can be assigned through the UI when creating a new network (see Adding an Additional Guest Network on page 44) or with the updateNetwork command in the CloudStack API.
* At the account, domain, or zone level, the DNS suffix can be assigned with the appropriate CloudStack API commands: createAccount, editAccount, createDomain, editDomain, createZone, or editZone.
* At the global level, use the configuration parameter guest.domain.suffix. To access the parameter through the UI, log in to the Admin UI and click Configuration, then Global Settings. You can also use the CloudStack API command updateConfiguration. After modifying this global configuration, restart the Management Server to put the new setting into effect.

1. To make the new DNS suffix take effect for an existing network, call the CloudStack API command updateNetwork. This step is not necessary when the DNS suffix was specified while creating a new network.

The source of the network domain that is used depends on the following rules.

* For all networks, if a network domain is specified as part of a network's own configuration, that value is used.
* For an account-specific network, the network domain specified for the account is used. If none is specified, the system looks for a value in the domain, zone, and global configuration, in that order.
* For a domain-specific network, the network domain specified for the domain is used. If none is specified, the system looks for a value in the zone and global configuration, in that order.
* For a zone-specific network, the network domain specified for the zone is used. If none is specified, the system looks for a value in the global configuration.

## Password and Key Encryption

CloudStack stores several sensitive passwords and secret keys that are used to provide security. These values are always automatically encrypted:

* Database secret key
* Database password
* SSH keys
* Compute node root password
* VPN password
* User API secret key
* VNC password

CloudStack uses the Java Simplified Encryption (JASYPT) library. The data values are encrypted and decrypted using a database secret key, which is stored in one of CloudStack’s internal properties files along with the database password. The other encrypted values listed above (SSH keys, etc.) are in the CloudStack internal database.

Of course, the database secret key itself can not be stored in the open – it must be encrypted. How then does CloudStack read it? A second secret key must be provided from an external source during Management Server startup. This key can be provided in one of two ways: loaded from a file or provided by the CloudStack administrator. The CloudStack database has a new configuration setting that lets it know which of these methods will be used. If the encryption type is set to “file,” the key must be in a file in a known location. If the encryption type is set to “web,” the administrator runs the utility com.cloud.utils.crypt.EncryptionSecretKeySender, which relays the key to the Management Server over a known port.

The encryption type, database secret key, and Management Server secret key are set during CloudStack installation. They are all new parameters to the CloudStack database setup script (cloud-setup-databases). The default values are file, password, and password. It is, of course, highly recommended that you change these to more secure keys.

# Working with Usage

The Usage Server provides aggregated usage records which you can use to create billing integration for the CloudStack platform. The Usage Server works by taking data from the events log and creating summary usage records that you can access using the listUsageRecords API call.

The usage records show the amount of resources, such as VM run time or template storage space, consumed by guest instances. In the special case of bare metal instances, no template storage resources are consumed, but records showing zero usage are still included in the Usage Server's output.

The Usage Server runs at least once per day. It can be configured to run multiple times per day. Its behavior is controlled by the following Configuration table settings.

|  |  |
| --- | --- |
| **Parameter Name** | **Parameter Definition** |
| usage.stats.job.exec.time | The time when the Usage Server processing will start. It is specified in 24-hour format (HH:MM) in the time zone of the server, which should be GMT. For example, to start the Usage job at 10:30 GMT, enter “10:30”.  If usage.stats.job.aggregation.range is also set, and its value is not 1440, then its value will be added to usage.stats.job.exec.time to get the time to run the Usage server job again. This is repeated until 24 hours have elapsed, and the next day's processing begins again at usage.stats.job.exec.time.  Default: 00:15. |
| usage.execution.timezone | The time zone for usage.stats.job.exec.time. Valid values for the time zone are specified in Appendix A—Time Zones.  Default: The time zone of the management server is used. |
| usage.stats.job.aggregation.range | The time period in minutes between Usage server processing jobs. For example, if you set it to 1440, the Usage server will run once per day. If you set it to 600, it will run every ten hours. In general, when a Usage server job runs, it processes all events generated since usage was last run.  There is special handling for the case of 1440 (once per day). In this case the Usage Server does not necessarily process all records since Usage was last run. The CloudStack platform assumes that you require processing once per day for the previous, complete day’s records. For example, if the current day is October 7, then it is assumed you would like to process records for October 6, from midnight to midnight. The CloudStack platform assumes this “midnight to midnight” is relative to the usage.execution.timezone.  Default: 1440 |

