Cloud Deployment and Service Models

Y. V. Lokeswari - AP/ CSE
SSN College of Engineering

Reference: Distributed and Cloud Computing
K. Hwang, G. Fox and J. Dongarra

SSN

Overview

- Cloud Deployment Models
  - Public Cloud
  - Private Cloud
  - Hybrid Cloud
  - Community Cloud
- Cloud Service Models
  - Infra-structure as a Service (IaaS)
  - Platform as a Service (PaaS)
  - Software as a Service (SaaS)
- Cloud Computing Challenges

Is Cloud environment centralized or distributed ???

Some argue as Centralized

And

Some argue as Distributed

Centralized and Distributed computing

- Cloud computing is indeed practicing distributed parallel computing over datacenter resources.
- All computations associated with a single cloud application are still distributed to many servers in multiple datacenters.
- Commercial cloud providers such as Amazon, Google and Microsoft created their platforms to be distributed geographically.
- These centers may have to communicate with each other around the globe

Deployment Models in Cloud

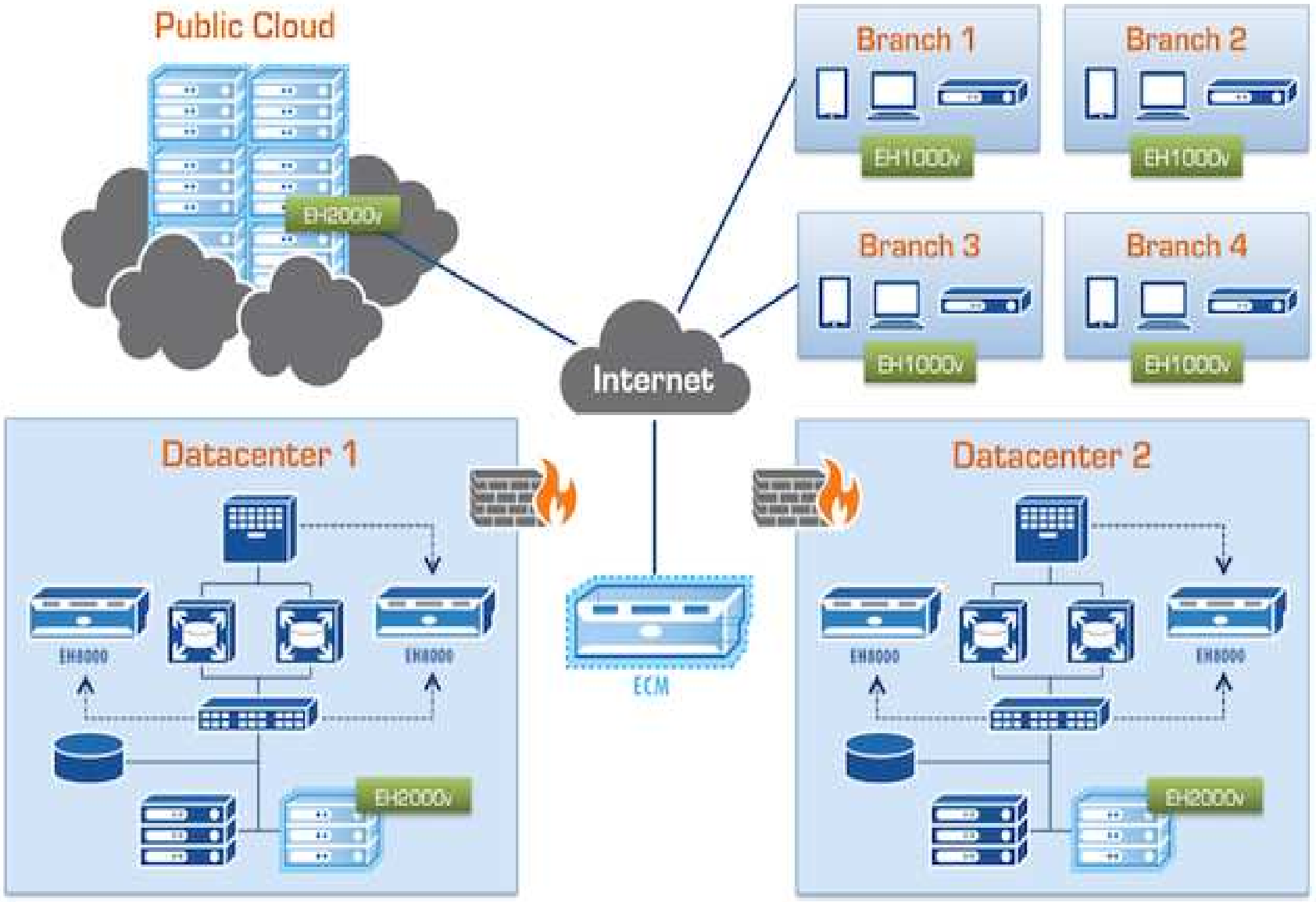
There are 4 Deployment models

1. Public Cloud
2. Private Cloud
3. Hybrid Cloud
4 .Community Cloud

Public Cloud

- Public cloud is built over the Internet, which can be accessed by any user who has paid for the service.
- Public clouds are owned by service providers.
- They are accessed by subscription.
- Commercial companies have built public clouds. They are
  - Google App Engine,
  - Amazon AWS,
  - Microsoft Azure,
  - IBMBlue Cloud, and
  - Salesforce Force.com.
- They offer a publicly accessible remote interface for creating and managing VM instances within their proprietary infrastructure.

Public Cloud Diagram



Private Cloud

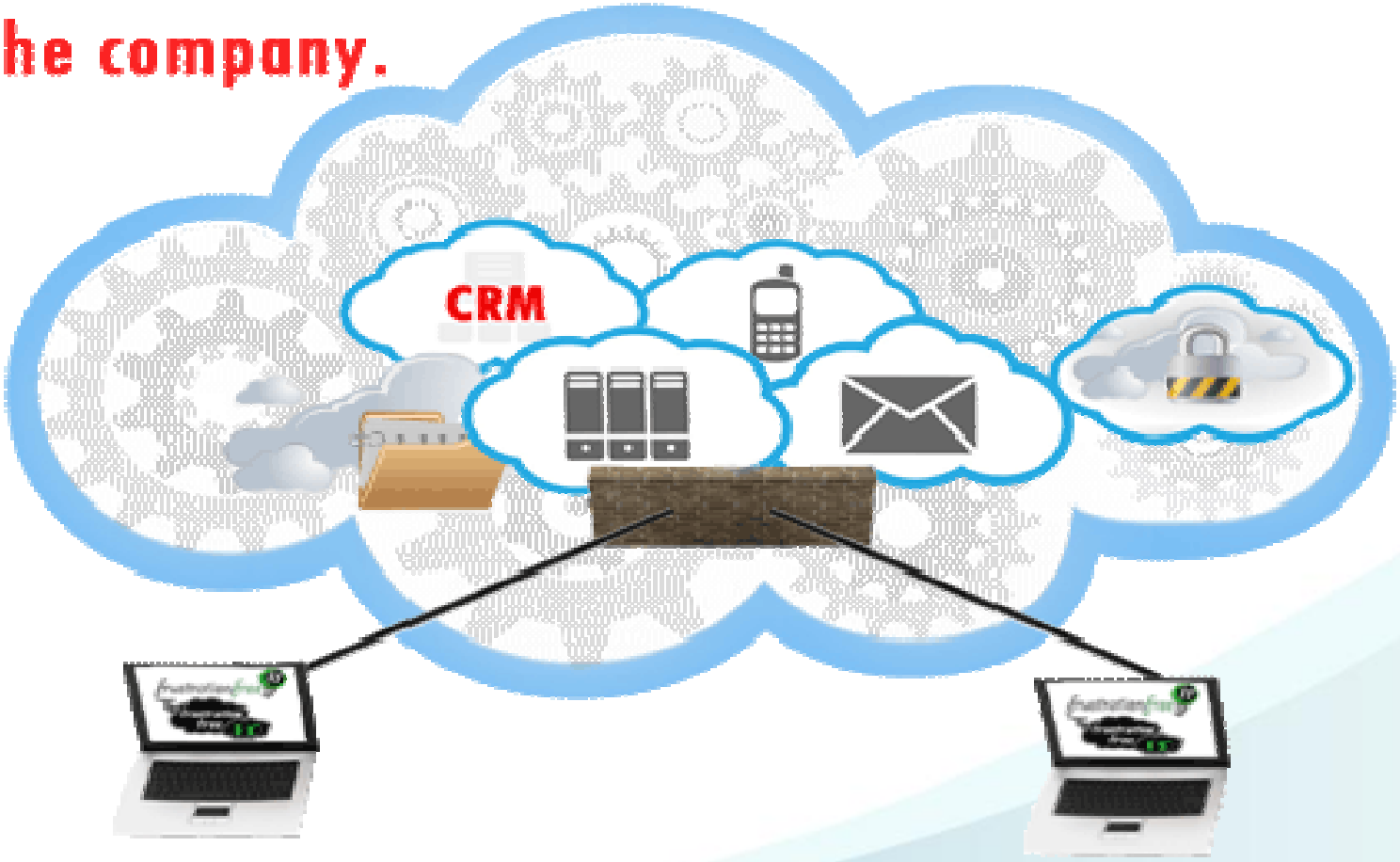
- Private cloud is built within the domain of an intranet owned by a single organization.
- They are client owned and managed.
- Their access is limited to the owning clients and their partners.
- Their deployment was not meant to sell capacity over the Internet through publicly accessible interfaces.
- Private clouds give local users a flexible and agile private infrastructure to run service workloads within their administrative domains.

