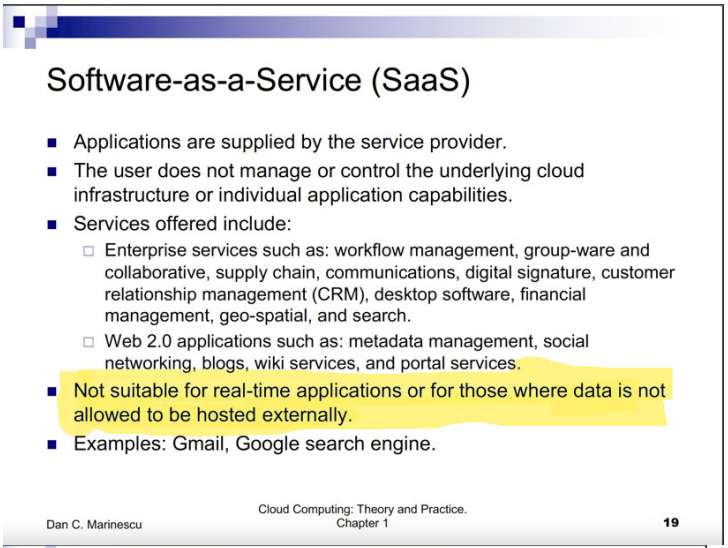
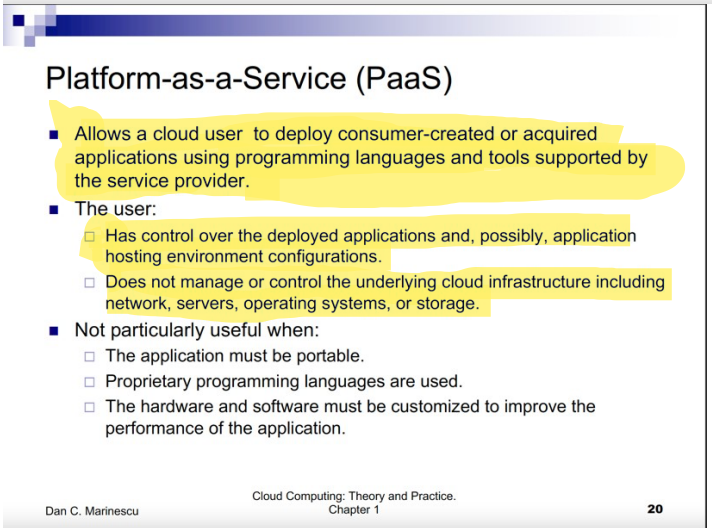
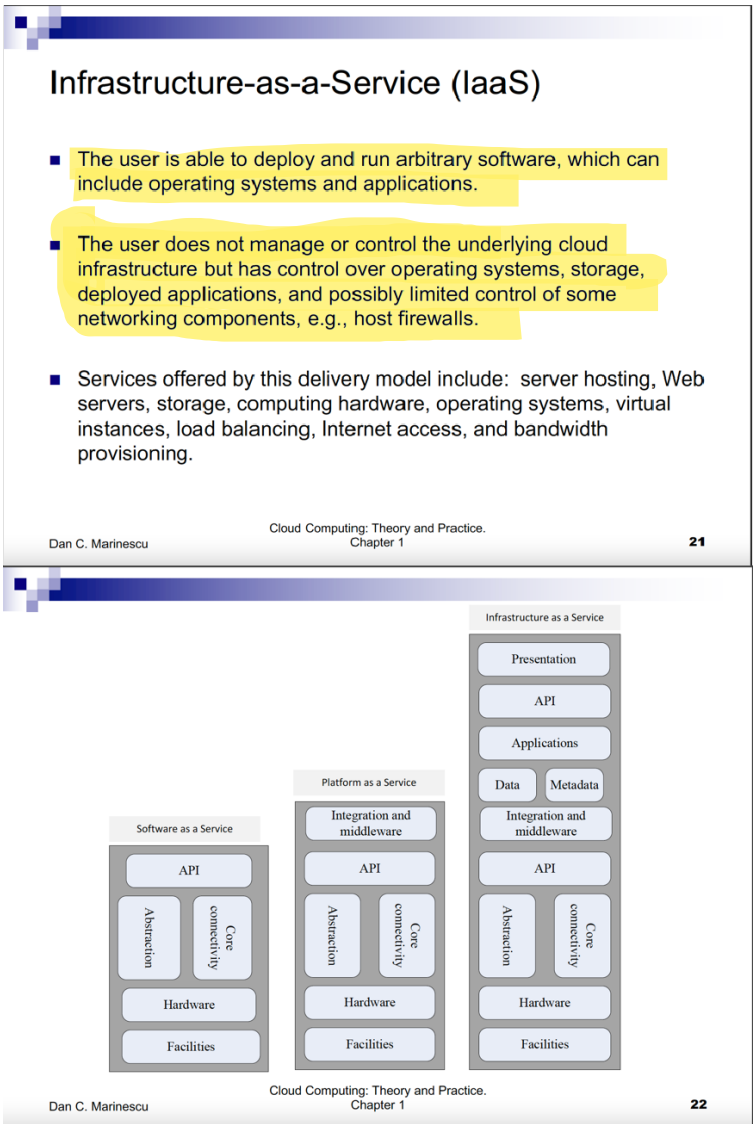
CCA Module 1 QB Solutions