For example, suppose that your server is in GMT, your user population is predominantly in the East Coast of the United States, and you would like to process usage records every night at 2 AM local (EST) time. Choose these settings:

* **usage.stats.job.exec.time** = 07:00. This will run the Usage job at 2:00 AM EST. Note that this will shift by an hour as the East Coast of the U.S. enters and exits Daylight Savings Time.
* usage.execution.timezone = America/New\_York
* usage.stats.job.aggregation.range = 1440

With this configuration, the Usage job will run every night at 2 AM EST and will process records for the previous day’s midnight-midnight as defined by the EST (America/New\_York) time zone.

**Note: Because the special value 1440 has been used for usage.stats.job.aggregation.range, the Usage Server will ignore the data between midnight and 2 AM. That data will be included in the next day's run.**

# User Interface and API

## User Interface

The system supports both an administrator interface and an end user interface. Both UIs can be displayed in a browser at http://<management-server-IP>:8080/client. The appropriate UI is displayed depending on whether the login account is an administrator or user account.

### Admin User Interface

The administrator UI supports the following functionalities:

* Service offering management
* User management
* Template management
* Virtual machine management
* Server management
* Storage management
* Network management
* Events
* Initial set up
* Dashboard

### End User Interface

The end user UI is an AJAX-based UI available in popular browsers including IE7, IE8, IE9, Firefox 3.5+, Firefox 4, Safari 4, and Safari 5. It offers a number of features for end users:

* Service Offering Description
* Template Management
* Virtual Machine Management
* Network Management
* Event Logs
* Snapshot Management
* Dashboard

## API

The CloudStack API is a low level API that has been used to implement the web UIs. It is also a good basis for implementing other popular APIs such as EC2/S3 and emerging DMTF standards.

In the 2.0 API, structural changes were implemented so that many previously synchronous calls are now asynchronous. These calls will return a Job ID immediately when called. This Job ID can be used to query the status of the job later. Also, status calls on impacted resources will provide some indication of their state.

The API has a REST-like query basis and returns results in XML or JSON.

See the Developer’s Guide and API Reference at <http://docs.cloud.com/CloudStack_Documentation>.

### Provisioning and Authentication API

The CloudStack platform expects that a customer will have their own user provisioning infrastructure. It provides APIs to integrate with these existing systems where the systems call out to the CloudStack platform to add/remove users.

The CloudStack platform supports pluggable authenticators. By default the CloudStack platform assumes it is provisioned with the user’s password, and as a result authentication is done locally. However, external authentication is possible as well. For example, see Using an LDAP Server for User Authentication on page 15.

### Allocators

The CloudStack platform enables administrators to write custom allocators that will choose the Host to place a new guest and the storage host from which to allocate guest virtual disk images.

### User Data and Meta Data

The CloudStack platform provides API access to attach user data to a deployed VM. Deployed VMs also have access to instance metadata via the virtual router.

User data can be accessed once the IP address of the virtual router is known. Once the IP address is known, use the following steps to access the user data:

1. Run the following command to find the virtual router.

# cat /var/lib/dhclient/dhclient-eth0.leases | grep dhcp-server-identifier | tail -1

1. Access user data by running the following command using the result of the above command.

# curl <http://10.1.1.1/latest/user-data>

Meta Data can be accessed similarly, using a URL of the form http://10.1.1.1/latest/meta-data/{metadata type}. (For backwards compatibility, the previous URL http://10.1.1.1/latest/{metadata type} is also supported.) For metadata type, use one of the following:

* **service-offering**. A description of the VMs service offering.
* **availability-zone**. The Zone name.
* **local-ipv4**. The guest IP of the VM.
* **local-hostname**. The hostname of the VM.
* **public-ipv4**. The first public IP for the router. (E.g. the first IP of eth2)
* **public-hostname**. This is the same as public-ipv4.
* **instance-id**. The instance name of the VM.

# Tuning

This section provides tips on how to improve the performance of your cloud.

## Performance Monitoring

Host and guest performance monitoring is available to end users and administrators. This allows the user to monitor their utilization of resources and determine when it is appropriate to choose a more powerful service offering or larger disk.