Problem

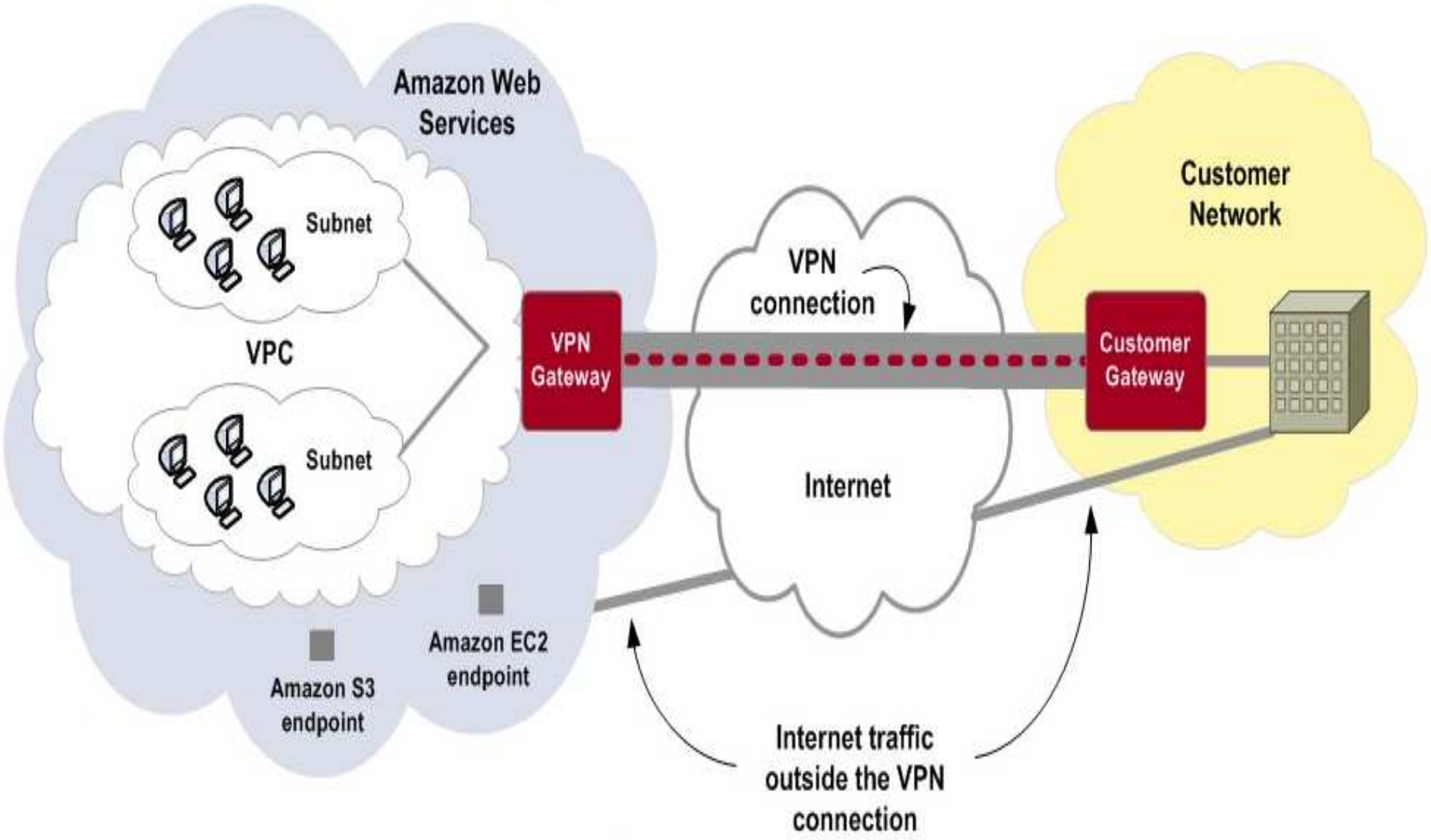
- They may impact the cloud standardization, while retaining greater customization and organizational control.

Private Cloud Diagram

Virtual Private Cloud Computing-
Designed & configured based off the needs of the company.



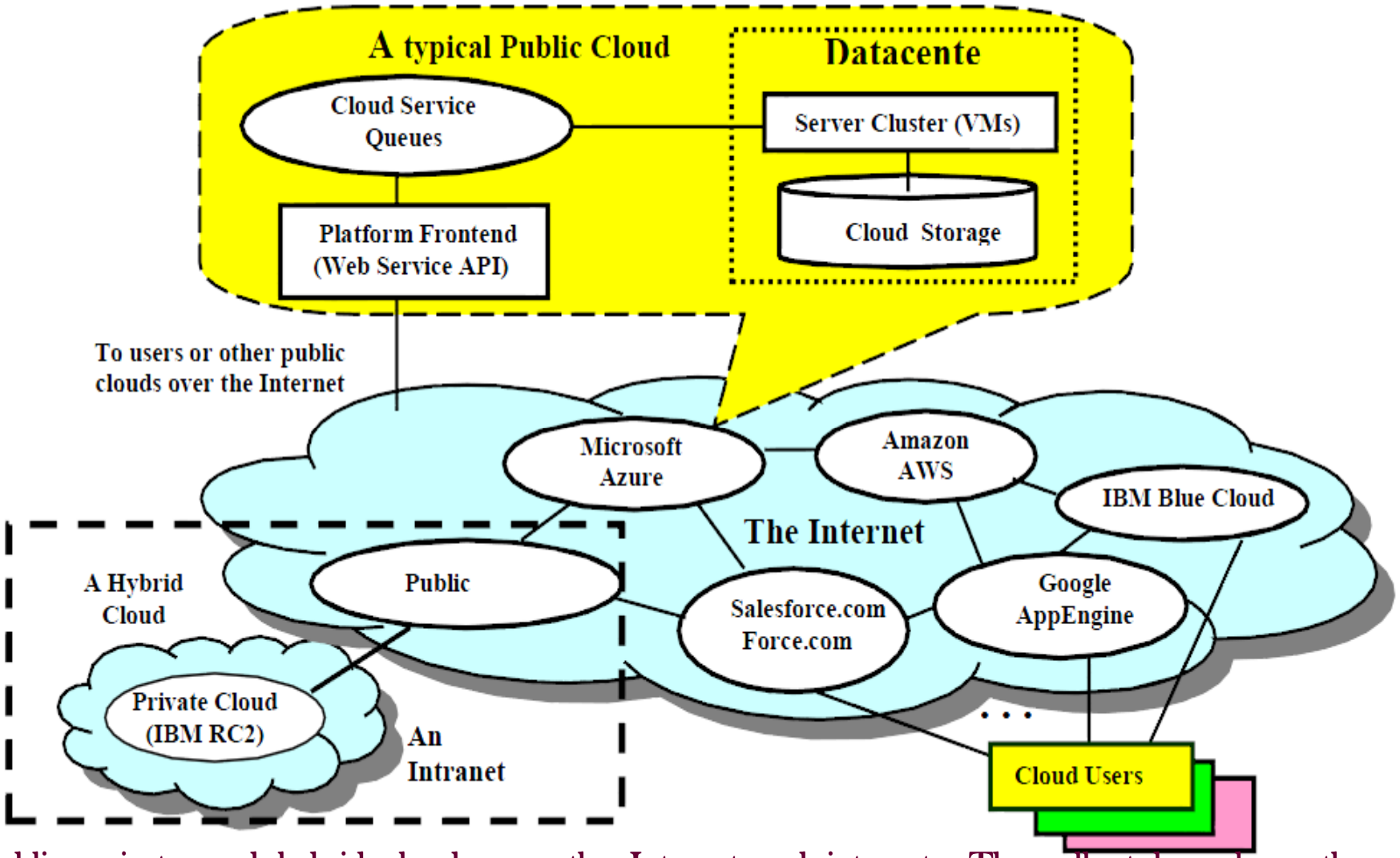
Amazon's Private Cloud



Hybrid Cloud

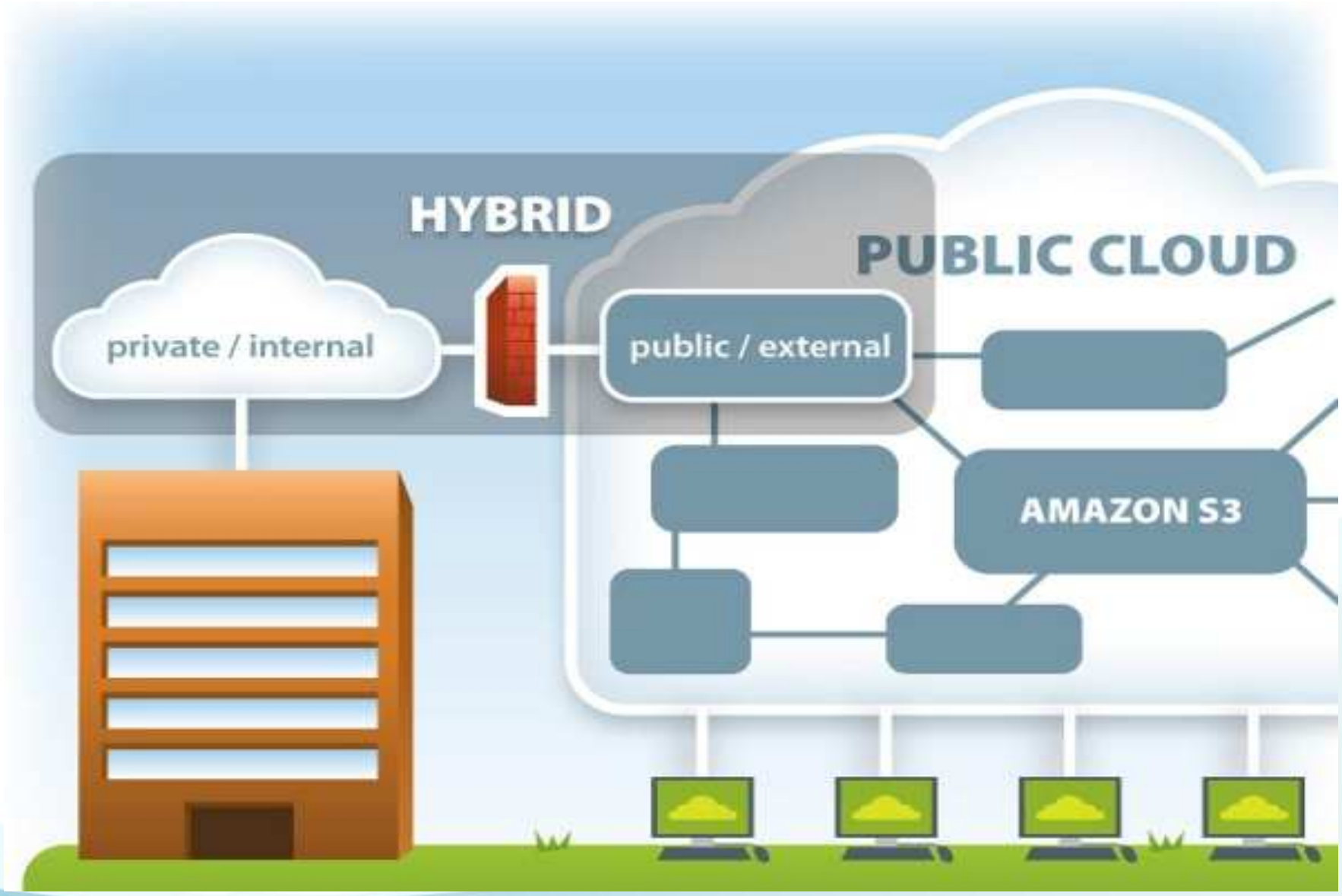
- Hybrid cloud is built with both public and private clouds
- Private clouds can also support a hybrid cloud model by supplementing local infrastructure with computing capacity from an external public cloud.
- For example, the Research compute cloud (RC2) is a private cloud built by IBM.
- The RC2 interconnects the computing and IT resources at 8 IBM Research Centers scattered in US, Europe, and Asia.