1. Define Cloud Computing elaborating its key characteristics.
   Cloud computing is the delivery of computing services—including servers, storage, databases, networking, software, analytics, and intelligence—over the Internet ("the cloud") to offer faster innovation, flexible resources, and economies of scale.
   Key Characteristics:
   - Uses Internet technologies to offer scalable and elastic services. The term "elastic computing" refers to the ability of dynamically acquiring computing resources and supporting a variable workload.
   - The resources used for these services can be metered and the users can be charged only for the resources they used.
   - The maintenance and security are ensured by service providers.
   - The service providers can operate more efficiently due to specialization and centralization.
   - Lower costs for the cloud service provider are past to the cloud users.
   - Data is stored:
     - closer to the site where it is used.
     - in a device and in a location-independent manner.
   - The data storage strategy can increase reliability, as well as security, and can lower communication costs.
2. With a help of a neat diagram explain the Cloud Computing delivery models and services.







3. Elaborate the NIST reference model and the various entities involved in Cloud Computing.

According to the NIST reference model in Figure 1.2 [260], the entities involved in cloud computing are the *service consumer*, the entity that maintains a business relationship with and uses service from service providers; the *service provider*, the entity responsible for making a service available to service consumers; the *carrier*, the intermediary that provides connectivity and transport of cloud services between providers and consumers; the *broker*, an entity that manages the use, performance, and delivery of cloud services and negotiates relationships between providers and consumers; and the *auditor*, a party that can conduct independent assessment of cloud services, information system operations, performance, and security of the cloud implementation. An *audit* is a systematic evaluation of a cloud system that measures how well it conforms to a set of established criteria. For example, a security audit evaluates

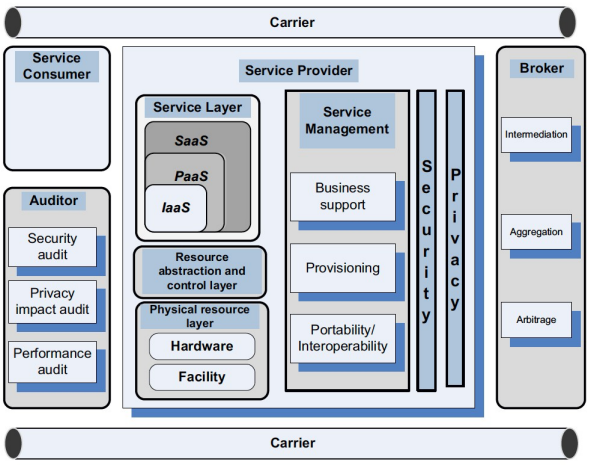


FIGURE 1.2

The entities involved in service-oriented computing and, in particular, in cloud computing, according to NIST. The carrier provides connectivity among service providers, service consumers, brokers, and auditors.