## Increase Management Server Maximum Memory

If the Management Server is subject to high demand, the default maximum JVM memory allocation can be insufficient. To increase the memory:

1. Edit the Tomcat configuration file /etc/cloud/management/tomcat6.conf.
2. Change the command-line parameter -Xmx*NNN*m to a higher value of *N*. For example, if the current value is -Xmx128m, change it to -Xmx1024m or higher.
3. To put the new setting into effect, restart the Management Server.

# service cloud-management restart

For more information about memory issues, see "FAQ: Memory" in the Tomcat Wiki at <http://wiki.apache.org/tomcat/FAQ/Memory>.

## Set Database Buffer Pool Size

It is important to provide enough memory space for the MySQL database to cache data and indexes.

1. Edit the MySQL configuration file /etc/my.cnf.
2. Insert the following line in the [mysqld] section, below the datadir line. Use a value that is appropriate for your situation. We recommend setting the buffer pool at 40% of RAM if MySQL is on the same server as the management server or 70% of RAM if MySQL has a dedicated server. The following example assumes a dedicated server with 1024M of RAM.

innodb\_buffer\_pool\_size=700M

1. Restart the MySQL service:

# service mysqld restart

For more information about the buffer pool, see "The InnoDB Buffer Pool" in the MySQL Reference Manual at <http://dev.mysql.com/doc/refman/5.5/en/innodb-buffer-pool.html>.

# Troubleshooting

This section describes how to diagnose and remedy runtime issues.

## Event Logs

There are two types of events logged in the CloudStack Event Log. Standard events log the success or failure of an event and can be used to identify jobs or processes that have failed. There are also long running job events. Events for asynchronous jobs log when a job is scheduled, when it starts, and when it completes. Other long running synchronous jobs log when a job starts, and when it completes. Long running synchronous and asynchronous event logs can be used to gain more information on the status of a pending job or can be used to identify a job that is hanging or has not started. The following sections provide more information on these events.

### Standard Events

The events log records three types of standard events.

* **INFO**. This event is generated when an operation has been successfully performed.
* **WARN**. This event is generated in the following circumstances.
* When a network is disconnected while monitoring a template download.
* When a template download is abandoned.
* When an issue on the storage server causes the volumes to fail over to the mirror storage server.
* **ERROR**. This event is generated when an operation has not been successfully performed.

### Long Running Job Events

In addition to the three standard event types, the events log also records the three following events for long running jobs.

* **SCHEDULED**. (Asynchronous jobs only) This event is generated when an asynchronous job is submitted.
* **STARTED**. This event is generated when a job begins execution.
* **COMPLETED**. This event is generated when a job is completed.

Both the Started and Completed events are logged for all long running job types. The Scheduled event is only logged for asynchronous events. When an action is initiated synchronously or as part of another asynchronous job, the Scheduled event won’t be logged.

### Event Log Queries

Database logs can be queried from the user interface. The list of events captured by the system includes:

* Virtual machine creation, deletion, and on-going management operations
* Virtual router creation, deletion, and on-going management operations
* Template creation and deletion
* Network/load balancer rules creation and deletion
* Storage volume creation and deletion
* User login and logout

The following is the full list of event types.

VM.CREATE

VM.DESTROY

VM.START

VM.STOP

VM.REBOOT

VM.UPGRADE

VM.RESETPASSWORD

ROUTER.CREATE

ROUTER.DESTROY

ROUTER.START

ROUTER.STOP

ROUTER.REBOOT

ROUTER.HA

PROXY.CREATE

PROXY.DESTROY

PROXY.START

PROXY.STOP

PROXY.REBOOT

PROXY.HA

VNC.CONNECT

VNC.DISCONNECT

NET.IPASSIGN

NET.IPRELEASE

NET.RULEADD

NET.RULEDELETE

NET.RULEMODIFY

NETWORK.CREATE  
NETWORK.DELETE  
LB.ASSIGN.TO.RULE  
LB.REMOVE.FROM.RULE  
LB.CREATE  
LB.DELETE  
LB.UPDATE  
USER.LOGIN