Public Clouds vs. Private Clouds

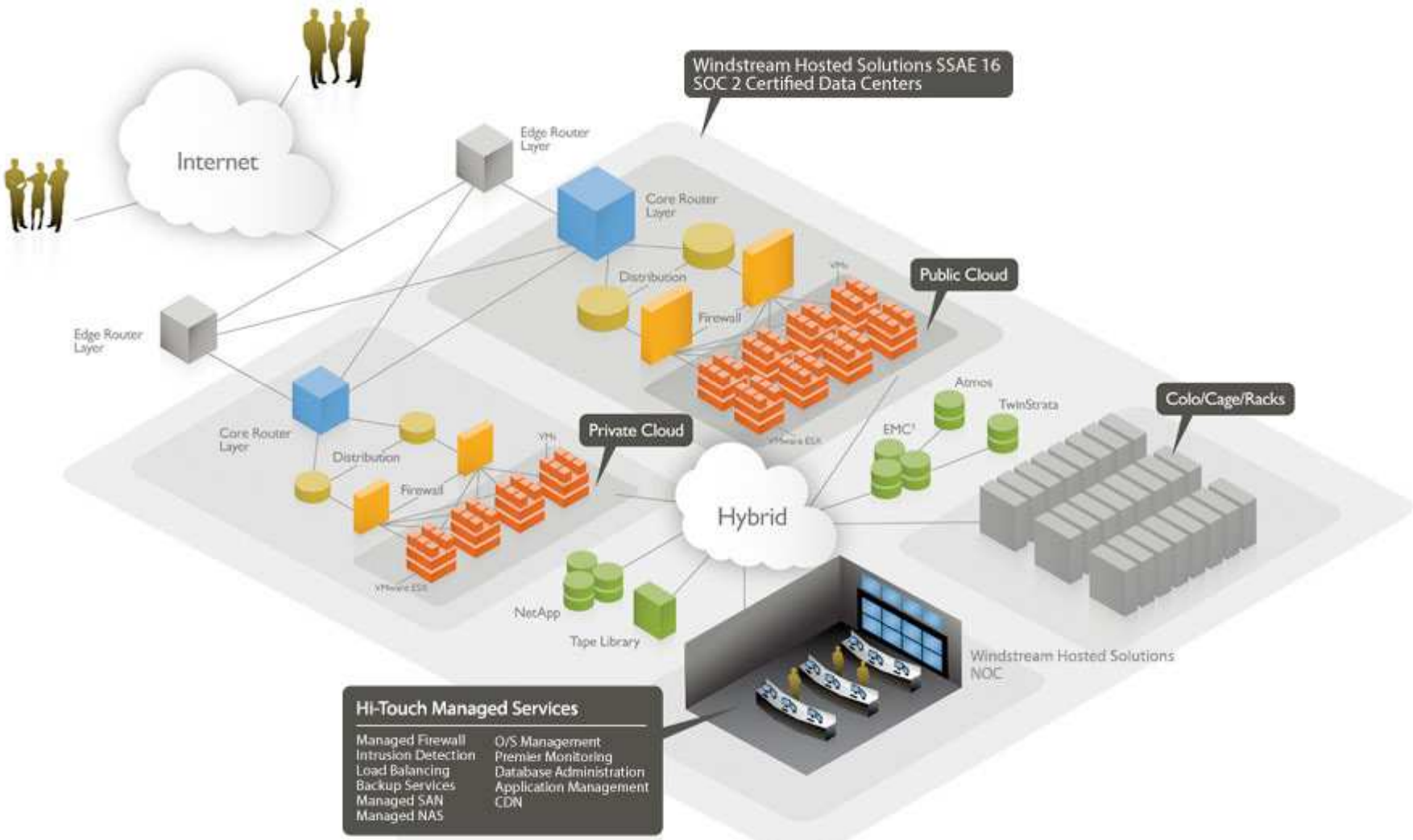


Public, private, and hybrid clouds over the Internet and intranets. The callout box shows the architecture of a typical public cloud. A private cloud is built within an intranet. A hybrid cloud involves both public and private clouds in its range. Users access the clouds from a web browser or through an special application programming interface (API).

Private, Public and Hybrid Cloud



Private, Public and Hybrid Cloud



Community Cloud

- Community cloud: Cloud infra-structure is shared by several organizations or community of people who have same vision, security requirements and policy.

- It may be managed by an organization or third-party.

Summary of Cloud Deployment Models

- Public clouds promotes
  - Standardization,
  - Preserves capital investigation,
  - Offers application flexibility.
- Private clouds attempt to
  - Achieve customization and
  - Offer higher efficiency,
  - Resiliency, Security, and Privacy.

- Hybrid clouds operates in the middle way with compromises

Public Clouds vs. Private Clouds

Characteristics	Public clouds	Private clouds
Technology leverage and ownership	Owned by service providers	Leverage existing IT infrastructure and personnel; owned by individual organization
Management of provisioned resources	Creating and managing VM instances within proprietary infrastructure; promote standardization, preserves capital investment, application flexibility	Client managed; achieve customization and offer higher efficiency
Workload distribution methods and loading policies	Handle workload without communication dependency; distribute data and VM resources; surge workload is off-loaded	Handle workload dynamically, but can better balance workloads; distribute data and VM resources
Security and data privacy enforcement	Publicly accessible through remote interface	Access is limited; provide pre-production testing and enforce data privacy and security policies
Example platforms	Google App Engine, Amazon AWS, Microsoft Azure	IBM RC2

PUBLIC vs. PRIVATE vs. HYBRID
CLOUD STORAGE

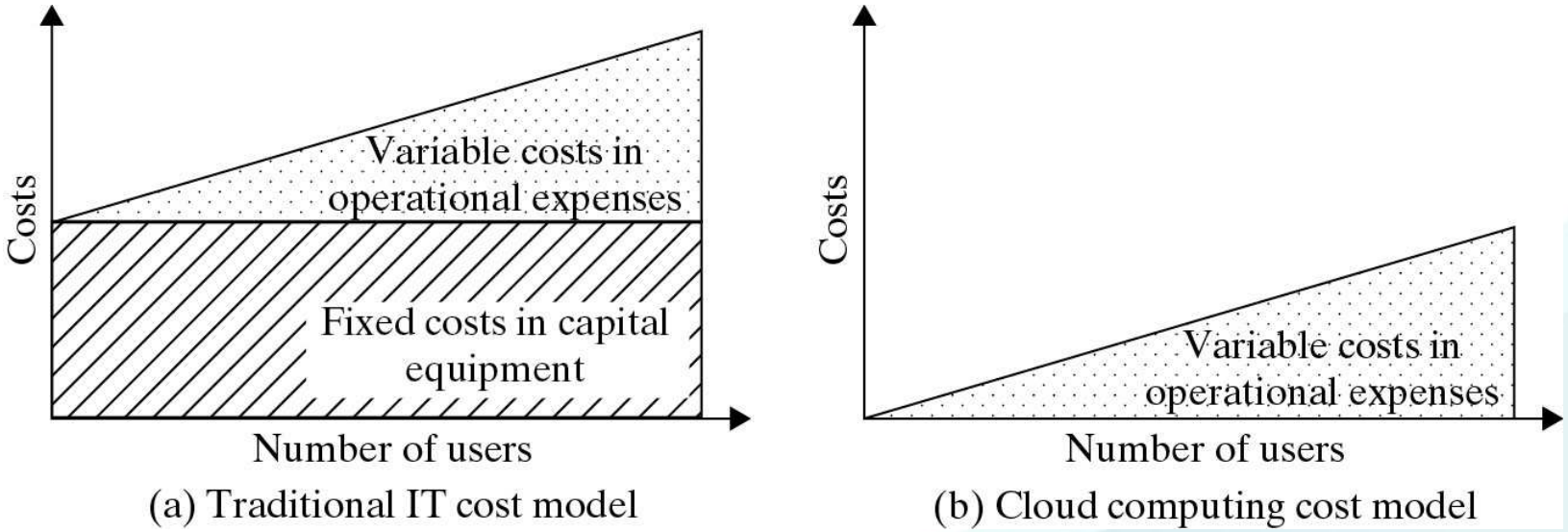
Characteristic	Public cloud storage	Private cloud storage	Hybrid cloud storage
Scalability	Very high	Limited	Very high
Security	Good, but depends on the security measures of the service provider	Most secure, as all storage is on-premise	Very secure; integration options add an additional layer of security
Performance	Low to medium	Very good	Good, as active content is cached on-premise
Reliability	Medium; depends on Internet connectivity and service provider availability	High, as all equipment is on premise	Medium to high, as cached content is kept on-premise, but also depends on connectivity and service provider availability
Cost	Very good; pay-as-you-go model and no need for on-premise storage infrastructure	Good, but requires on-premise resources, such as data center space, electricity and cooling	Improved, since it allows moving some storage resources to a pay-as-you-go model

Cost-Effectiveness in Cloud Computing vs. Datacenter Utilization

(Courtesy of M. Ambrust, et al 2009)

$$\text{UserHours}_{\text{cloud}} \times (\text{revenue} - \text{Cost}_{\text{cloud}}) \geq$$

$$\text{UserHours}_{\text{datacenter}} \times \left(\text{revenue} - \frac{\text{Cost}_{\text{datacenter}}}{\text{Utilization}}\right)$$



