Chap-04
Open Source Cloud Implementation , Administration and Deployment Techniques

- # Open Source Eucalyptus Cloud Architecture
- Eucalyptus is an open source Linux based software architecture which provides an EC2-compatible cloud computing platform and S3-compatible cloud storage platform.

- It implements scalable, efficient-enhancing and private and hybrid clouds within and organization's IT infrastructure.

- It gives an Infrastructure as a Service (IaaS) solution.
- Users can use commodity hardware.

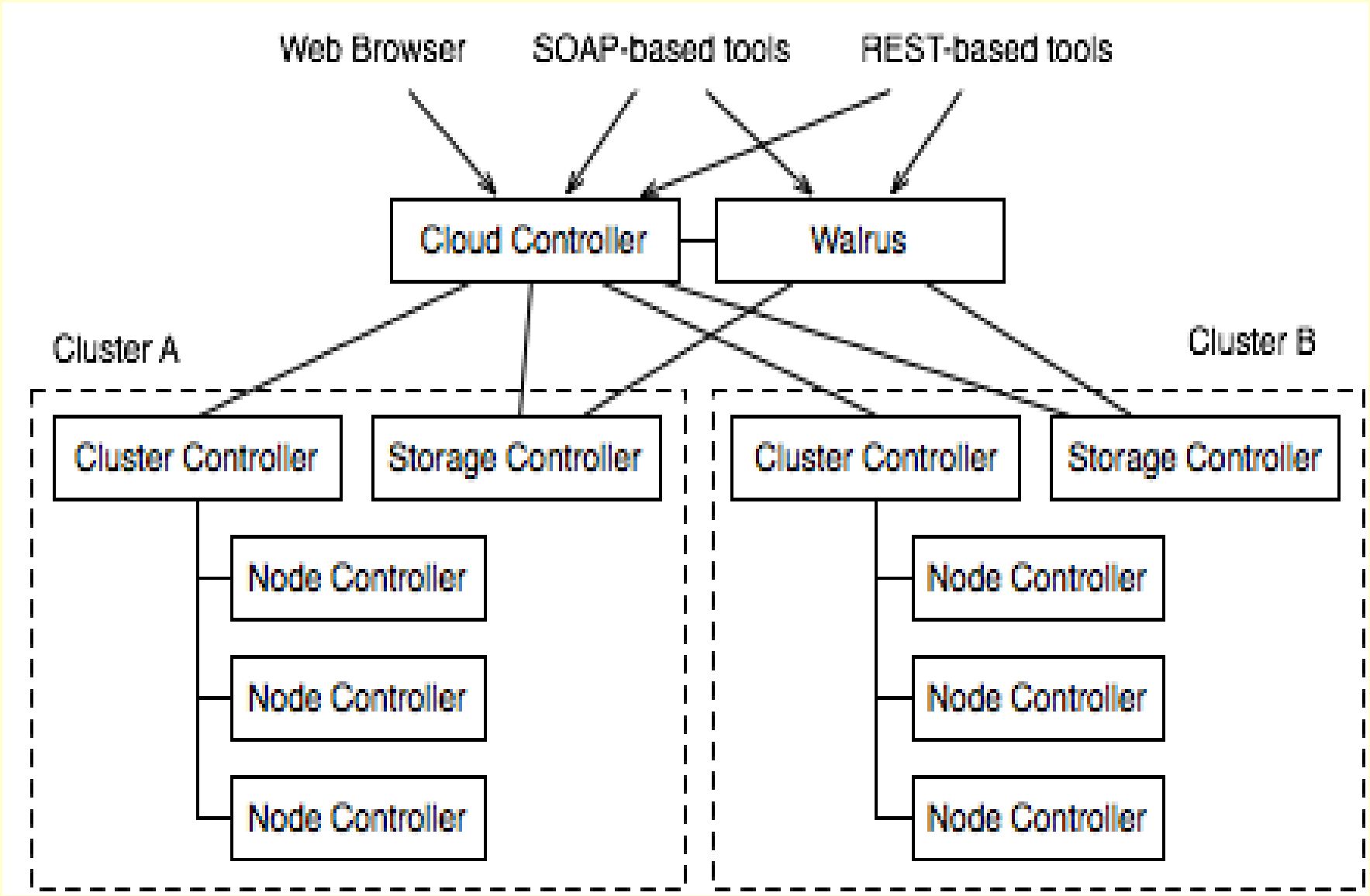
- Eucalyptus was developed to support the high performance computing (HPC).

- Eucalyptus can be deployed without modification on all major Linux OS distributions, including Ubuntu, RHEL/CentOS, openSUSE, and Debian.

- Eucalyptus features include:
  - Supports both Linux and Windows virtual machines (VMs).
  - Application program interface- (API)compatible with Amazon EC2
  - Compatible with Amazon Web Services (AWS) and Simple Storage Service (S3).
  - Works with multiple hypervisors including VMware, Xen and KVM.
  - Can be installed and deployed from source code or DEB and RPM
  - Internal processes communications are secured through SOAPand WS-Security.
  - Multiple clusters can be virtualized as a single cloud.
  - Administrative features such as user and group management and reports.

- For implementing, managing and maintaining the virtual machines, network and storage Eucalyptus has variety of features.
  - SSH Key Management
  - Image Management
  - Linux-based VM Management
  - IP Address Management
  - Security Group Management
  - Volume and Snapshot Management
- Important Features of Eucalyptus
  - Network Isolation
  - Elastic IPs
  - Security Groups
  - Metadata Service

Eucalyptus Fundamental Architecture



- **Components of Eucalyptus:**

1. Cluster Controller (CC) Cluster Controller manages the one or more Node controller and responsible for deploying and managing instances on them.

- It communicates with Node Controller and Cloud Controller simultaneously.
- CC also manages the networking for the running instances under certain types of networking modes available in Eucalyptus.

2. Cloud Controller (CLC) Cloud Controller is front end for the entire ecosystem.

- CLC provides an Amazon EC2/S3 compliant web services interface to the client tools on one side and interacts with the rest of the components of the Eucalyptus infrastructure on the other side.

3. Node Controller (NC) It is the basic component for Nodes.

- Node controller maintains the life cycle of the instances running on each nodes.
- Node Controller interacts with the OS, hypervisor and the Cluster Controller simultaneously.

4. Walrus Storage Controller (WS3) Walrus Storage Controller is a simple file storage system.

- WS3 stores the machine images and snapshots.
- It also stores and serves files using S3 APIs.

5. Storage Controller (SC) Allows the creation of snapshots of volumes.

- It provides persistent block storage over AoE or iSCSI to the instances.

•**Cloud Controller (CLC)**: This is the controller that manages virtual resources like servers, network and storage.

- •It is at the highest level in hierarchy.
- •It is a Java program with web interface for outside world.
- •It can do resource scheduling as well as system accounting.
- •There is only one CLC per cloud.
- •It can handle authentication, accounting, reporting and quota management in cloud.

•**Walrus**: This is another Java program in Eucalyptus that is equivalent to AWS S3 storage.

- •It provides persistent storage.
- •It also contains images, volumes and snapshots similar to AWS.
- •There is only one Walrus in a cloud.

•**Cluster Controller (CC)**: It is a C program that is the front end for a Eucalyptus cloud cluster.

- •It can communicate with Storage controller and Node controller.
- •It manages the instance execution in cloud.

- **Storage Controller (SC)**: It is a Java program equivalent to EBS in AWS.
  - It can interface with Cluster Controller and Node Controller to manage persistent data via Walrus.