USER.LOGOUT

USER.CREATE

USER.DELETE

USER.UPDATE

USER.DISABLE

TEMPLATE.CREATE

TEMPLATE.DELETE

TEMPLATE.UPDATE

TEMPLATE.COPY

TEMPLATE.DOWNLOAD.START

TEMPLATE.DOWNLOAD.SUCCESS

TEMPLATE.DOWNLOAD.FAILED

TEMPLATE.EXTRACT  
TEMPLATE.UPLOAD  
TEMPLATE.CLEANUP  
VOLUME.CREATE

VOLUME.DELETE

VOLUME.ATTACH

VOLUME.DETACH

VOLUME.EXTRACT  
VOLUME.UPLOAD       
SERVICEOFFERING.CREATE

SERVICEOFFERING.UPDATE

SERVICEOFFERING.DELETE

DOMAIN.CREATE

DOMAIN.DELETE

DOMAIN.UPDATE

SNAPSHOT.CREATE

SNAPSHOT.DELETE

SNAPSHOTPOLICY.CREATE

SNAPSHOTPOLICY.UPDATE

SNAPSHOTPOLICY.DELETE

ISO.CREATE

ISO.DELETE

ISO.COPY

ISO.ATTACH

ISO.DETACH

ISO.EXTRACT  
ISO.UPLOAD  
SERVICE.OFFERING.CREATE  
SERVICE.OFFERING.EDIT  
SERVICE.OFFERING.DELETE  
DISK.OFFERING.CREATE  
DISK.OFFERING.EDIT  
DISK.OFFERING.DELETE  
NETWORK.OFFERING.CREATE  
NETWORK.OFFERING.EDIT  
NETWORK.OFFERING.DELETE  
POD.CREATE  
POD.EDIT  
POD.DELETE  
ZONE.CREATE  
ZONE.EDIT  
ZONE.DELETE  
VLAN.IP.RANGE.CREATE  
VLAN.IP.RANGE.DELETE  
CONFIGURATION.VALUE.EDIT  
SG.AUTH.INGRESS  
SG.REVOKE.INGRESS  
HOST.RECONNECT  
MAINT.CANCEL  
MAINT.CANCEL.PS  
MAINT.PREPARE  
MAINT.PREPARE.PS  
VPN.REMOTE.ACCESS.CREATE  
VPN.REMOTE.ACCESS.DESTROY  
VPN.USER.ADD  
VPN.USER.REMOVE  
NETWORK.RESTART  
UPLOAD.CUSTOM.CERTIFICATE  
STATICNAT.ENABLE  
STATICNAT.DISABLE  
SSVM.CREATE

SSVM.DESTROY

SSVM.START

SSVM.STOP

SSVM.REBOOT

SSVM.HA

The following is the list of alert type numbers.

MEMORY = 0

CPU = 1

STORAGE =2

STORAGE\_ALLOCATED = 3

PUBLIC\_IP = 4

PRIVATE\_IP = 5

HOST = 6

USERVM = 7

DOMAIN\_ROUTER = 8

CONSOLE\_PROXY = 9

ROUTING = 10// lost connection to default route (to the gateway)

STORAGE\_MISC = 11 // lost connection to default route (to the gateway)

USAGE\_SERVER = 12 // lost connection to default route (to the gateway)

MANAGMENT\_NODE = 13 // lost connection to default route (to the gateway)

DOMAIN\_ROUTER\_MIGRATE = 14

CONSOLE\_PROXY\_MIGRATE = 15

USERVM\_MIGRATE = 16

VLAN = 17

SSVM = 18

USAGE\_SERVER\_RESULT = 19

## Working with Server Logs

The CloudStack Management Server logs all web site, middle tier, and database activities for diagnostics purposes in /var/log/cloud/management/. The CloudStack logs a variety of error messages. We recommend this command to find the problematic output in the Management Server log:

When copying and pasting a command, be sure the command has pasted as a single line before executing. Some document viewers may introduce unwanted line breaks in copied text.

grep -i -E 'exc|unable|fail|invalid|leak|warn|error' /var/log/cloud/management/management-server.log

The CloudStack processes requests with a Job ID. If you find an error in the logs and you are interested in debugging the issue you can grep for this job ID in the management server log. For example, suppose that you find the following ERROR message:

2010-10-04 13:49:32,595 ERROR [cloud.vm.UserVmManagerImpl] (Job-Executor-11:job-1076) Unable to find any host for [User|i-8-42-VM-untagged]

Note that the job ID is 1076. You can track back the events relating to job 1076 with the following grep:

grep "job-1076)" management-server.log

The CloudStack Agent Server logs its activities in /var/log/cloud/agent/.