(a) Traditional IT cost model

(b) Cloud computing cost model

Cloud Service Models

Mainly are 3 Service models

1. Infra-structure as a Service (IaaS)
2. Platform as a Service (PaaS)
3. Software as a Service (SaaS)

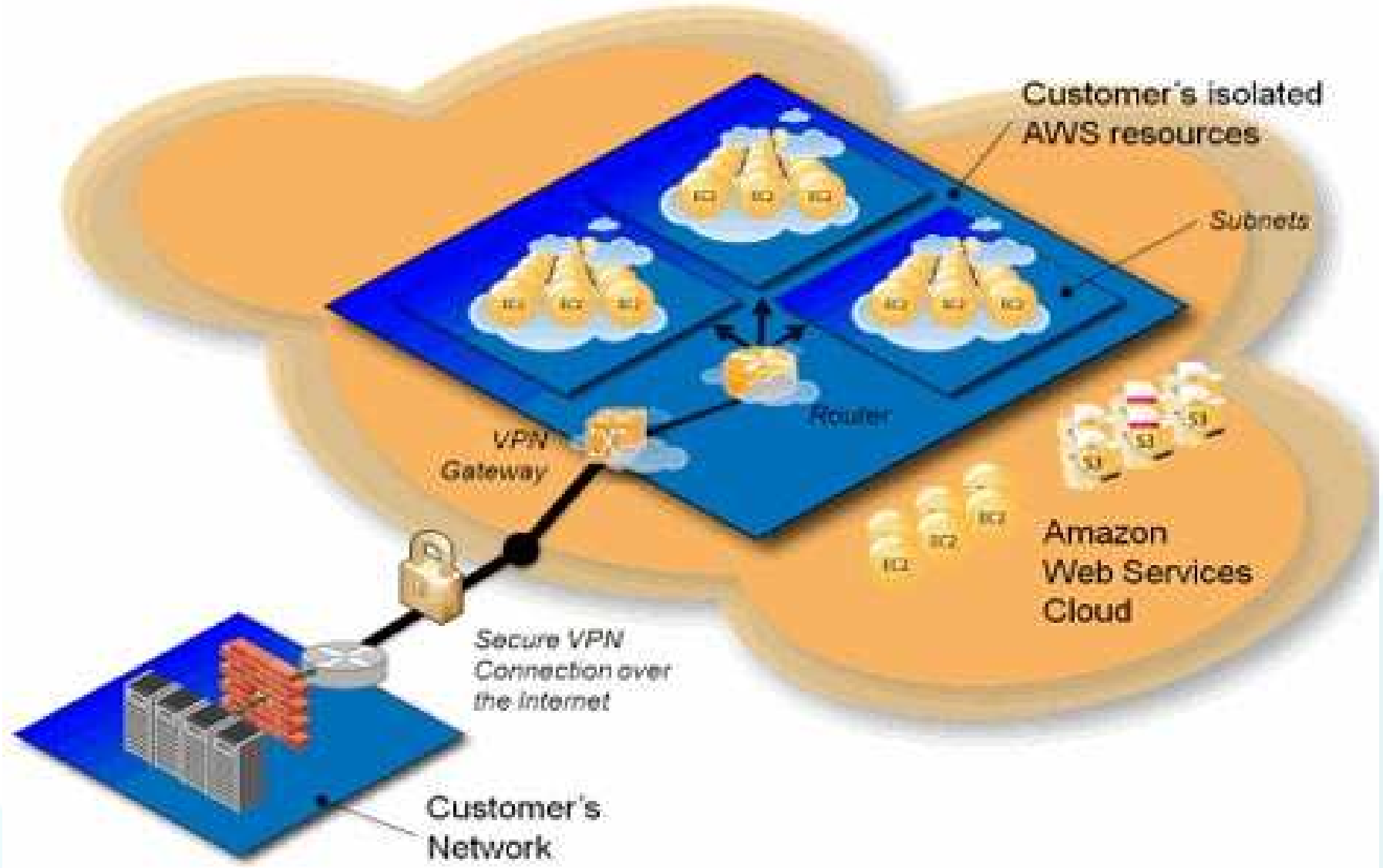
Cloud Service Models

- Cloud computing delivers infrastructure, platform, and software (application) as services
- Available as subscription-based services in a pay-as-you-go model to consumers.
- All the three models allow the user to access the services over the Internet, relying entirely on the infrastructures of the cloud service providers
- These models are offered based on various SLAs between the providers and Consumers.
- The SLA for cloud computing is addressed in terms of the service availability performance and data protection and security aspects

Infra-structure as a Service (IaaS)

- This model allows users to rent processing, storage, networks, and other resources.
- The user can deploy and run the guest OS and applications.
- The user does not manage or control the underlying cloud infrastructure but has control over OS, storage, deployed applications, and possibly select networking components.
- This IaaS model encompasses the storage as a service, computation resource as a service, and communication resource as a service

Amazon's Virtual Private Cloud
Infra-structure as a Service (IaaS)



Example for Infra-structure as a Service (IaaS)

Amazon's VPC for Multiple Tenants

- Virtual Private Cloud (VPC) is designed to address privacy concerns of public cloud that hamper application when sensitive data or software are involved.
- VPC allows users to isolate their provisioned AWS processor, memory and storage from other users.
- Auto-scaling : enables users to automatically scale their VM instances capacity up or down.
- Auto-scaling ensures sufficient number of Amazon EC2 instances are provisioned to meet desired performance.
- Or scale down the VM instance capacity to reduce cost when workload is reduced.

Amazon offers below (IaaS) Services

- EC2 (Elastic compute cloud) allows users to rent virtual computers to run their own computer applications.
- S3 (simple storage service) provides the object-oriented storage service for users.
- EBS (Elastic block service) provides the block storage interface.
- Amazon DevPay is a simple to use online billing and account management service.
- MPI clusters uses hardware-assisted virtualization instead of paravirtualization.
- AWS import/export allows shipping data to and from EC2.
- CloudWatch monitors running instances.
- Amazon CloudFront implements a content distribution network.

Amazon Web Services

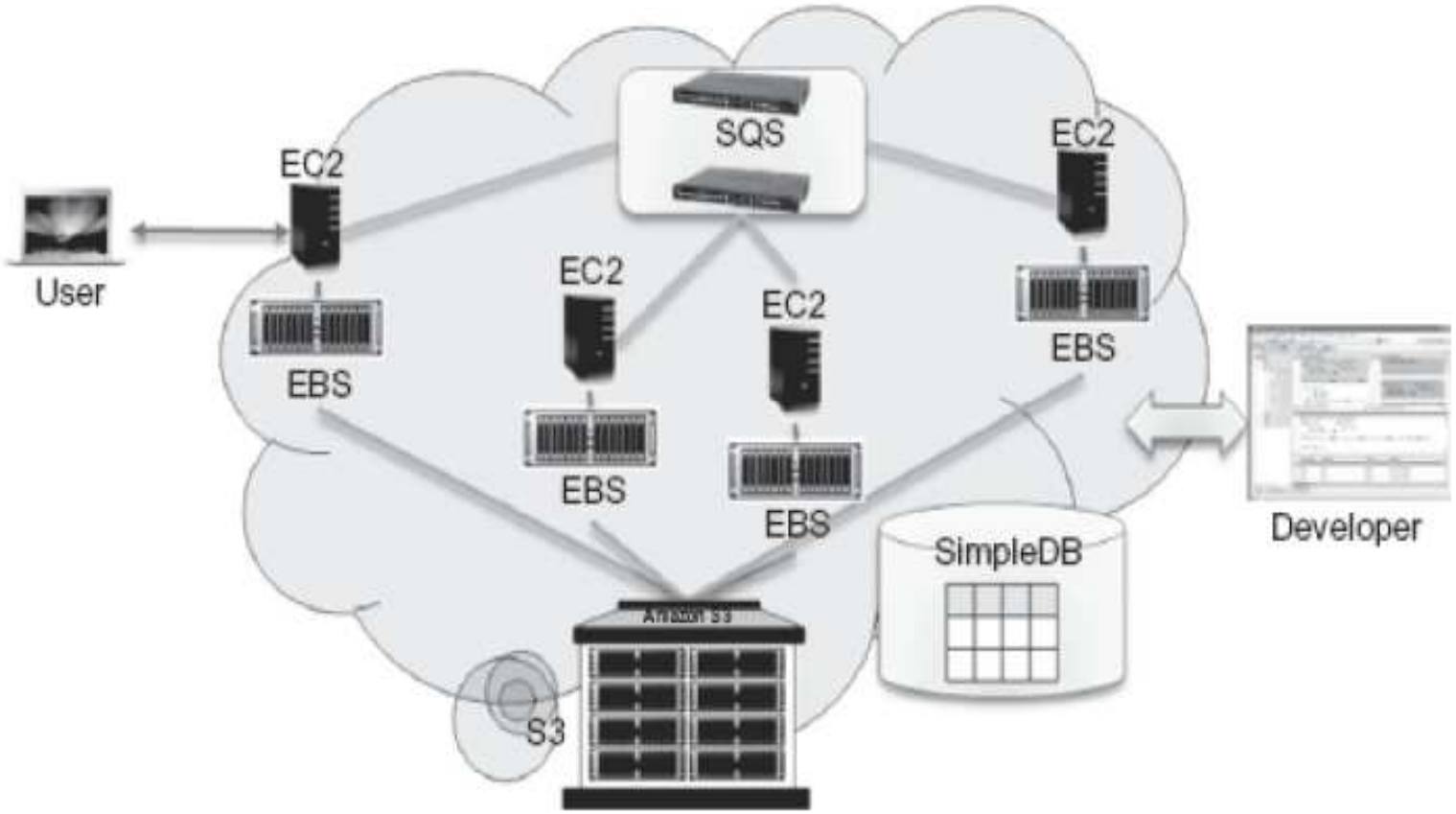


FIGURE 4.21

Amazon cloud computing infrastructure (Key service is identified here; many more are listed in Table 4.5).

(Courtesy of Kang Chen, Tsinghua University, China

Amazon Web Services

Compute

- Amazon Elastic Compute Cloud (EC2)
- Amazon Elastic MapReduce
- Auto Scaling

Content Delivery

- Amazon CloudFront

Database

- Amazon SimpleDB
- Amazon Relational Database Service (RDS)

E-Commerce

- Amazon Fulfillment Web Service (FWS)

Messaging

- Amazon Simple Queue Service (SQS)
- Amazon Simple Notification Service (SNS)

Monitoring

- Amazon CloudWatch

Networking

- Amazon Virtual Private Cloud (VPC)
- Elastic Load Balancing

Payments & Billing

- Amazon Flexible Payments Service (FPS)
- Amazon DevPay

Storage

- Amazon Simple Storage Service (S3)
- Amazon Elastic Block Storage (EBS)
- AWS Import/Export