- **Node Controller (NC)**: It is a C program that can host a virtual machine instance.
  - It is at the lowest level in Eucalyptus cloud.
  - It downloads images from Walrus and creates an instance for computing requirements in cloud.

- **VMWare Broker**: It is an optional component in Eucalyptus.
  - It provides AWS compatible interface to VMWare environment.

- The following terminology is used by Eucalyptus.

Images: Any software module, configuration, application software or system software bundled and deployed in the Eucalyptus cloud is called a Eucalyptus machine image (EMI).

Instances: When we run the image and use it, it becomes an instance. The controller will decide how much memory to allocate and provide all other resources.

Networking: The Eucalyptus network is divided into three modes:

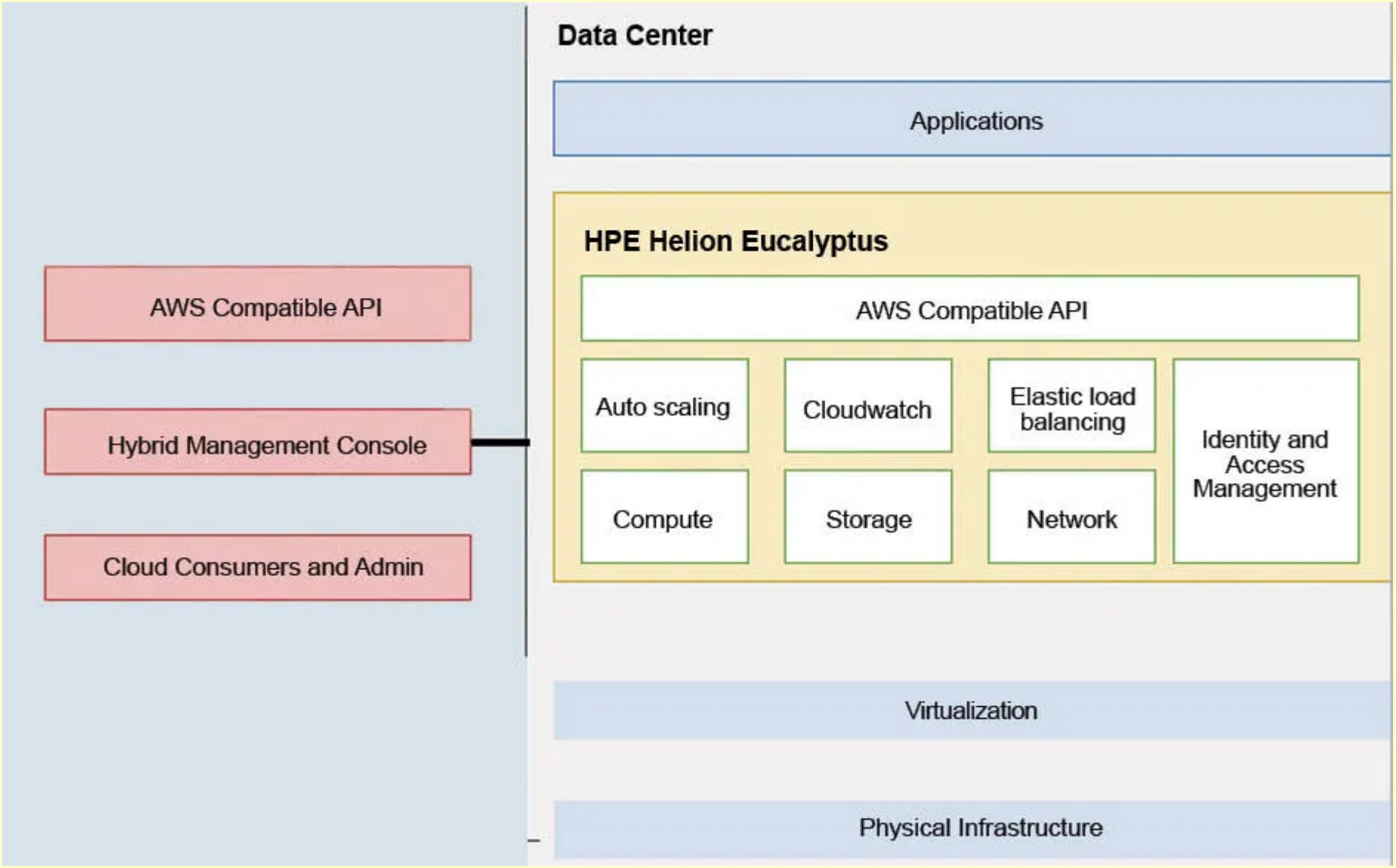
- *Managed mode:* In this mode, it just manages a local network of instances, which includes security groups and IP addresses.
- *System mode:* In this mode, it assigns a MAC address and attaches the instance's network interface to the physical network through the NC's bridge.
- *Static mode:* In this mode, it assigns IP addresses to instances.

Static and system mode do not assign elastic IPs, security groups, or VM isolation.

- ***Access control*** is used to provide restriction to users. Each user will get a unique identity. All identities can be grouped and managed by access control.

- ***Eucalyptus elastic block storage (EBS)*** provides block-level storage volumes, which we can attach to an instance.

- ***Auto scaling and load balancing*** is used to automatically create or destroy instances or services based on requirements. CloudWatch provides different metrics for measurement.


Data Center
Applications
HPE Helion Eucalyptus
AWS Compatible API
Auto scaling
Cloudwatch
Elastic load balancing
Identity and Access Management
Compute
Storage
Network
AWS Compatible API
Hybrid Management Console
Cloud Consumers and Admin
Virtualization
Physical Infrastructure

The advantages of the Eucalyptus cloud

- Eucalyptus can be used to get the advantages of both the public and private clouds.