4. Discuss the major challenges of Cloud Computing and the ethical issues in Cloud Computing.

Challenges for cloud computing

- Availability of service; what happens when the service provider cannot deliver?
- Diversity of services, data organization, user interfaces available at different service providers limit user mobility; once a customer is hooked to one provider it is hard to move to another. Standardization efforts at NIST!
- Data confidentiality and auditability, a serious problem.
- Data transfer bottleneck; many applications are data-intensive.

More challenges

- Performance unpredictability, one of the consequences of resource sharing.
  - How to use resource virtualization and performance isolation for QoS guarantees?
  - How to support elasticity, the ability to scale up and down quickly?
- Resource management; are self-organization and self-management the solution?
- Security and confidentiality; major concern.
- Addressing these challenges provides good research opportunities!!

Ethical issues

- Paradigm shift with implications on computing ethics:
  - The control is relinquished to third party services.
  - The data is stored on multiple sites administered by several organizations.
  - Multiple services interoperate across the network.
- Implications
  - Unauthorized access.
  - Data corruption.
  - Infrastructure failure, and service unavailability.

5. a. Explain the different cloud types and the suitability of their use.

Types of clouds

- Public Cloud - the infrastructure is made available to the general public or a large industry group and is owned by the organization selling cloud services.
- Private Cloud – the infrastructure is operated solely for an organization.
- Community Cloud - the infrastructure is shared by several organizations and supports a community that has shared concerns.
- Hybrid Cloud - composition of two or more clouds (public, private, or community) as unique entities but bound by standardized technology that enables data and application portability.

The "good" about cloud computing

- Resources, such as CPU cycles, storage, network bandwidth, are shared.
- When multiple applications share a system, their peak demands for resources are not synchronized thus, *multiplexing leads to a higher resource utilization*.
- Resources can be aggregated to support data-intensive applications.
- Data sharing facilitates collaborative activities. Many applications require multiple types of analysis of shared data sets and multiple decisions carried out by groups scattered around the globe.

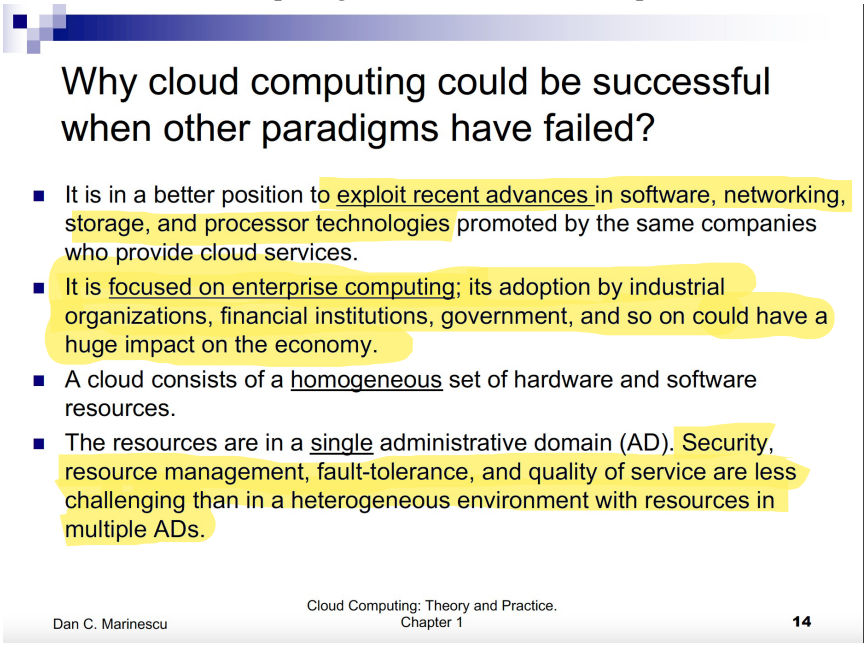
More "good" about cloud computing

- Eliminates the initial investment costs for a private computing infrastructure and the maintenance and operation costs.
- Cost reduction: concentration of resources creates the opportunity to pay as you go for computing.
- Elasticity: the ability to accommodate workloads with very large peak-to-average ratios.
- User convenience: virtualization allows users to operate in familiar environments rather than in idiosyncratic ones.

b. Explain the cloud type that will suit
   i. banking application where privacy of data is very important.
   ii. University management system.
   iii. Engineering research community

i. Banking application uses **private cloud**. The infrastructure is operated solely for an organization. It may be managed by the organization or a third party and may exist on or off the premises of the organization.
ii. University management system uses **public cloud**. The infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services.
iii. Engineering research community uses **community cloud**. The infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be managed by the organizations or a third party and may exist on premises or off premises.