Support

- AWS Premium Support

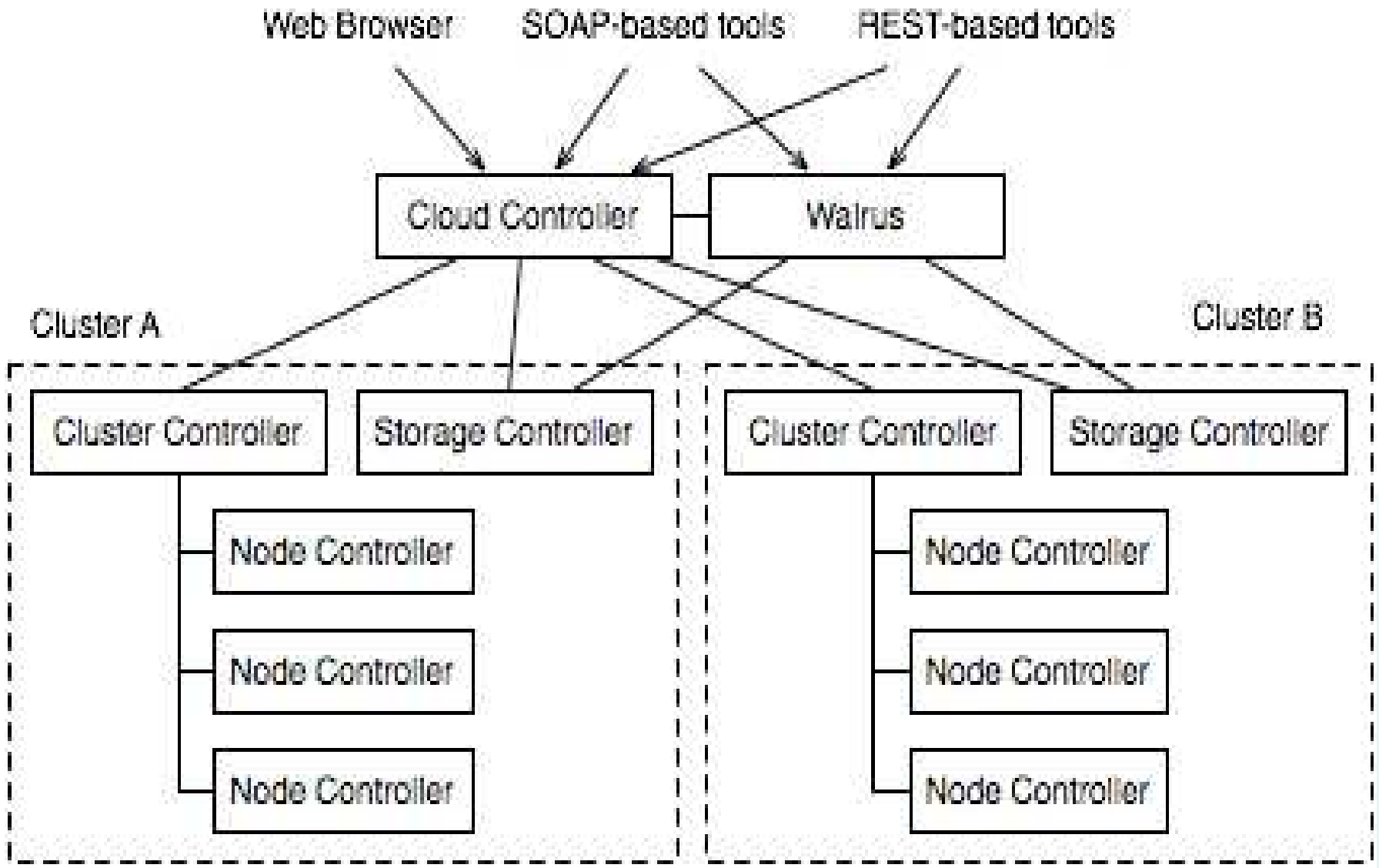
Web Traffic

- Alexa Web Information Service
- Alexa Top Sites

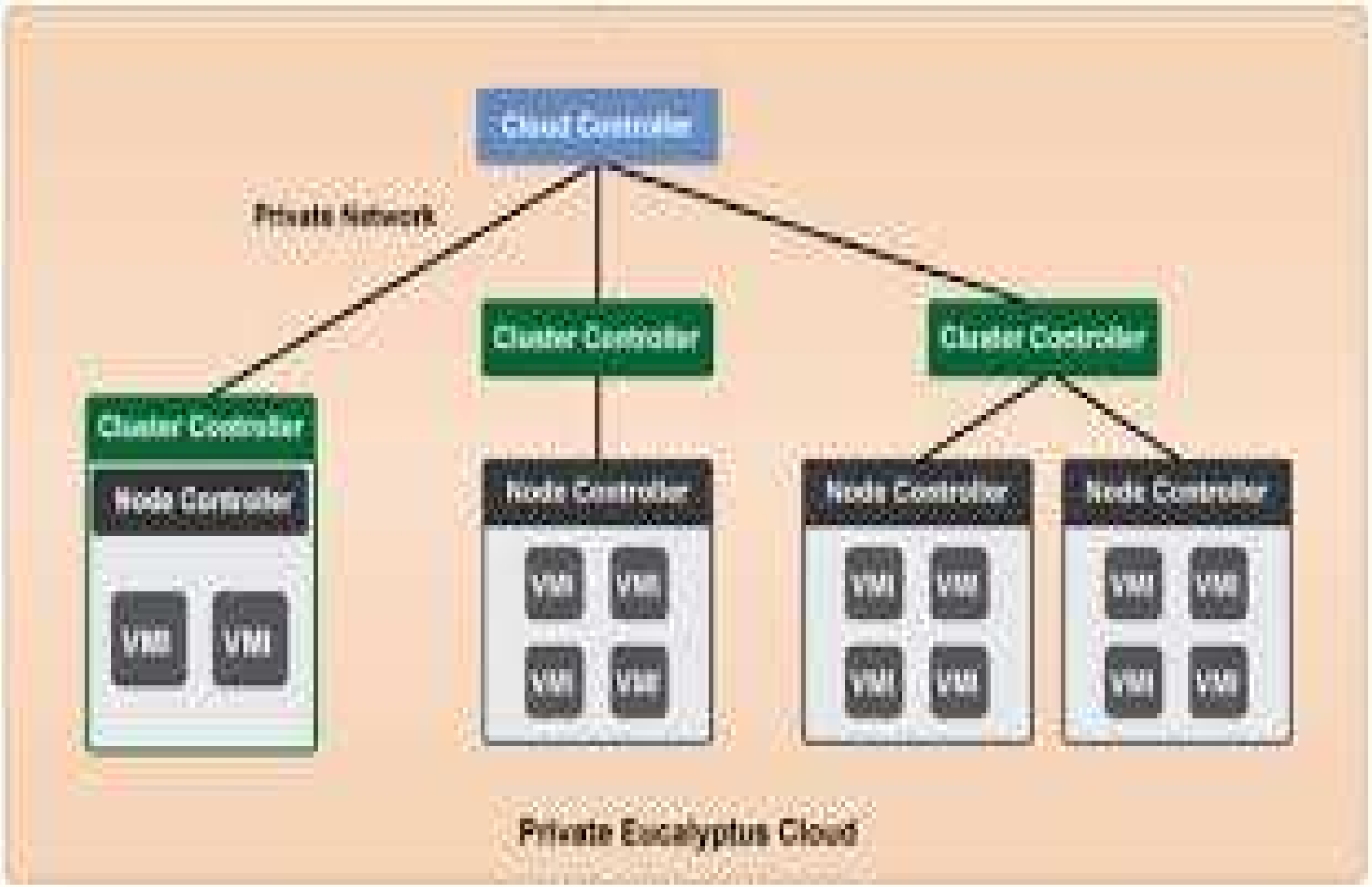
Workforce

- Amazon Mechanical Turk

Eucalyptus Private Cloud



Eucalyptus Private Cloud