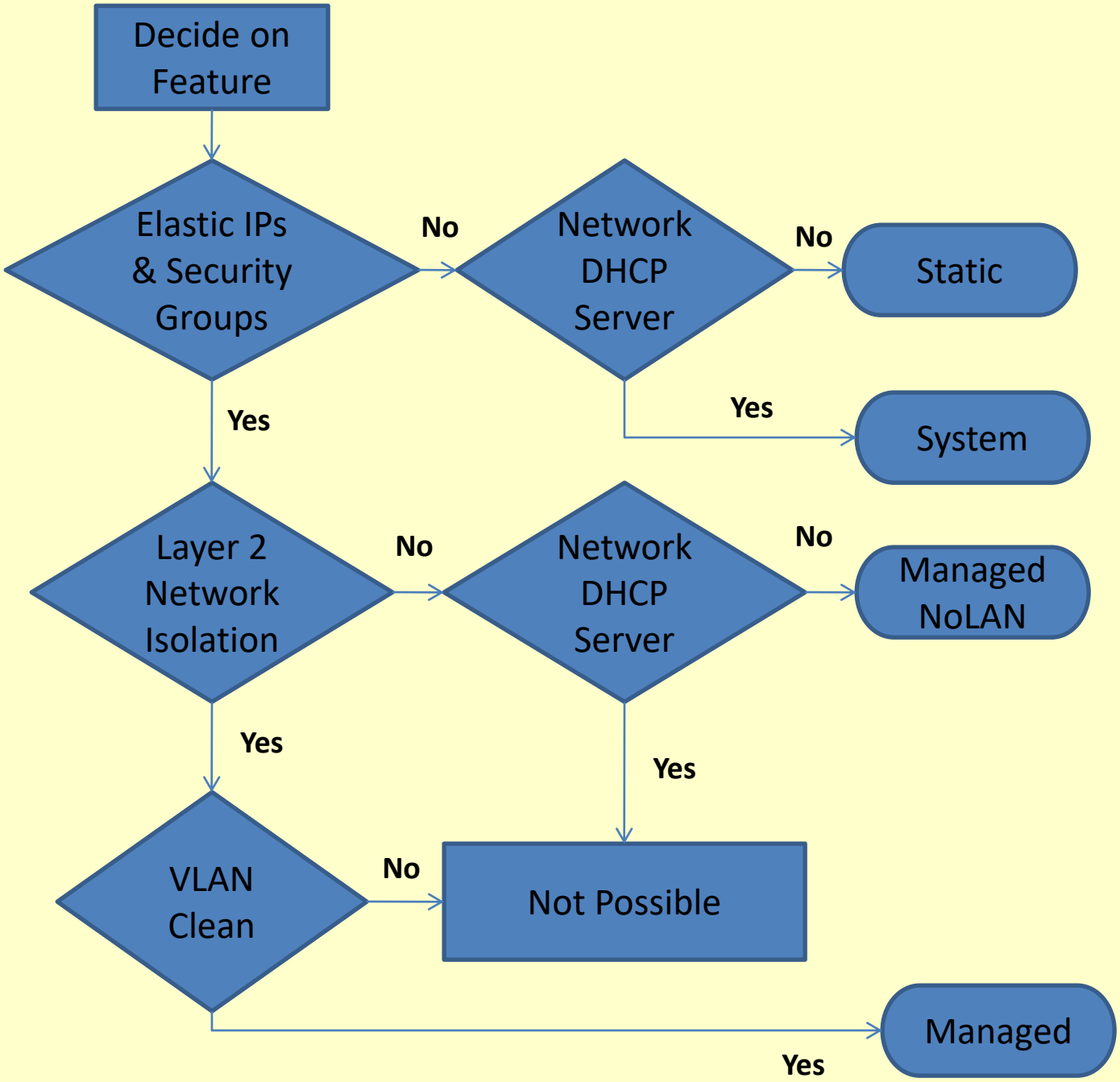
- Users can run Amazon or Eucalyptus machine images as instances on both the clouds.

- It has 100 per cent API compatibility with all the AWS services. There are many tools developed to interact seamlessly between AWS and Eucalyptus.

- Eucalyptus can be used with DevOps tools such as Puppet and Chef. Popular SDKs like AWS SDKs for Java and Ruby and Fog work smoothly with Eucalyptus.

- It is not very popular in the market but is a strong competitor to OpenStack and CloudStack.

- **Modes of operation** Eucalyptus supports four modes of operation in its networking configuration:
- static mode,
- managed mode,
- managed (noVLAN) mode
- & system mode.


Decide on Feature
Elastic IPs & Security Groups
No
Network DHCP Server
No
Static
Yes
Yes
System
Layer 2 Network Isolation
No
Network DHCP Server
No
Managed NoLAN
Yes
Yes
VLAN Clean
No
Not Possible
Yes
Managed

- System
  - In System mode, CC generates and assigns a random MAC address to the VM instance while requesting NC to bring up the instance.
  - NC attaches the VM instance's virtual NIC to the physical NIC on the node through a bridge.
  - This mode requires that the Nodes are connected to the enterprise network directly.
  - Instances obtain an IP address using DHCP, just as physical machines on the network do.
  - This mode is very easy to setup as it does not have any additional prerequisites in terms of networking,
    - except for a running DHCP server on enterprise network,
  - and is a good way to get started with Eucalyptus, particularly if you want to set it up on your laptop/desktop to get a basic understanding.
  - This mode of networking is similar to "Bridged Networking" that hypervisors like VMware, VirtualBox etc. offer or like "tap" networking offered by KVM/Qemu.

- Static
  - Static mode offers the Eucalyptus administrator more control over VM IP address assignment than System mode does.
  - In this mode, the administrator configures Eucalyptus with a ‘map’ of MAC address/IP Address pairs on CC.
  - Before requesting NC to raise an instance, CC sets up a static entry within a Eucalyptus controlled DHCP server, takes the next free MAC/IP pair, and passes on to NC,
    - which attaches the virtual NIC of the instance to the physical NIC of the Node through a bridge similar to how it is handled in ‘System’ mode.
  - This mode of networking is similar to “Bridged Networking” that hypervisors like VMware, VirtualBox etc. offer or like “tap” networking offered by KVM/Qemu.

– This mode is useful for administrators who have a pool of MAC/IP addresses that they wish to always assign to their instances without relying on the DHCP server running in the enterprise network.

Note – Running Eucalyptus in System or Static mode disables some of the following key functionalities that would make an enterprise deployment more manageable:

- Ingress filtering for the instances (Security Groups)
- User Controlled dynamic assignment of IPs to instances (Elastic IPs)
- Isolation of network traffic between instances VMs

- Managed
  - Managed mode is the most feature rich mode offered by Eucalyptus.
  - In this mode, the Eucalyptus administrator defines a large network (usually private and unroutable) from which VM instances will draw their IP addresses.
  - As with Static mode, CC will maintain a DHCP server with static mappings for each instance that is raised and allocate the right IPs at the time of requesting an NC to raise the instance.

- Managed mode implements ‘security groups’ for ingress filtering and isolation of instances.

- The user specifies a security group to which the new instance should be associated with, at the time of requesting a new instance.

- CC allocates a subset of the entire range of IPs to each security group in such a way that all the instances raised to be a part of the same security group use IPs from the same subset.

- The user can define ingress filtering rules at the ‘security group’ level.

- In addition, the administrator can specify a pool of public IP addresses that users may allocate, either while raising the instances or later at run-time.

- This functionality is similar to ‘elastic IPs’ of AWS.

- Eucalyptus administrators who need to implement require security groups, elastic IPs, and VM network isolation must use this mode.

- Managed NoVLAN
  - This mode is identical to MANAGED mode in terms of features (dynamic IPs and security groups), but does not provide VM network isolation.
  - Eucalyptus administrators who want dynamic assignable IPs and the security groups, but are not in a position to run on a network that allows VLAN tagged packets or those who do not have a need for VM network isolation can use this mode.

Open Stack Cloud Architecture

- OpenStack is a cloud operating system that controls large pools of compute, storage, and networking resources throughout a datacenter,
- all managed and provisioned through APIs with common authentication mechanisms.

- A dashboard is also available, giving administrators control while empowering their users to provision resources through a web interface.
- Beyond standard infrastructure-as-a-service functionality, additional components provide,
  - orchestration,
  - fault management
  - and service management amongst other services to ensure high availability of user applications.

- OpenStack is one among several open-source cloud building software through which various organizations offer their cloud s service to clients.

- OpenStack cloud leverage the pre-existing infrastructure of the organization.

- The cloud can run on the commodity hardware that are available at economical costs.

- It also provides a facility of scaling the cloud resources so that whenever organizations need to add more computing and storage resources it could be done easily without interrupting the operations or hampering the performance.