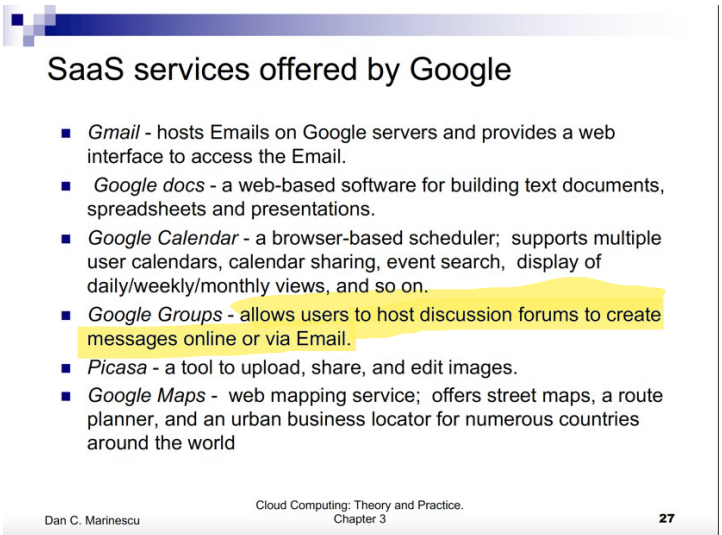
6. What are the reasons that cloud computing could be successful? Explain

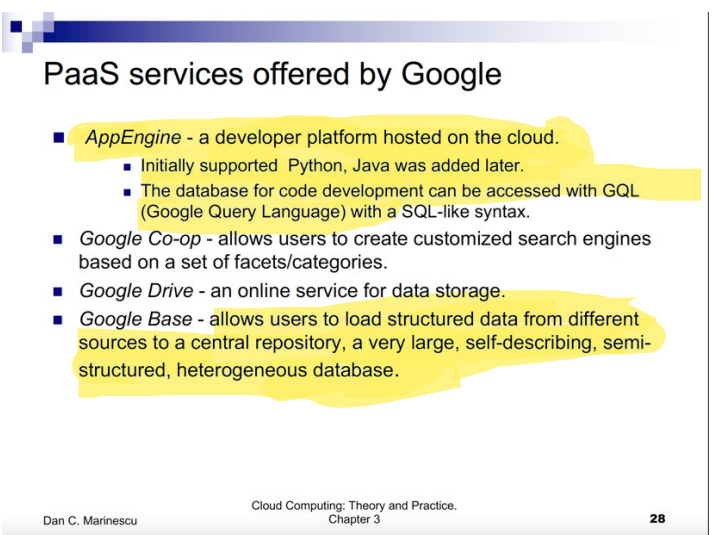


7. Analyze and justify the success of cloud computing as against traditional network systems.

Same answer as in Q 6

8. Elaborate on Cloud computing services from Google.





9. Explain the services offered by AWS along with a neat diagram

EC2 – Elastic Cloud Computing

- *EC2* - web service for launching instances of an application under several operating systems, such as:
  - Several Linux distributions.
  - Microsoft Windows Server 2003 and 2008.
  - OpenSolaris.
  - FreeBSD.
  - NetBSD.
- A user can
  - Load an *EC2* instance with a custom application environment.
  - Manage network's access permissions.
  - Run the image using as many or as few systems as desired.