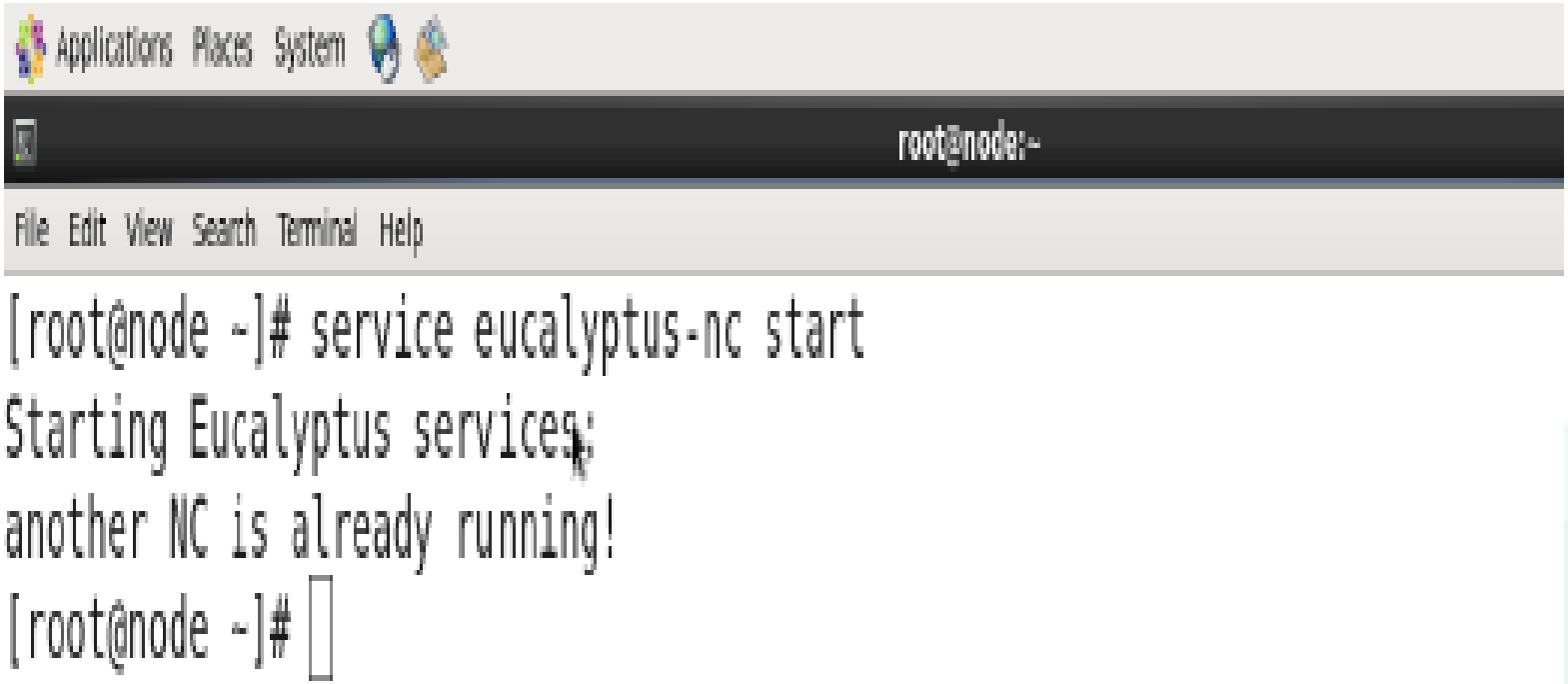


Eucalyptus Private Cloud

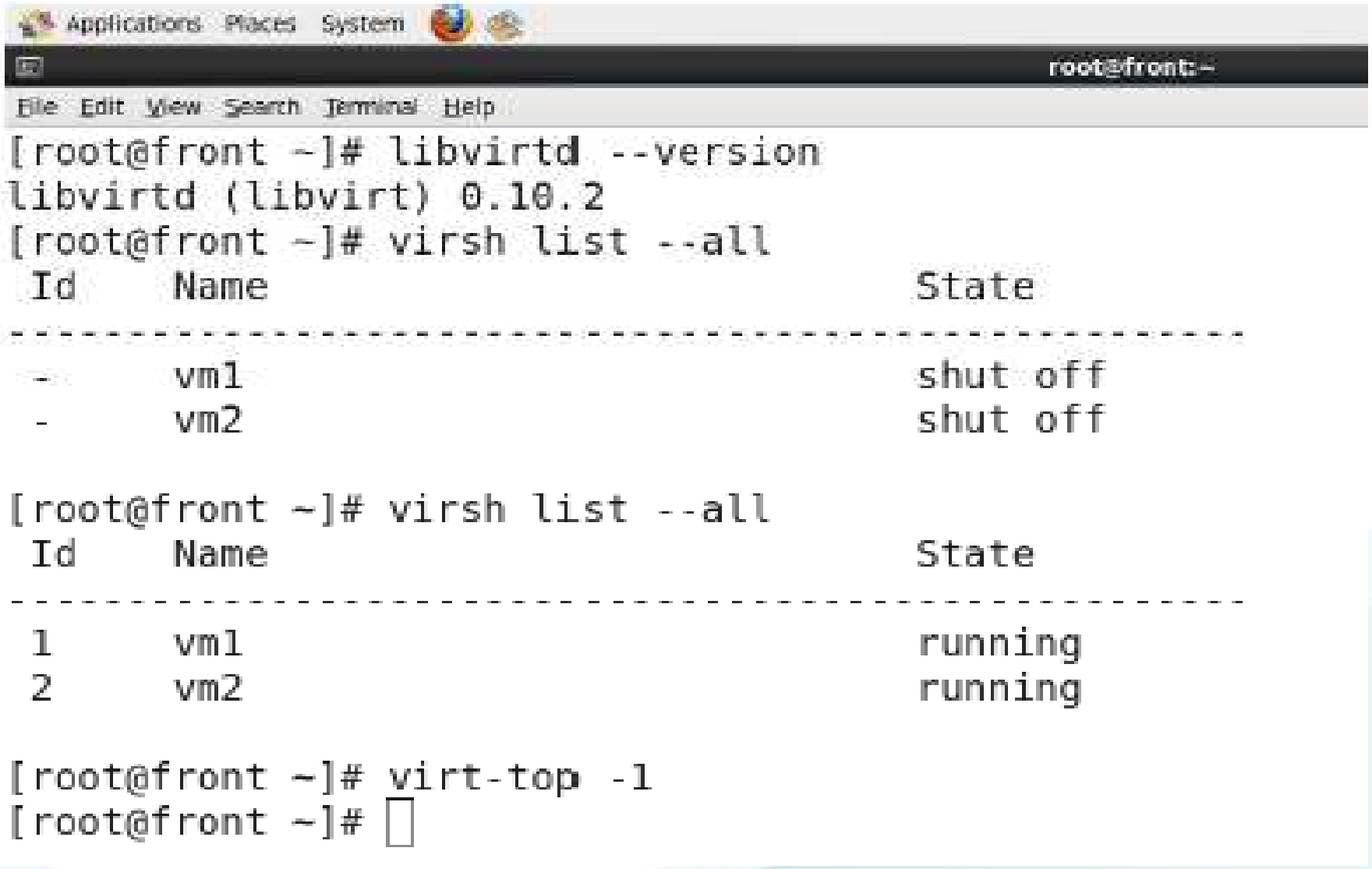
Cloud and Cluster Start

Eucalyptus Private Cloud

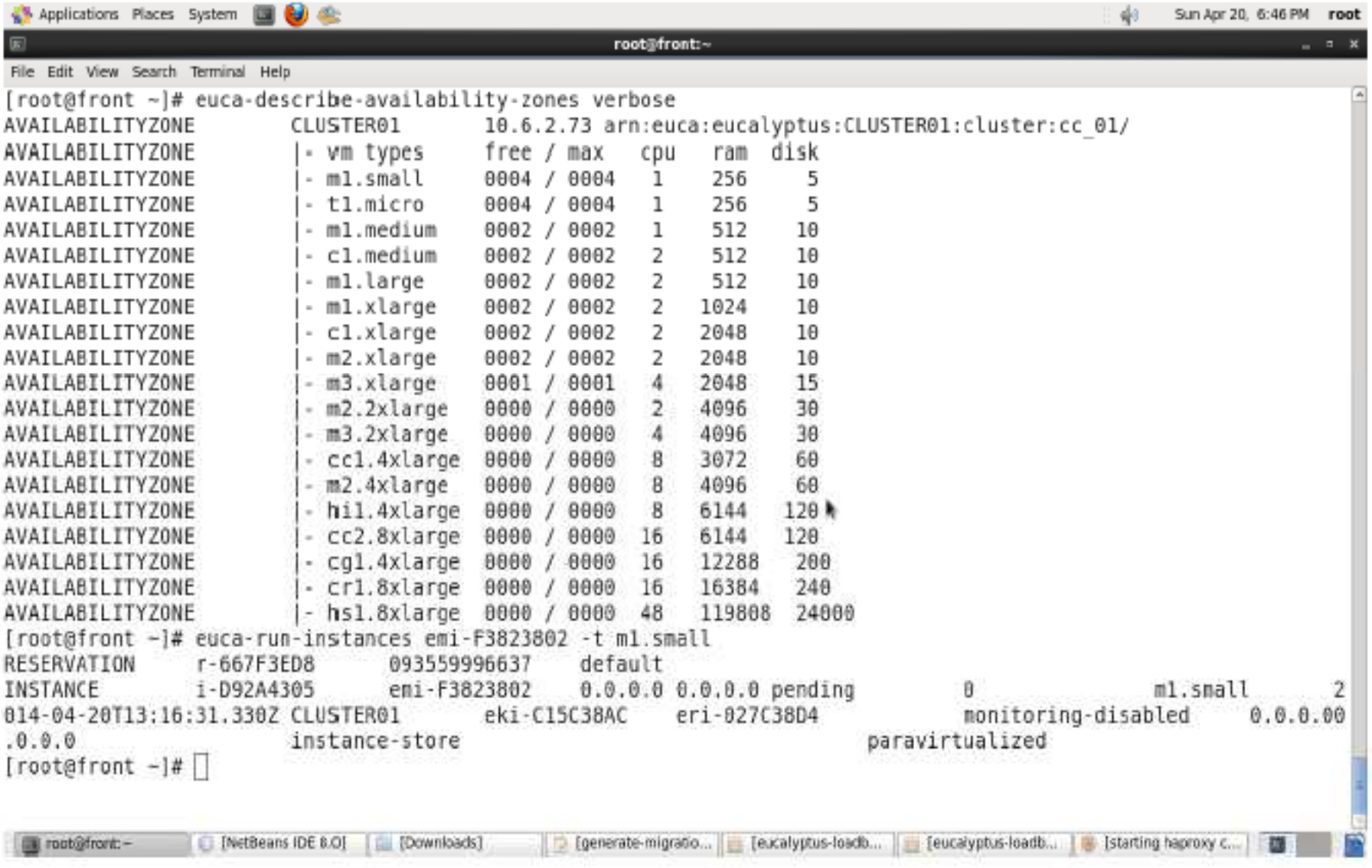
On Node Controller: Service eucalyptus-nc start