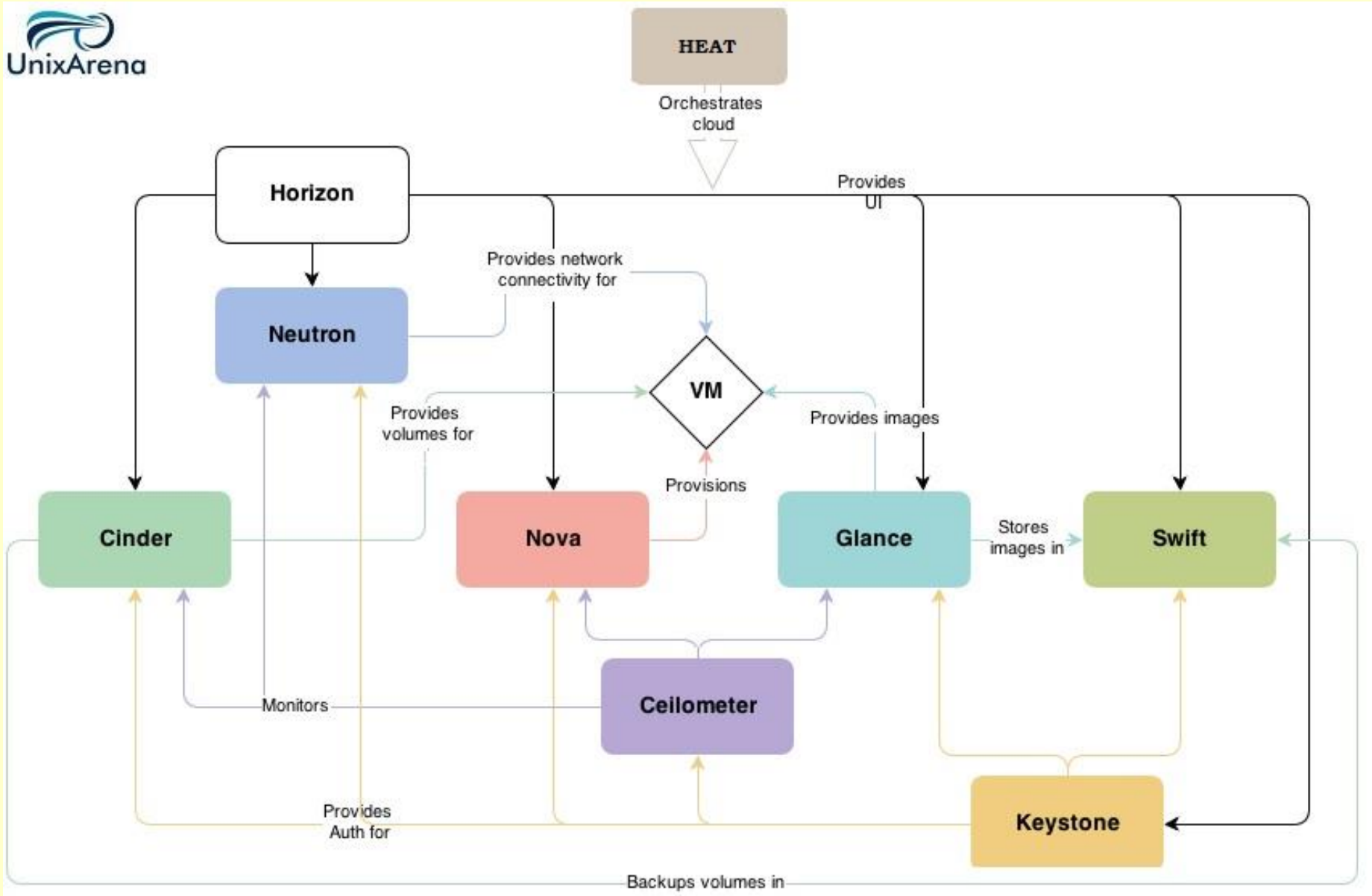
- OpenStack is a free and open source software platform for cloud computing.

- It is mostly deployed as infrastructure as a Service(IAaaS) where virtual servers and other resources are made available to customers.

- OpenStack has a modular architecture where we have different modules or open source projects which are from different vendors but all this projects are connected to give us this infrastructure.

- OpenStack Cloud follows two distinct architecture
  - Conceptual Architecture
  - Logical Architecture

Conceptual Architecture



Here is the list of openstack Services , project name and description.

Service	Project name	Description	Requirement
Dashboard	Horizon	Web-Based Dashboard	Mandatory
Compute	Nova	Create virtual Machine & manage VM	Mandatory
Networking	Neutron	Software defined networking (Advanced Networking)	Optional
Object Storage	Swift	Store files & Directories	Optional
Block Storage	Cinder	Volume & Snapshot Management	Mandatory
Identity service	Keystone	Creating Projects/User/Roles/Token Management/Authentication	Mandatory
Image Service	Glance	To Manage OS Images	Optional
Telemetry	Ceilometer	Monitoring & Billing purpose	Optional
Orchestration	Heat	HOT(Heat Orchestration Template) based on YAML	Optional
Database Service	Trove	Database as a Service	Optional
Hadoop as Service	sahara	Hadoop as Service	Optional
Messaging	RabbitMQ	Messaging	Mandatory

- In the conceptual architecture we can see there are 9 different components or projects and how they conceptually interact with each other is shown here.

- Let us first understand what these components provide us.

- **Code Name Services provided**
  - **Nova** -Compute
  - **Cinder** -Block Storage
  - **Swift**- Object Storage
  - **Glance**- Image
  - **Neutron**-Networking
  - **Keystone**- Identity management
  - **Horizon**- Dashboard
  - **Ceilometer**- Metering and Monitoring(Telemetry)
  - **Heat**- Orchestration

Nova(Compute)

- It provides compute services i.e It provides virtual servers upon demand.
- It automates and manages pools of compute resources.

Cinder(Block Storage)

- It provides Block Storage as a service for OpenStack.

- It is designed to present storage resources to end users and these storage resources will then be used by Nova.

- The short description of Cinder is that it virtualizes the management of block storage devices and provides end users with a self service API to request to consume those resources.

Swift(Object Storage)

•It provides Object Storage i.e. the data is stored in the form of objects.

•Unlike traditional file systems here if you want to modify some object, you will have to pull that entirely out, make modifications and then push it back in.

•You may feel that this is tedious but for data which doesn't require much modification we can use this type of storage. For example, we can store images or videos which don't require much modification and just by passing the objects you can load images.

•Swift also provides replication and scalability which isn't provided by Cinder.

•Replication as in data is stored at different places so it can be recovered easily during system crash and scalability as in you can scale up(increase) or scale down(decrease) your storage as per your need.

Glance(Image Service)

- It provides Image Services for OpenStack.
- The ISO images for virtual machines and metadata are stored here and they can be discovered, registered and retrieved by the users i.e you can find them and use ISO image for installing that O.S. on your virtual machine.
- If you want to take backups of data stored on your server you can create, you can create server images i.e. copy all the data server contains and store it at multiple locations.

Neutron(Networking)

- Neutron provides networking services.
- It is a system to manage networks and IP addresses. It provides scalability and Neutron's services can be used through an API.
- Users can use this API to create networks for their different user groups or different applications.

Keystone(Identity Service)

- Keystone is a central component for authentication and authorization.
- Before using any of the other projects or services of OpenStack, Keystone authenticates you and authorizes you to check whether you are allowed to use that service.
- Authentication is done using username & password credentials, token based systems,etc
- It also provides a catalog which shows a list of all the services deployed on the cloud.