EC2 (cont'd)

- Import virtual machine (VM) images from the user environment to an instance through *VM import*.
- *EC2* instances boot from an AMI (Amazon Machine Image) digitally signed and stored in *S3*.
- Users can access:
  - Images provided by Amazon.
  - Customize an image and store it in *S3*.
- An *EC2* instance is characterized by the resources it provides:
  - VC (Virtual Computers) – virtual systems running the instance.
  - CU (Compute Units) – measure computing power of each system.
  - Memory.
  - I/O capabilities.

S3 – Simple Storage System

- Service designed to store large objects; an application can handle an unlimited number of objects ranging in size from 1 byte to 5 TB.
- An object is stored in a bucket and retrieved via a unique, developer-assigned key; a bucket can be stored in a Region selected by the user.
- Supports a minimal set of functions: write, read, and delete; it does not support primitives to copy, to rename, or to move an object from one bucket to another.
- The object names are global.
- S3 maintains for each object: the name, modification time, an access control list, and up to 4 KB of user-defined metadata.

S3 (cont'd)

- Authentication mechanisms ensure that data is kept secure.
- Objects can be made public, and rights can be granted to other users.
- S6 computes the MD5 of every object written and returns it in a field called ETag.
- A user is expected to compute the MDS of an object stored or written and compare this with the ETag; if the two values do not match, then the object was corrupted during transmission or storage.

Elas"tic"Block S ore (EBS)*""""

Root volume is Ebs
Root volumes are attached with EC2 instance and contain the memory required for operating system and storing OS.

- Provides persistent block level storage volumes for use with EC2 instances; suitable for database applications, file systems, and applications using raw data devices.
- A volume appears to an application as a raw, unformatted and reliable physical disk; the range 1 GB -1 TB.
- An *EC2* instance may mount multiple volumes, but a volume cannot be shared among multiple instances
- EBS supports the creation of snapshots of the volumes attached to an instance and then uses them to restart the instance.
- The volumes are grouped together in Availability Zones and are automatically replicated in each zone.

Persistent Block means that it won't get deleted while rebooting instance, it gets deleted when we terminate instance and that also we can remove

SimpleDB

- Non-relational data store. Supports store and query functions traditionally provided only by relational databases.
- Supports high performance Web applications; users can store and query data items via Web services requests.
- Creates multiple geographically distributed copies of each data item
- It manages automatically:
  - The infrastructure provisioning.
  - a Hardware and software maintenance.
  - Replication and indexing of data items.
  - Performance tuning.

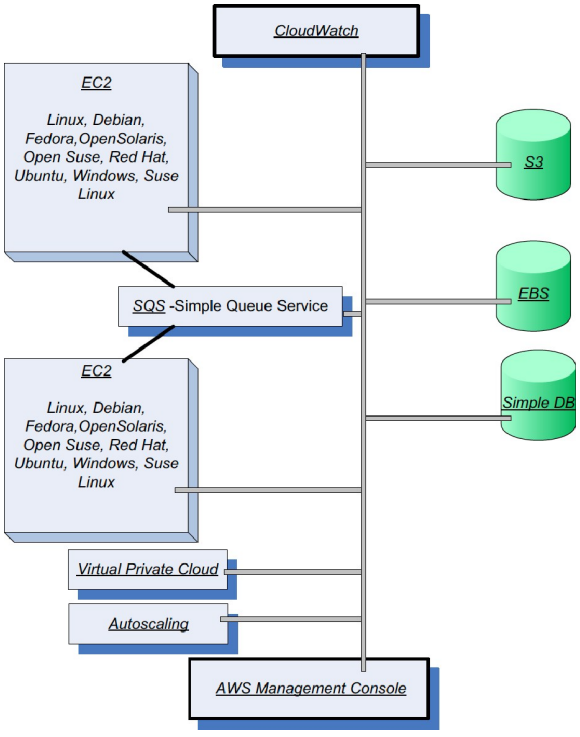
SQS - Simple Queue Service

- Hosted message queues are accessed through standard SOAP and Query interfaces.
- Supports automated workflows - *EC2* instances can coordinate by sending and receiving SQS messages.
- Applications using SQS can run independently and asynchronously, and do not need to be developed with the same technologies.
- A received message is “locked" during processing; if processing fails, the lock expires and the message is available again.
- Queue sharing can be restricted by IP address and time-of-day.