## Data Loss on Exported Primary Storage

###### Symptom

Loss of existing data on primary storage which has been exposed as a Linux NFS server export on an iSCSI volume.

###### Cause

It is possible that a client from outside the intended pool has mounted the storage. When this occurs, the LVM is wiped and all data in the volume is lost.

###### Solution

When setting up LUN exports, restrict the range of IP addresses that are allowed access by specifying a subnet mask. For example:

echo “/export 192.168.1.0/24(rw,async,no\_root\_squash)” > /etc/exports

Adjust the above command to suit your deployment needs.

###### More Information

See the export procedure in the "Secondary Storage" section of the CloudStack Installation Guide.

## Maintenance mode not working on vCenter

###### Symptom

Host was placed in maintenance mode, but still appears live in vCenter.

###### Cause

The CloudStack administrator UI was used to place the host in scheduled maintenance mode. This mode is separate from vCenter's maintenance mode.

###### Solution

Use vCenter to place the host in maintenance mode.

###### More Information

See Scheduled Maintenance and Maintenance Mode for Hosts on page 34.

## Unable to deploy VMs from uploaded vSphere template

###### Symptom

When attempting to create a VM, the VM will not deploy.

###### Cause

If the template was created by uploading an OVA file that was created using vSphere Client, it is possible the OVA contained an ISO image. If it does, the deployment of VMs from the template will fail.

###### Solution

Remove the ISO and re-upload the template.

## Unable to power on virtual machine on VMware

###### Symptom

Virtual machine does not power on. You might see errors like:

* Unable to open Swap File
* Unable to access a file since it is locked
* Unable to access Virtual machine configuration

###### Cause

A known issue in VMware. ESX hosts lock certain critical virtual machine files and file systems to prevent concurrent changes. Sometimes the files are not unlocked when the virtual machine is powered off. When a virtual machine attempts to power on, it can not access these critical files, and the virtual machine is unable to power on.

###### Solution

See <http://kb.vmware.com/selfservice/microsites/search.do?language=en_US&cmd=displayKC&externalId=10051>.

# Contacting Support

###### Open-source community

A variety of channels are available for getting help with CloudStack, from forums to IRC chat and more. For details, see http:// <http://cloudstack.org/discuss/>.

###### Commercial customers

The CloudStack support team is available to help commercial customers plan and execute their installations. To contact the support team, log in to the support portal at <https://na6.salesforce.com/sserv/login.jsp?orgId=00D80000000LWom> using the account credentials you received when you purchased your support contract.

# Appendix A—Time Zones

The following time zone identifiers are accepted by CloudStack. There are several places that have a time zone as a required or optional parameter. These include scheduling recurring snapshots, creating a user, and specifying the usage time zone in the Configuration table.

Etc/GMT+12

Etc/GMT+11

Pacific/Samoa

Pacific/Honolulu

US/Alaska

America/Los\_Angeles

Mexico/BajaNorte

US/Arizona

US/Mountain

America/Chihuahua

America/Chicago

America/Costa\_Rica

America/Mexico\_City

Canada/Saskatchewan

America/Bogota

America/New\_York

America/Caracas

America/Asuncion

America/Cuiaba

America/HalifaxAmerica/La\_Paz

America/Santiago

America/St\_Johns

America/Araguaina

America/Argentina/Buenos\_Aires

America/Cayenne

America/Godthab

America/Montevideo

Etc/GMT+2

Atlantic/Azores

Atlantic/Cape\_Verde

Africa/Casablanca

Etc/UTC

Atlantic/Reykjavik

Europe/London

CET

Europe/Bucharest

Africa/Johannesburg

Asia/Beirut

Africa/CairoAsia/Jerusalem

Europe/Minsk

Europe/Moscow

Africa/Nairobi

Asia/Karachi

Asia/Kolkata

Asia/Bangkok

Asia/Shanghai

Asia/Kuala\_Lumpur

Australia/Perth

Asia/Taipei

Asia/Tokyo

Asia/Seoul

Australia/Adelaide

Australia/Darwin

Australia/Brisbane

Australia/Canberra

Pacific/Guam

Pacific/Auckland

1. The steps outlined here are derived from the excellent guide by Charity Shelbourne, originally published at the following URL. <http://blogs.technet.com/askcore/archive/2008/10/31/automating-the-oobe-process-during-windows-server-2008-sysprep-mini-setup.aspx> [↑](#footnote-ref-1)