•Horizon(Dashboard)

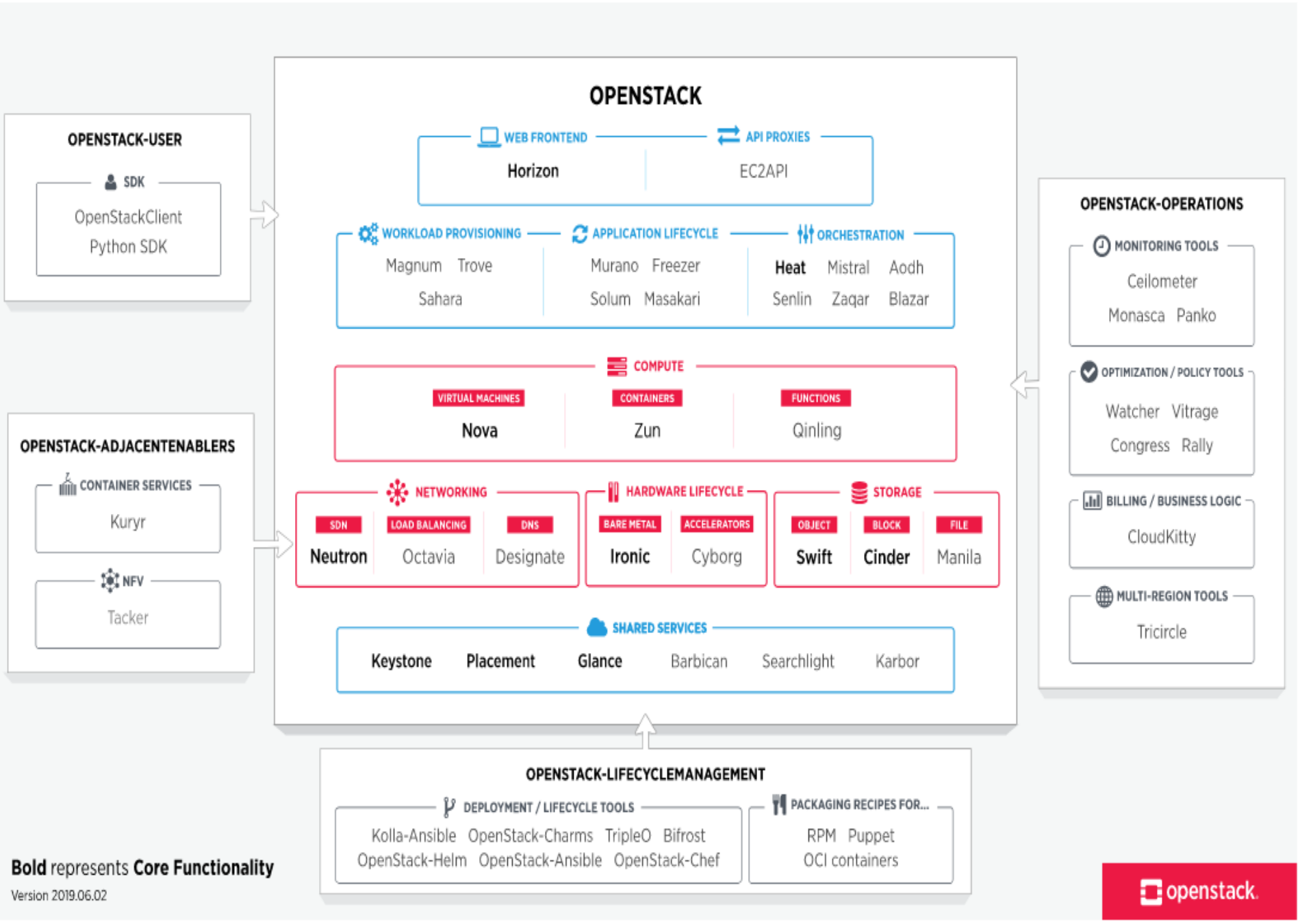
- It provides a dashboard using which the user can access other services easily.
- With this dashboard you can perform most of the operations like launching a VM, assigning IP addresses and setting access controls.

Ceilometer

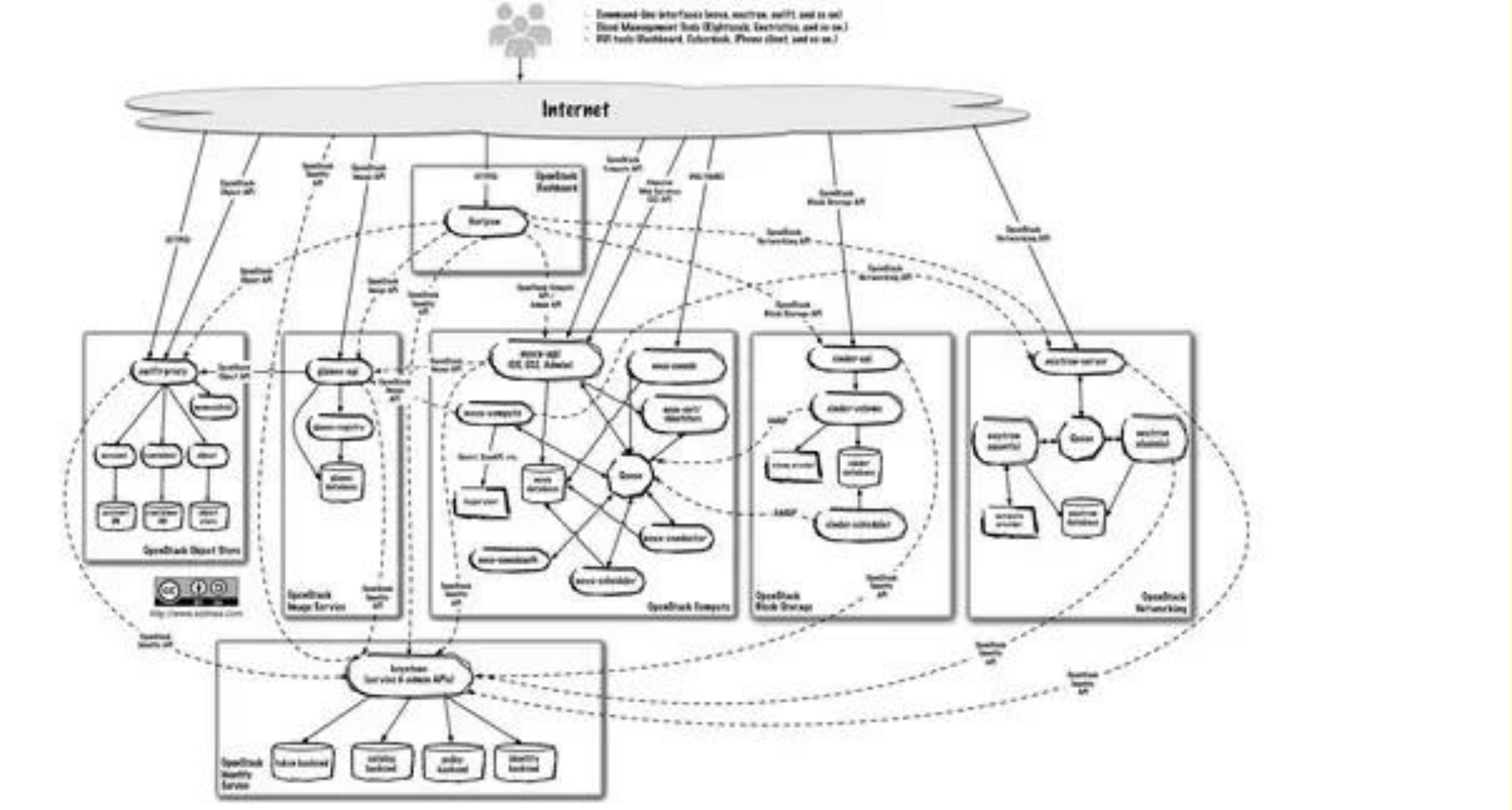
- Often known as Telemetry provides metering and monitoring services.
- It provides us data about how much physical and virtual resources are being used on the cloud.
- Based on this data cloud providers can charge their users and also we can generate certain triggers(steps to be taken when data shows certain danger or critical condition)

Heat

- It provides orchestration Service.
- You need to create a template of your infrastructure and load it in heat and based on that template Heat will generate your infrastructure.
- If you want to update your cloud by increasing some services or decreasing them, you can make changes in the template and load it in Heat and your new infrastructure will be generated.
- Heat also provides auto scaling features i.e. for example based on the data showed by Ceilometer if we come to know that CPU utilization is more than 70% for more than 5 minutes, we can define a trigger that will add more front end servers automatically.