Hosted Message queues r accessed through SOAP and Query interfaces

CloudWatch

- Monitoring infrastructure used by application developers, users, and system administrators to collect and track metrics important for optimizing the perfomance of applications and for increasing the efficiency of resource utilization.
- Without installing any software a user can monitor either seven or eight pre-selected metrics and then view graphs and statistics for these metrics.
- When launching an Amazon Machine Image (AMI) the user can start the CloudWatch and specify the type of monitoring:
  - a Basic Monitoring - free of charge; oollects data at five-minute intervals for up to seven metrics.
  - a Detailed Monitoring - subject to charge; oollects data at one minute interval.



10. With a neat diagram, explain the Configuration of an Availability zone supporting AWS services.

AWS instances

- An instance is a virtual server with a well specified set of resources including: CPU cycles, main memory, secondary storage, communication and I/O bandwidth.
- The user chooses:
  - The region and the availability zone where this virtual server should be placed.
  - An instance type from a limited menu of instance types.
- When launched, an instance is provided with a DNS name; this name maps to a
  - *private IP address* → for internal communication within the internal EC2 communication network.
  - *public IP address* → for communication outside the internal Amazon network, e.g., for communication with the user that launched the instance.

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AWS instances (cont'd)

- Network Address Translation (NAT) maps external IP addresses to internal ones.
- The public IP address is assigned for the lifetime of an instance.
- An instance can request an *elastic IP address*, rather than a public IP address. The elastic IP address is a static public IP address allocated to an instance from the available pool of the availability zone.
- An elastic IP address is not released when the instance is stopped or terminated and must be released when no longer needed.

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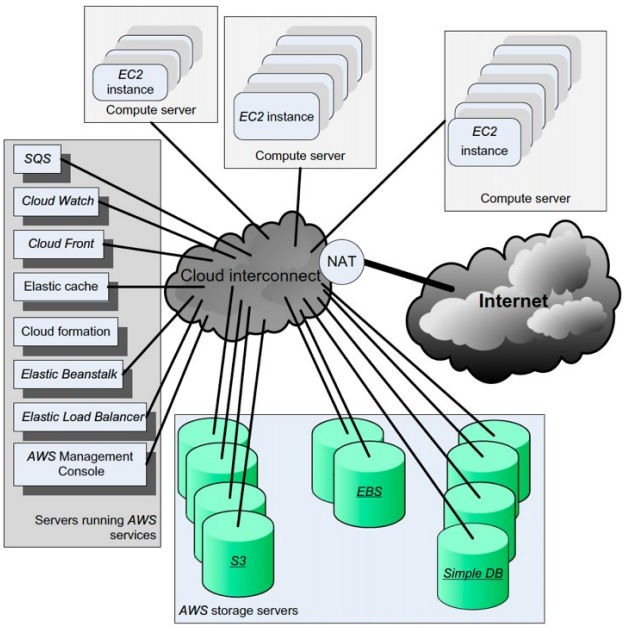
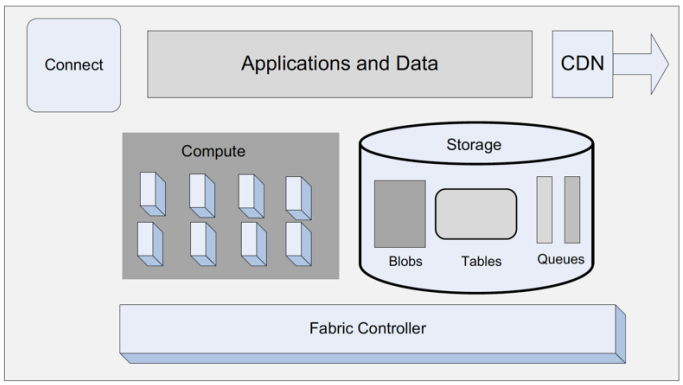


FIGURE 3.2

The configuration of an availability zone supporting *AWS* services. A cloud interconnect supports high-speed communication among compute and storage servers in the zone. It also supports communication with servers in other availablity zones and with cloud users via a Network Address Translation (NAT). NAT maps external IP addresses to internal ones. Multitenancy increases server utilization and lowers costs.