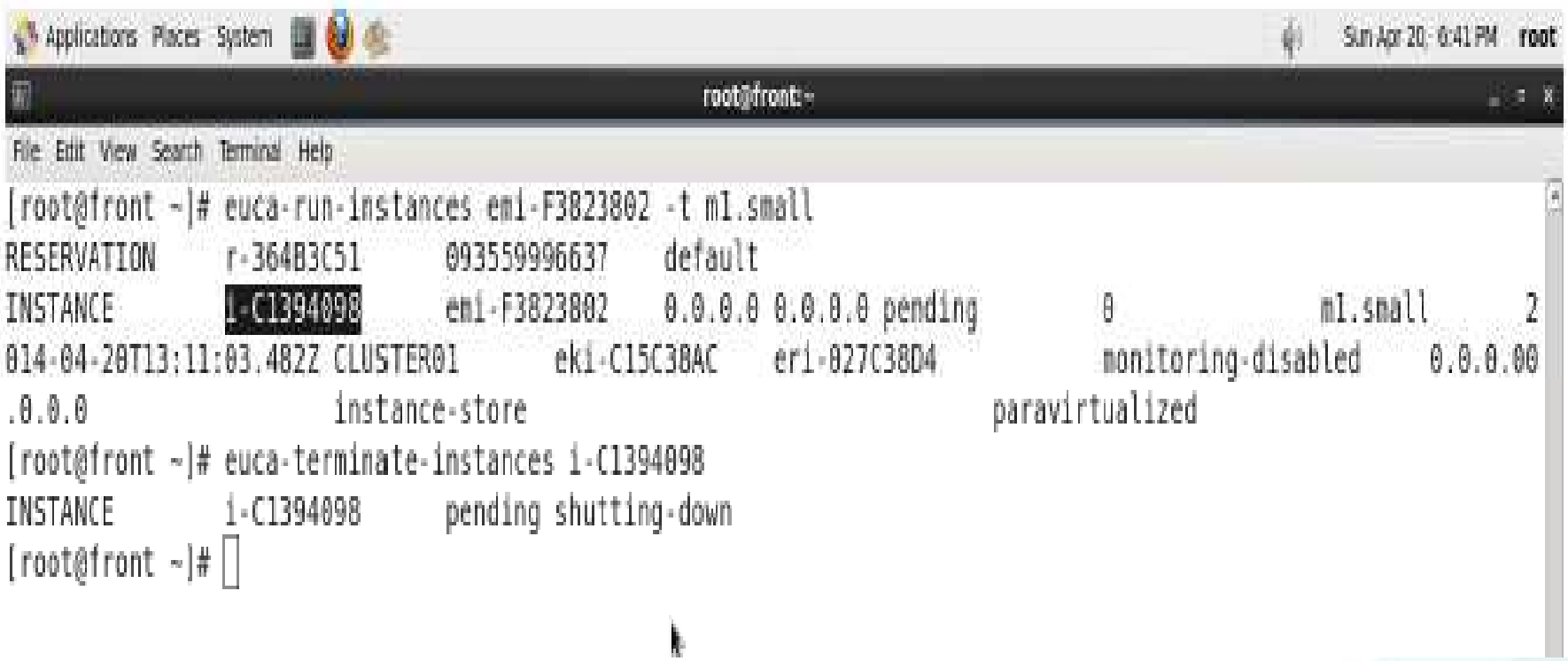
Eucalyptus Private Cloud



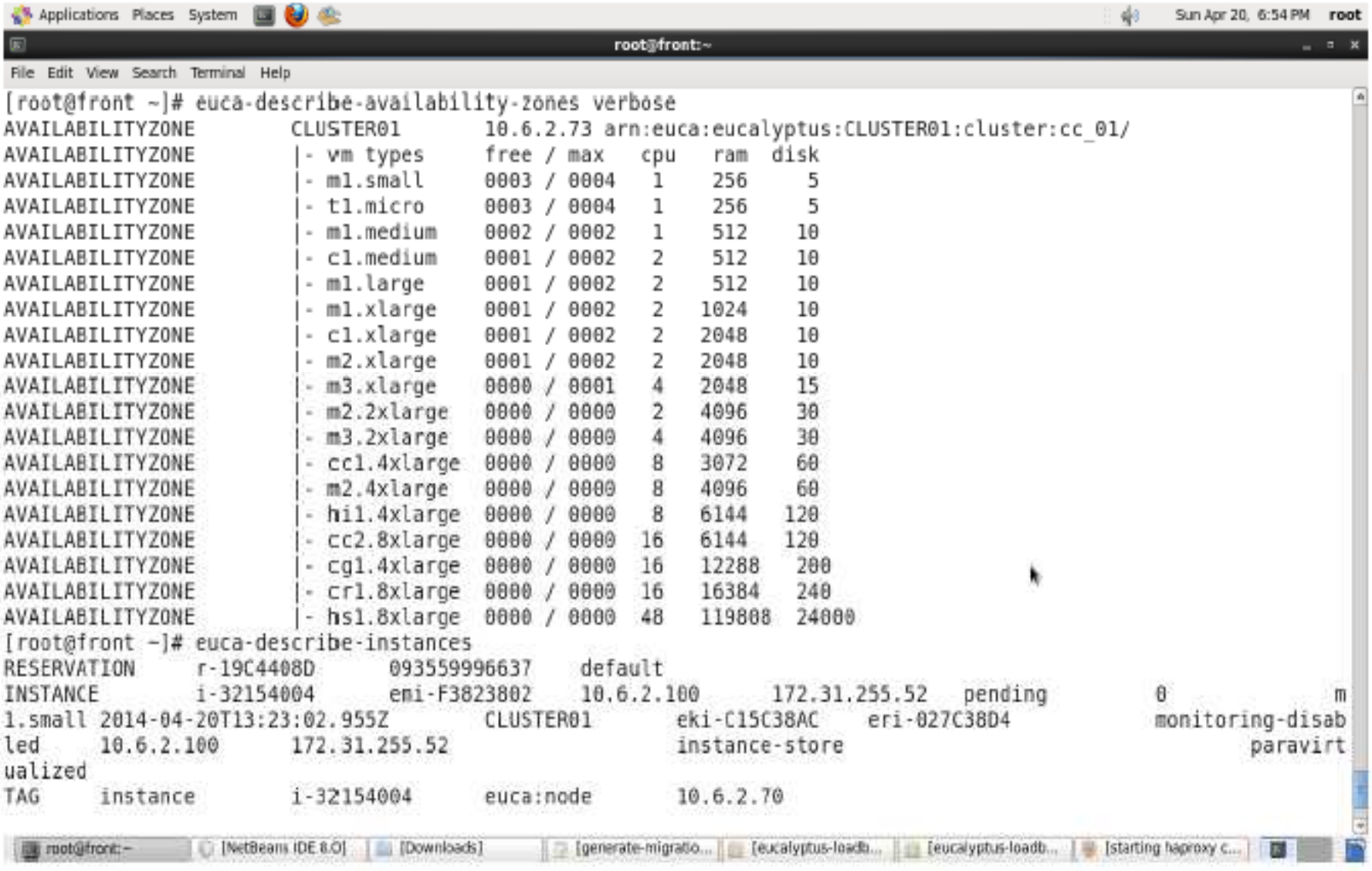
Eucalyptus Private Cloud



Eucalyptus Private Cloud



Eucalyptus Private Cloud



Eucalyptus Private Cloud

```
[root@front ~]# euca_conf --register-nodes 10.6.2.72
INFO: We expect all nodes to have eucalyptus installed in $EUCALYPTUS for key sy
nchronization.
root@10.6.2.72's password:
...done
[root@front ~]# euca-describe-availability-zones verbose
AVAILABILITYZONE        CLUSTER01       10.6.2.71 arn:euca:eucalyptus:CLUSTER01:
cluster:cc_01/
AVAILABILITYZONE        |- vm types     free / max   cpu   ram  disk
AVAILABILITYZONE        |- m1.small     0008 / 0008   1    256     5
AVAILABILITYZONE        |- t1.micro     0008 / 0008   1    256     5
AVAILABILITYZONE        |- c1.medium    0004 / 0004   2    512    10
AVAILABILITYZONE        |- m1.large     0004 / 0004   2    512    10
AVAILABILITYZONE        |- m1.xlarge    0004 / 0004   2   1024    10
AVAILABILITYZONE        |- c1.xlarge    0003 / 0003   2   2048    10
AVAILABILITYZONE        |- m2.xlarge    0003 / 0003   2   2048    10
AVAILABILITYZONE        |- m3.xlarge    0002 / 0002   4   2048    15
AVAILABILITYZONE        |- m1.medium    0005 / 0005   1    512    16
AVAILABILITYZONE        |- m2.2xlarge   0000 / 0000   2   4096    30
AVAILABILITYZONE        |- m3.2xlarge   0000 / 0000   4   4096    30
AVAILABILITYZONE        |- cc1.4xlarge  0000 / 0000   8   3072    60
AVAILABILITYZONE        |- m2.4xlarge   0000 / 0000   8   4096    60
AVAILABILITYZONE        |- hi1.4xlarge  0000 / 0000   8   6144   120
AVAILABILITYZONE        |- cc2.8xlarge  0000 / 0000  16   6144   120
AVAILABILITYZONE        |- cg1.4xlarge  0000 / 0000  16   12288   200
AVAILABILITYZONE        |- cr1.8xlarge  0000 / 0000  16   16384   240
AVAILABILITYZONE        |- hs1.8xlarge  0000 / 0000  48   119808  24000
[root@front ~]#
```

root@front:~ [aa.png]

Some IaaS Offerings from Public Clouds :

Table 4.1 Public Cloud Offerings of IaaS [10,18]

Cloud Name	VM Instance Capacity	API and Access Tools	Hypervisor, Guest OS
Amazon EC2	Each instance has 1–20 EC2 processors, 1.7–15 GB of memory, and 160–1.69 TB of storage.	CLI or Web Service (WS) portal	Xen, Linux, Windows
GoGrid	Each instance has 1–6 CPUs, 0.5–8 GB of memory, and 30–480 GB of storage.	REST, Java, PHP, Python, Ruby	Xen, Linux, Windows
Rackspace Cloud	Each instance has a four-core CPU, 0.25–16 GB of memory, and 10–620 GB of storage.	REST, Python, PHP, Java, C#, .NET	Xen, Linux
FlexiScale in the UK	Each instance has 1–4 CPUs, 0.5–16 GB of memory, and 20–270 GB of storage.	Web console	Xen, Linux, Windows
Joyent Cloud	Each instance has up to eight CPUs, 0.25–32 GB of memory, and 30–480 GB of storage.	No specific API, SSH, Virtual/Min	OS-level virtualization, OpenSolaris

Platform as a Service (PaaS)

- User can develop, deploy, and manage execution of applications using basic capabilities offered under IaaS model.
- But it is very complex to do so due to lack of platform and required tools.
- Platform includes operating system and run time library support.
- PaaS provides such platform and enables users to develop and deploy their applications
- User application can be developed on virtualized cloud platform using programming languages and software tools such as Java, Python, . NET, RUBY, Perl, R, Hive etc...

Platform as a Service (PaaS)

- The user does not manage the underlying cloud infrastructure.
- The cloud provider facilitates to support the entire application development, testing and operation support.
- Enables third party to provide software management, integration and service monitoring solutions
- Cloud services offered under PaaS model includes Google App Engine, Microsoft Azure, and Manjrasoft Aneka

Google App Engine (GAE) Platform as a Service (PaaS)

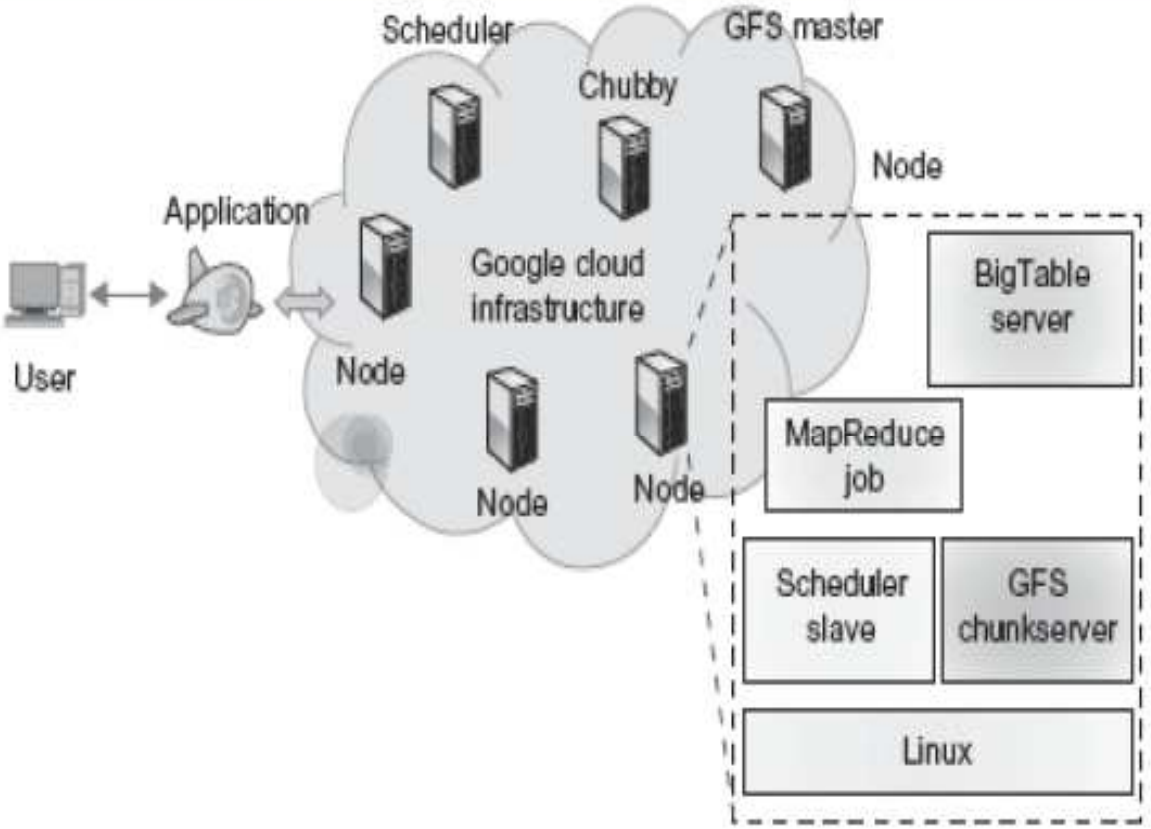


FIGURE 4.20

Google cloud platform and major building blocks, the blocks shown are large clusters of low-cost Servers.