OPENSTACK
OPENSTACK-USER
SDK
OpenStackClient
Python SDK
WEB FRONTEND
Horizon
API PROXIES
EC2API
WORKLOAD PROVISIONING
Magnum Trove
Sahara
APPLICATION LIFECYCLE
Murano Freezer
Solum Masakari
ORCHESTRATION
Heat Mistral Aodh
Senlin Zaqar Blazar
COMPUTE
VIRTUAL MACHINES
Nova
CONTAINERS
Zun
FUNCTIONS
Qinling
OPENSTACK-ADJACENTENABLERS
CONTAINER SERVICES
Kuryr
NFV
Tacker
NETWORKING
SDN
Neutron
LOAD BALANCING
Octavia
DNS
Designate
HARDWARE LIFECYCLE
BARE METAL
Ironic
ACCELERATORS
Cyborg
STORAGE
OBJECT
Swift
BLOCK
Cinder
FILE
Manila
SHARED SERVICES
Keystone
Placement
Glance
Barbican
Searchlight
Karbor
OPENSTACK-OPERATIONS
MONITORING TOOLS
Ceilometer
Monasca Panko
OPTIMIZATION / POLICY TOOLS
Watcher Vitrage
Congress Rally
BILLING / BUSINESS LOGIC
CloudKitty
MULTI-REGION TOOLS
Tricircle
OPENSTACK-LIFECYCLEMANAGEMENT
DEPLOYMENT / LIFECYCLE TOOLS
Kolla-Ansible OpenStack-Charms TripleO Bifrost
OpenStack-Helm OpenStack-Ansible OpenStack-Chef
PACKAGING RECIPES FOR...
RPM Puppet
OCI containers
Bold represents Core Functionality
Version 2019.06.02
openstack.

Logical Architecture



- First of all we have internet using which user can access the horizon or the dashboard.

- Horzon provides GUI for all other services.

- For communication between various projects or between user and projects, each project will provide one or more Http/RESTful Interfaces.

- REST stands for representational state transfer and it is a way of providing interoperability between computer systems on the internet.

•REST is used over SOAP because REST uses less bandwidth and hence it is suitable for internet usage.

•For communication between different components of the same project a message queue is used.

•At the bottom of the Logical Architecture we have keystone or Authentication and Authorization centre which authenticates i.e. checks if the user is a valid user or not and authorizes i.e. checks if the user is allowed to access that specific service or not.

Features of OpenStack

OpenStack software provides the flexibility of integrating various technologies with it that helps in building the cloud environment according to choice and needs.

1. Live Upgrades

   Openstack previously did not have any support for live upgrades.

   Any upgrades would require to shut the entire cloud down.

   Now we can upgrade cloud by first upgrading the controller infrastructure and then upgrading the compute nodes one by one in the sequence.

   This will keep cloud system running and will require only individual components to be shut.

2. Federated Identity

OpenStack provides a federated identity system called Shibboleth which can be used for logging into multiple OpenStack nodes through a single user ID.

OpenStack included this feature on special request by the Europian

Organization for Nuclear Research(CERN)

3. Trove

The original term used for this feature is “Project Red Dwarf”.

We can use this feature to manage database resources.

User can manage MySQL system for manipulating users and schemas defined in MySQL.

The manipulation is done through Trove APIs.

4. Object storage replication

- A new mechanism for replication of the object storage has been included with OpenStack's object storage system, Swift.

- This mechanism is known as ssync and is used for intercepting request that are forwarded to Swift or are coming out of swift.

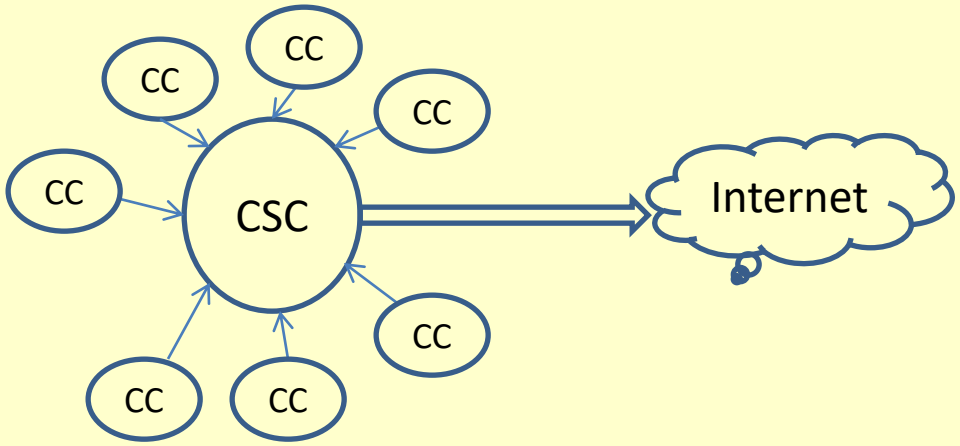
- This mechanism syncs the requests more intelligently than the earlier mechanism rsync.

Modes of Operation OpenStack

- Single host mode
  - Central Server
  - Passage of traffic
- Multi host mode
  - No central server
  - Compute nodes as gateways
  - Public IP addresses

- Disadvantages
  - Single host mode: One point failure
  - Multi host mode: unavailability of public IP’s

- Single Host Mode
  - Network service based on a CLC(Cluster Controller)
  - CLS receives traffic from all compute nodes
  - Then CLC forwards traffic to Internet (act as internet gateway)
  - Floating IP's and security groups being hosted



- Limitations
  - Single point failure: Unavailability of CLC will stop the instances communicating on the network

- Multi Host Mode
  - A copy of the network is run on each of the compute nodes and these nodes are used as Internet Gateway
  - Consumed by the instances that are running on each individual nodes
  - Floating IP's and security groups are also hosted on those compute nodes for each instances.

- Limitations
  - Requires nodes to have public IP address for communicating on the internet. If not available the unable to operation on this mode

- Cloud Administration and Management
  - Cloud management is how admins have control over everything that operates in a cloud.
  - The users, data, applications, and services.
  - Cloud management tools help admins oversee all types of cloud activities,
  - such as resource deployment, use tracking, data integration, and even disaster recovery.
  - Cloud management tools provide administrative control over the infrastructure, platforms, applications, and data that together create a cloud.

- To administrate and manage cloud you need to create a Web-Based console for users to interact with the systems providing cloud services.