11. Explain with a neat diagram Windows Azure components and online services.

Azure



- *Azure* and *Online Services* are, respectively, *PaaS* and *SaaS* cloud platforms from Microsoft.
- *WindowsAzure* is an operating system,
- *SQLAzure* is a cloud-based version of theSQLServer, and
- *AzureAppFabric* (formerly .NET Services) is a collection of services for cloud applications.

Windows Azure has three core components:

- *Compute*, which provides a computation environment;
- *Storage* for scalable storage; and
- *Fabric Controller*, which deploys, manages, and monitors applications; it interconnects nodes consisting of servers, high-speed connections, and switches.

- The *Content Delivery Network* (CDN) maintains cache copies of data to speed up computations.
- The *Connect* subsystem supports IP connections between the users and their applications running on *Windows Azure*.

12. Discuss the different open source software platforms for private clouds.

Open-source platforms for private clouds

- *Eucalyptus* - can be regarded as an open-source counterpart of Amazon's EC2.
- *Open-Nebula* - a private cloud with users actually logging into the head node to access cloud functions. The system is centralized and its default configuration uses the NFS file system.
- *Nimbus* - a cloud solution for scientific applications based on Globus software; inherits from Globus:
  - The image storage.
  - The credentials for user authentication.
  - The requirement that a running Nimbus process can **ssh** into all compute nodes.
- *Open Stack – started by NASA & Rackspace*

Eucalyptus

- *Virtual Machines* - run under several VMMs including Xen, KVM, and VMware.
- n /Vode *Controller* - runs on server nodes hosting a VM and controls the activities of the node.
- *Cluster Controller* - controls a number of servers.
- *Cloud Controller* - provides the cloud access to end-users, developers, and administrators.
- *Storage Controller* - provides persistent virtual hard drives to applications. It is the correspondent of EBS.
- *Storage Service (Walrus)* - provides persistent storage; similar to S3ttt allows users top store objects in buckets.

- The procedure to construct a virtual machine is based on the generic one described :
  - The *euca2ools* from end is used to request a VM.
  - The VM disk image is transferred to a compute node.
    This disk image is modified for use by the VMM on the compute node.
  - The compute node sets up network bridging to provide a virtual network interface controller (NIC) with a virtual M|edia Access Control (MAC) address.
    In the head node the DHCP is set up with the MAC/IP pair.
    VMM activates the VM.
    The user can now ssh directly into the VM.

Open Nebula

is a private cloud with users actually logging into the head node to access cloud functions.
The system is centralized and its default configuration uses NFS (Network File System).
The procedure to construct a virtual machine consists of several steps'

(i) the user signs into the head nodeusing ssh;
(ii) the system uses the on|ovm command to request a VM;
(iii) Ihe VM template disk image is transformed to fit the correct size and configuration within the NFS directory on the head node;
(iv) the oned daemon on the head node uses ssh to log into a compute node;
(v) The compute node sets up network bridging to provide a vinual NIC with a virtual MAC;
(vi) fhe files needed by the VMM are Transferred fa the compute node via theNKS:
(vii) the VMM on the oompute node starts the VM: and
(viii) the user is able to ssh directly to the VM on the compute node.

- *Nimbus* (`www.nimbusproject.org`) is a cloud solution for scientific applications based on the Globus software.
- The system inherits from Globus the image storage, the credentials for user authentication, and the requirement that a running Nimbus process can `ssh` into all compute nodes.
- Customization in this system can only be done by the system administrators.

- *OpenStack* is an open-source project started in 2009 at the National Aeronautics and Space Administration (NASA) in collaboration with Rackspace (`www.rackspace.com`) to develop a scalable cloud operating system for farms of servers using standard hardware.
- Though recently NASA has moved its cloud infrastructure to *AWS* in addition to Rackspace, several other companies, including HP, Cisco, IBM, and Red Hat, have an interest in *OpenStack*.
- The current version of the system supports a wide range of features such as application programming interfaces (APIs) with rate limiting and authentication; live VM management to run, reboot, suspend, and terminate instances; role-based access control; and the ability to allocate, track, and limit resource utilization.
- The administrators and the users control their resources using an extensible Web application called the *Dashboard*.

Table 3.5 A side-by-side comparison of *Eucalyptus*, *OpenNebula*, and *Nimbus*.

	Eucalyptus	*OpenNebula*	*Nimbus*
Design	Emulate *EC2*	Customizable	Based on Globus
Cloud type	Private	Private	Public/Private
User population	Large	Small	Large
Applications	All	All	Scientific
Customizability	Administrators and limited users	Administrators and users	All but image storage and credentials
Internal security	Strict	Loose	Strict
User access	User credentials	User credentials	x509 credentials
Network access	To cluster controller	—	To each compute node

13. Explain the various components of Eucalyptus system and also discuss the procedure for constructing a VM.

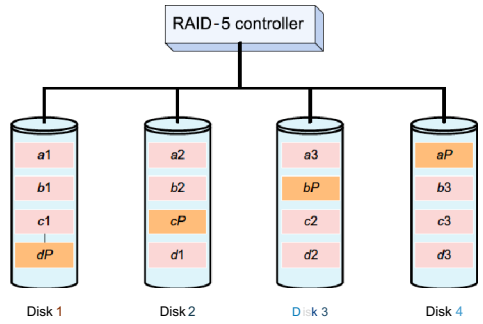
Refer Q12

14. Explain the application of RAID 5. With a diagram explain the working of RAID-5 controller for data storage diversity in cloud. (Q14 & Q15 same answer)

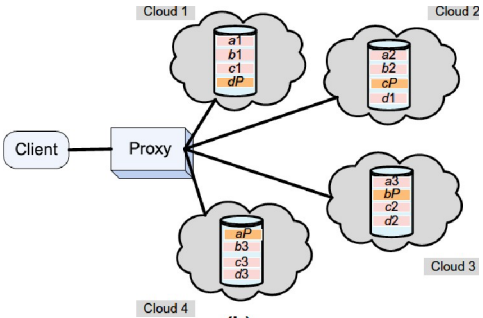
15. What is the drawback of Cloud storage diversity and vendor lock-in? Explain the approach of using RAID5 controller principal to overcome the same.

Cloud storage diversity and vendor lock-in

- Risks when a large organization relies on a single cloud service provider:
  - Cloud services may be unavailable for a short or an extended period of time.
  - Permanent data loss in case of a catastrophic system failure.
  - The provider may increase the prices for service.
- Switching to another provider could be very costly due to the large volume of data to be transferred from the old to the new provider.
- A solution is to replicate the data to multiple cloud service providers, similar to data replication in RAID.



(a)



(b)

FIGURE 3.5
(a) A 4) RAID-5 configuration in which individual blocks are strioped over three disks and a parity block is added; the parity block is constructed by XOR-Ing the data blocks (e.g., a-P aL XOR a2XOR a3). The parity blocks are distributed am0ng the Jour dis s: aP is on disk 4, 6P on disk 2, and dP on disk 1. (b) A system that strips data across four the proxy provides transparent access to data.

A=a1+a2+a3
Ap=a1XORa2XORa3

B=b1+b2+b3
Bp=b1XORb2XORb3

C
Cp=c1XORc2XORc3

D
Dp=d1XORd2XORd3

- A RAID-5 system uses block-level stripping with distributed parity over a disk array, as shown in Figure 3.5(a);
- the disk controller distributes the sequential blocks of data to the physical disks and computes a parity block by bit-wise XOR-ing of the data **blocks.**
- The parity block is written on a different disk for each file to avoid the bottleneck possible when all parity blocks are written to a dedicated disk,
- as is done in the case of RAID-4 systems.
- This technique allows us to recover the data after a single disk loss.
- For example, if Disk 2 in Figure 3.5 is lost, we still have all the blocks of the third file, c1, c2, and c3, and we can recover the missing blocks for the others as follows:

  a2 = *(a1)* XOR *(aP)* XOR *(a3)*
  b2 = *(b1)* XOR *(bP)* XOR *(b3)*
  d1 = *(dP)* XOR *(d2)* XOR *(d3)*