- The Openstack cloud environment provides dashboards as the interaction console

- whereas Eucalyptus provides both the command line interface(CLI) and the web based console for interaction purposes.

- The administrators can create accounts and interfaces for both users and administrators.

- User can access a system efficiently if they are provided with interfaces

- Cloud management software is typically deployed into existing cloud environments as a virtual machine (VM) that contains a database and a server.

- The server communicates with application programming interfaces (APIs) to connect the database and the virtual resources holding up the cloud.

- The database collects information on how the virtual infrastructure is performing and sends analyses to a web interface where cloud admins can visualize cloud performance.

- Admins can also relay commands back to the cloud, which are carried out by the virtual server.

- Bundling or Uploading Virtual machine images on the Cloud Controller
  - Images can be uploaded through Euca2ool commands in two ways.
  - One way is to upload a bootable image, which is in fully working mode and the other way is to upload the kernel and initrd as well as the root partition separately.
  - **initrd** (initial ramdisk) is a scheme for loading a temporary root file system into memory, which may be used as part of the **Linux** startup process

- Uploading bootable images is simpler than uploading the components separately.

- However I involves numerous restrictions that are not involved in separately uploading components.

- E.g. the image does not allow growing of its disk space when a bootable image is uploaded, even if larger flavors are used.

- GUI Access to VM instances over SSH(Secure Shell)
  - Virtual Network Computing (VNC) is a graphical way to access the desktop environments of a machine from a remote system.
  - This kind of access is allowed by the VNC server.
  - The remote machine is allowed to launch the keyboard and mouse events on the machine being accessed.
  - The VNC connection mode over an SSH tunnel ensures security and encryption for the current session over the public network

- **Cloud Deployment Techniques.**
- Some of the questions that can help an organization decide whether to avail the services of cloud or not
  - What cloud based service do you plan to offer to your customers?
  - What are you service level agreements(SLA) with your clients?
  - Which compliance or regulatory requirements do you need to satisfy?
  - What services can be hosted on an external IT infrastructure versus having to host them internally?
  - How much control do you need on the cloud infrastructure?

- Steps to assess whether moving to the cloud is worthwhile for you.
  - Identify the end Goals
  - Calculate the upfront and operational expenses
  - Assess the risk
  - Pay close attention
  - Include and emergency plan

- Potential Network Problems and their Mitigation
  - Network Node Latency
  - Transport protocol Latency
  - Number of nodes traversed
  - TCP congestion

- Cloud Network Topologies
- Automation for Cloud Deployments
- Self service features in a Cloud Deployment
- Federated Cloud deployments
- Cloud Performance
- Cloud Performance Monitoring and Tuning
- Impact of memory on Cloud Performance
- Improving Cloud Database Performance

- Cloud Performance
  - Refers to the performance of cloud applications and severs as well as access speeds of network and storage I/O.
  - It is measured preliminary by the round trip response time
  - which is the time interval between a user issued command and receipt of the result from the cloud.
  - It can be quantified in terms of the maximum response time experienced by the end user.
  - This must be key metric for the performance of applications and an important SLA(Service level agreement) criterion

- Another performance impact is from numbers of hops.

- Within the cloud data center, resources need to communicate and the number of network hops between the resources and applications add significantly to response delays.

- A robust performance monitoring system provides benefits such as
  - tracking workload patterns,
  - identifying peak resource utilization,
  - and isolating potential problems and their causes.

- Cloud Performance Monitoring and Tuning
  - There are various issues related to monitoring and tuning cloud performance.
  - The performance of virtual machines is difficult to track since the resources are dynamic and based on the workload.
  - All cloud aspects are not in the control of particular organization.
  - The division of control depends on the cloud service offered.

- For PaaS e.g. the provider controls the hardware, network, security, servers, operating system, patches, development environment, database configuration and compilers.

- The consumer controls the applications, use of resources, database instances, application-level security and authentication for users.

- There are also problems with selecting the right performance management tool.

- Any selected tool needs to be customized and configured, to a large extent, to suit the cloud environment.

- Impact of memory on Cloud Performance
  - In cloud computing memory performance and utilization is fundamental for overall performance.
  - Large database transactions require massive amounts of memory to meet the various expected performance levels.
  - Moreover multi-tenancy and simultaneous user task put a lot of demand on memory.
  - The coordination between different cloud services to meet a particular demand requires in memory task.
  - Job need to be split and assembled after processing which increases overhead cost.

- Another problem in cloud relates to memory leaks.

- It is situation where a user job, database, or application does not return back the temporarily-allocated memory to the operating system
- even after it has been cleaned up and is no longer in use.

- This can be due to a bug, malware, or a deliberate user job that wants to consume all memory.

- Improving Cloud Database Performance
  - Cloud database offers noteworthy benefits over traditionally hosted internal databases.
  - Moreover cloud vendors continue to add and improve their database offering to make it a convincing option for enterprises.
  - Cloud database have higher ease of accessibility, better replication to remote datacenters alongside automation and better elasticity.
  - Sharding a cloud database is another technique to improve performance.

- It is a process of splitting a large database into a number of smaller database, each being hosted on a separate server.

- It helps to boost the performance of applications that require frequent and large database transactions.

- Sharding also helps reduce the size of the database index, thus decreasing the time needed for searches within the database.

- To further improve performance and availability, providers offer a horizontally scaled servers environment,
- where it is quick and easy to bring up more virtual machines to meet higher workloads.

- Besides performance providers focus upon improving database integrity by using database profilers.

- Sharding analyze the source database for inconsistencies in index, table relationships, or data structure.

- By examining the data quality and utilization pattern, it is able to point out the potential problems, if any, within a database

- This improves the performance of the database.

- Cloud Services Brokerage(CSB)
  - CSB is an organization that plays a role as Facilitator or inter-mediator for delivering Cloud Services
  - The CSB is usually a telecommunication or data center hosting service provider with large number of customers
  - In cloud provider-consumer relationship CSB's are optional entity mediating between the two
  - Helps providers by relieving them of acquiring customers billing and enabling integrated access to multiple cloud services
  - Helps consumers to get integrated access to one or more cloud and value added services such as backups SaaS and Idm

Direct SaaS Model and the role of CSB as an Intermediary

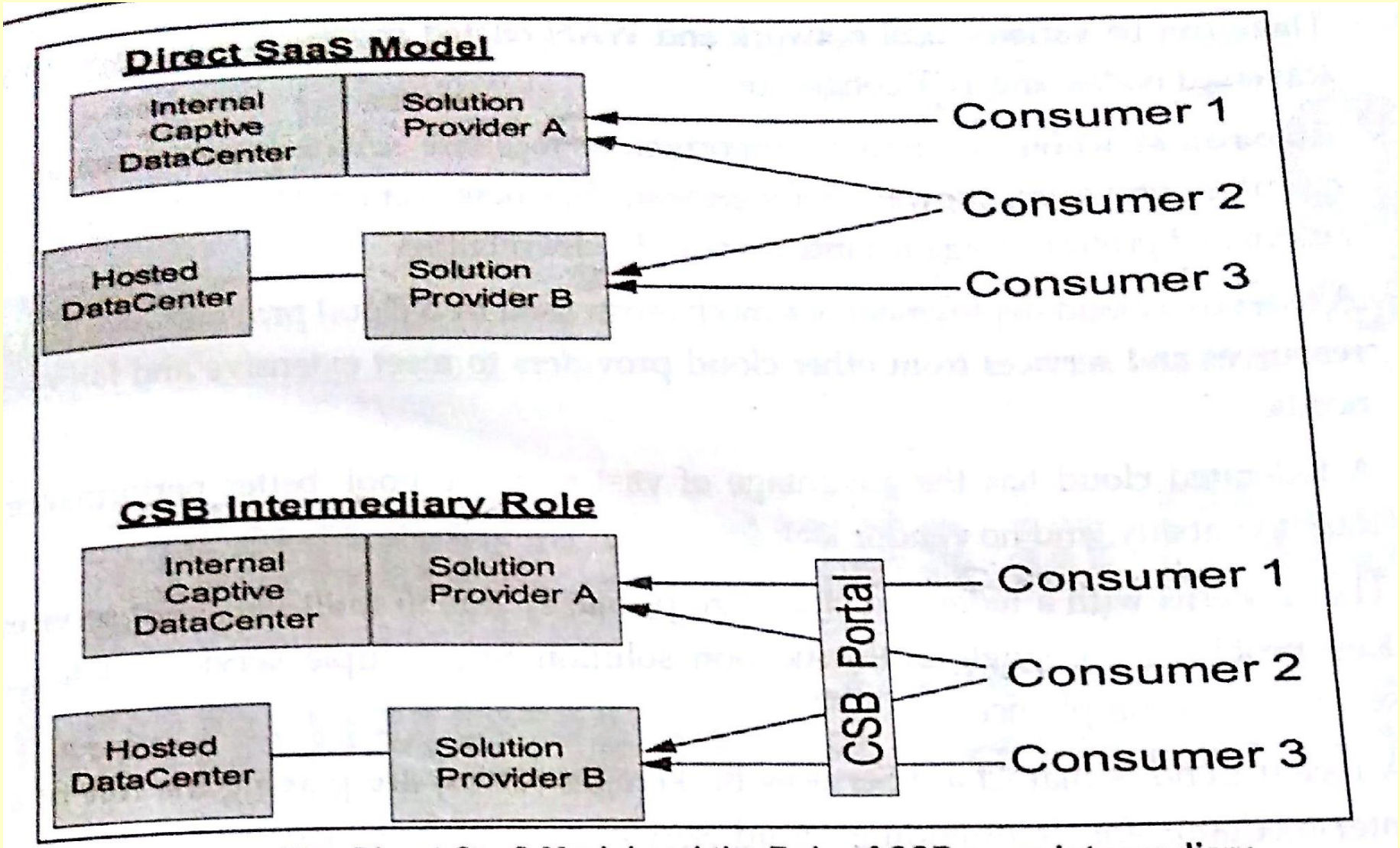


Figure 2: The Direct SaaS Model and the Role of CSB as an Intermediary

- Above fig shows consumer directly accessing public cloud services
- and a model where a CSB offers a portal to access multiple clouds.

- These clouds can be resident of a CSB datacenter, the cloud providers premises, or at a hosting providers site.

CSB Services as an Aggregator for Public Cloud Services

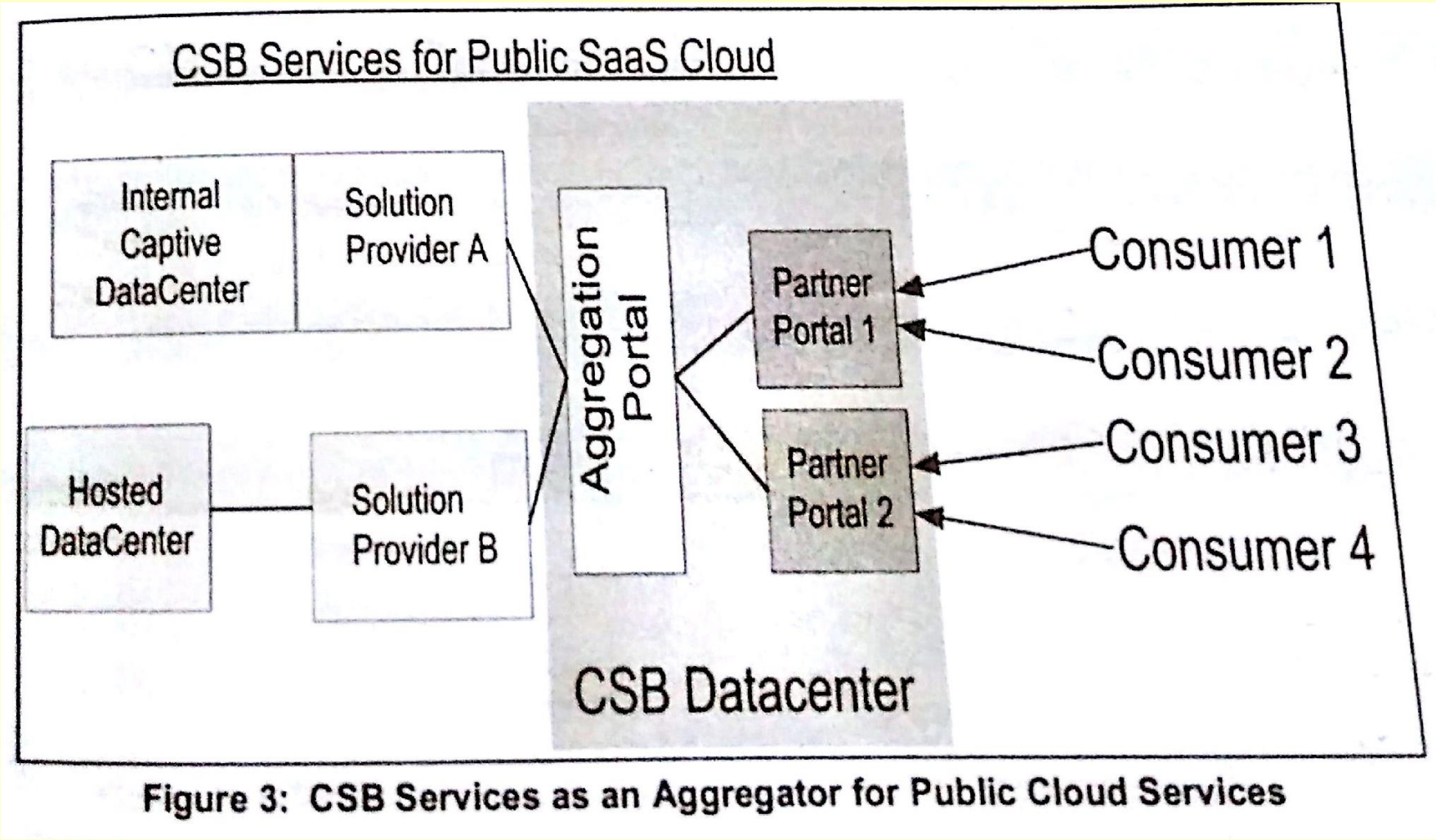


Figure 3: CSB Services as an Aggregator for Public Cloud Services

Above fig shows how a CSB can use partner portals to unify or aggregate the access to various clouds.

- https://www.youtube.com/watch?v=jr4e3V2O5p0 (Modes of Operation OpenStack)
- https://www.youtube.com/watch?v=65BDQ4EqlF4 (Cloud Service brokerage)
- https://www.youtube.com/watch?v=W34jhsOjt34 (Cloud Storage Gateway)
- https://www.youtube.com/watch?v=sEyr79nKPhk&list=PLPN-43XehstNd5WsXQ9y3GFXyagkX1PC3 (Cloud Computing Tutorials by ranji raj)