(Courtesy of Kang Chen, Tsinghua University, China)

Google App Engine (GAE)
Platform as a Service (PaaS)

Figure 7.24 Functional components in the Google App Engine (GAE)
(Courtesy of Google, http://code.google.com/appengine/)

Google App Engine Front Page: http://code.google.com/appengine/

Signing up for an account or use your gmail account name : https://appengine.google.com/

Downloading GAE SDK : http://code.google.com/appengine/downloads.html

Python Getting Started Guide: http://code.google.com/appengine/docs/python/gettingstarted/

Java Getting Started Guide: http://code.google.com/appengine/docs/java/gettingstarted/

Quota page for free service: http://code.google.com/appengine/docs/quotas.html#Resources

Billing page if you go over the quota:
http://code.google.com/appengine/docs/billing.html#Billable_Quota_Unit_Cost

Google App Engine (GAE)
Platform as a Service (PaaS)

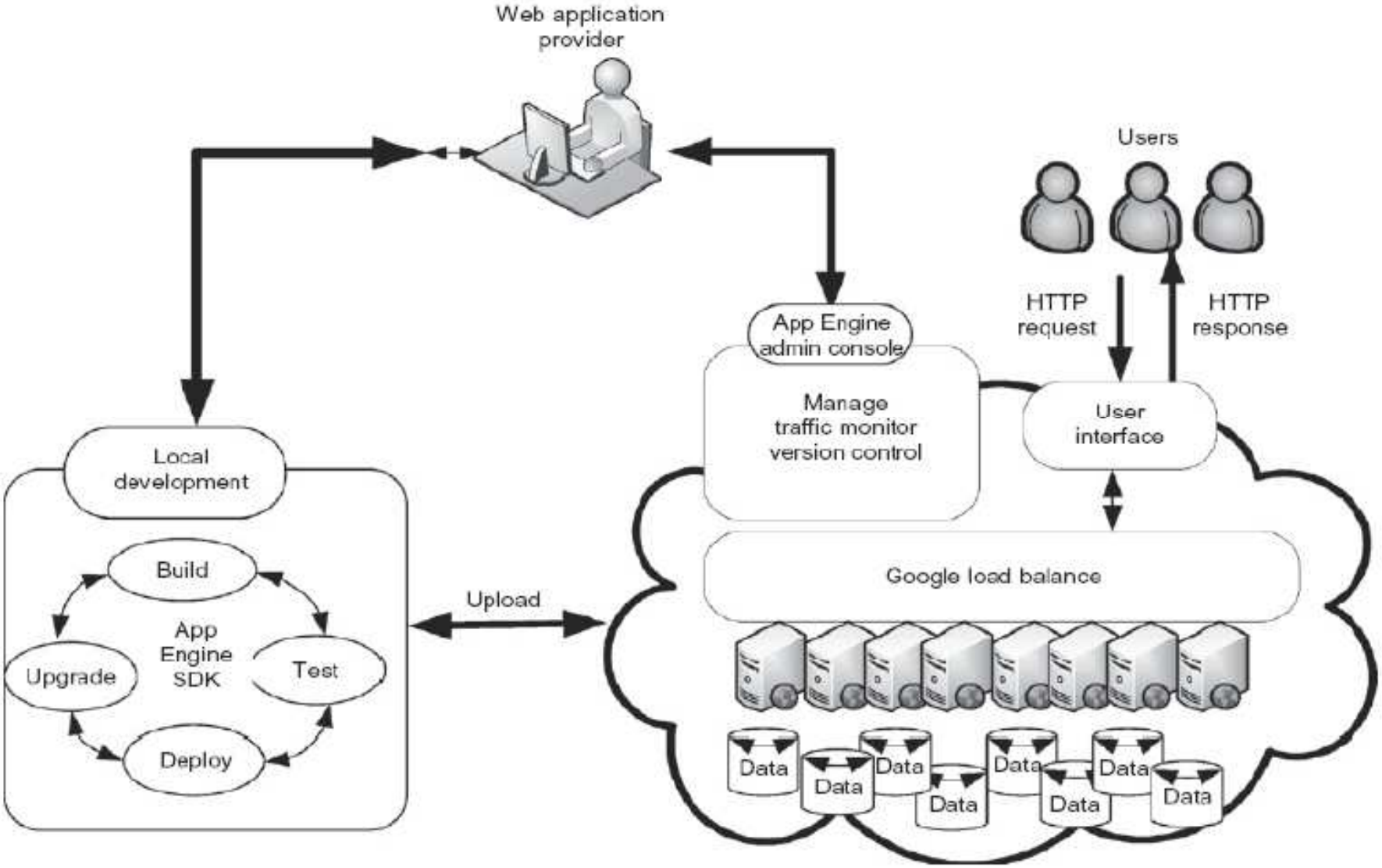


FIGURE 4.7

Google App Engine platform for PaaS operations.

Example for Platform as a Service (PaaS)

Google App Engine

- Web applications are running on a Google's server cluster.
- Application has features such as automatic scaling and load balancing which are convenient for building applications.
- Google provides fully featured local development environment that simulates GAE in developer's computer.
- All functions, and application logic are implemented locally. Coding and debugging are performed locally.
- SDK provides a tool for uploading the user's application to Google Infrastructure.

Microsoft Windows Azure
Platform as a Service (PaaS)

- Windows Azure offers a cloud platform built on Windows OS and based on MS virtualization technologies.

- All cloud services can interact with traditional MS software applications such as Windows Live, Office Live, Exchange Online, SharePoint online, Dynamic CRM online.

- The Azure platform applies the standard web communication protocols SOAP and REST

Microsoft Windows Azure Platform as a Service (PaaS)

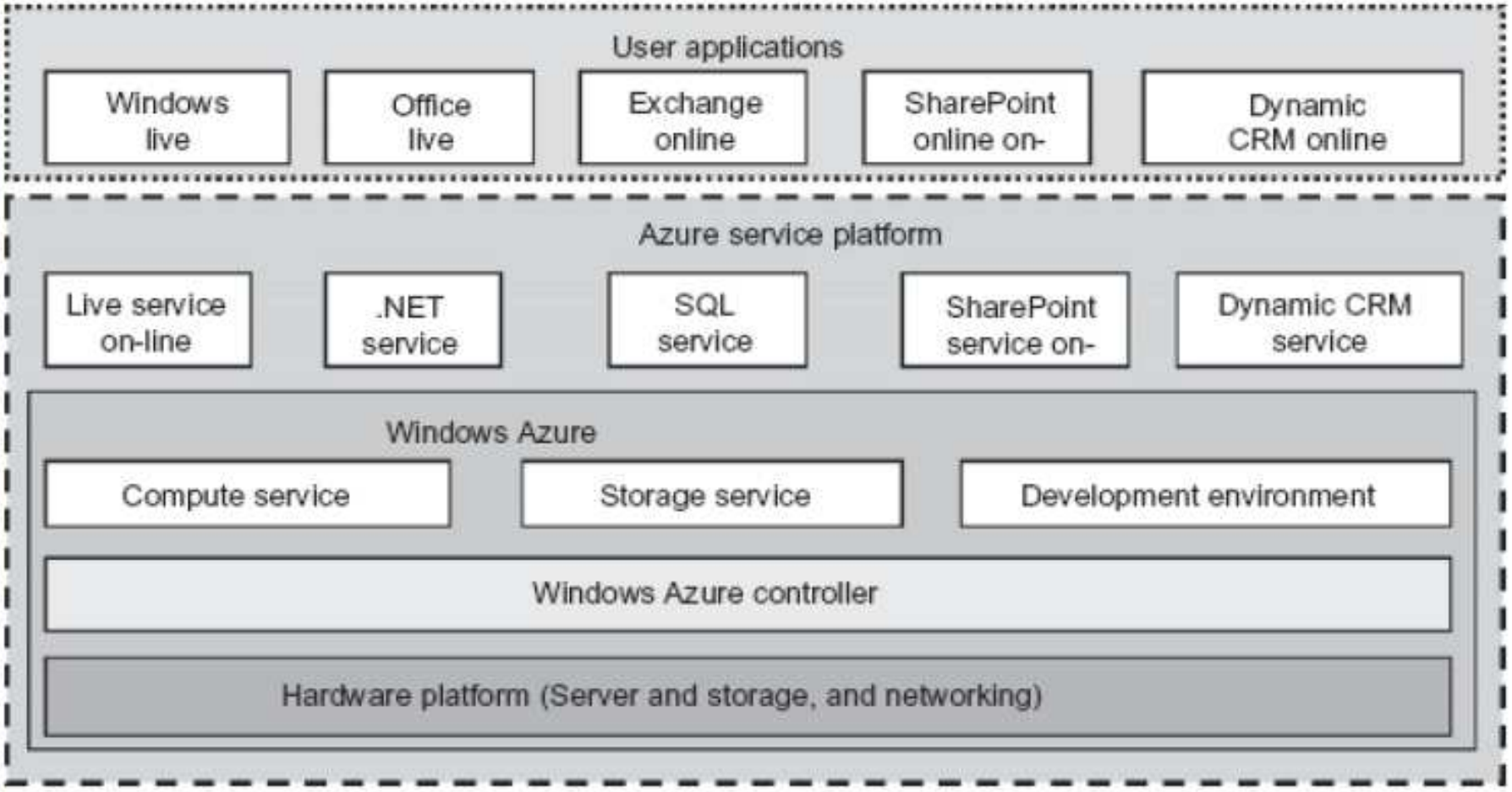


FIGURE 4.22

Microsoft Windows Azure platform for cloud computing.

(Courtesy of Microsoft, 2010, http://www.microsoft.com/windowsazure)

Microsoft Windows Azure
Platform as a Service (PaaS)

- *Live service* : Users can visit Microsoft Live applications and apply the data involved across multiple machines concurrently.
- *.NET service* : This package supports the application development on local hosts and the execution on the cloud machines.
- *SQL Azure* : This function facilitates users to visit and use the relational database associated with the SQL server in the cloud.
- *SharePoint service*: This provides a scalable and manageable platform for users to develop their special business applications in upgraded Web services.
- *Dynamic CRM service*: This provides software developers a business platform in managing CRM applications in financing, marketing, sales and promotions, etc.

PaaS Offerings from Public Clouds

Table 4.2 Five Public Cloud Offerings of PaaS [10,18]

Cloud Name	Languages and Developer Tools	Programming Models Supported by Provider	Target Applications and Storage Option
Google App Engine	Python, Java, and Eclipse-based IDE	MapReduce, Web programming on demand	Web applications and BigTable storage
Salesforce.com's Force.com	Apex, Eclipse-based IDE, Web-based Wizard	Workflow, Excel-like formula, Web programming on demand	Business applications such as CRM
Microsoft Azure	.NET, Azure tools for MS Visual Studio	Unrestricted model	Enterprise and Web applications
Amazon Elastic MapReduce	Hive, Pig, Cascading, Java, Ruby, Perl, Python, PHP, R, C++	MapReduce	Data processing and e-commerce
Aneka	.NET, stand-alone SDK	Threads, task, MapReduce	.NET enterprise applications, HPC

Software as a Service (SaaS)

- This refers to browser-initiated application software over thousands of cloud customers.

- Services and tools offered by PaaS are utilized in construction of applications and management of their deployment on resources offered by IaaS providers.

- SaaS model provides the software applications as a service.
- As a result, on the customer side, there is no upfront investment in servers or software licensing.

- On the provider side, costs are rather low, compared with conventional hosting of user applications.

Software as a Service (SaaS)

- Examples: Google Gmail, Google Docs, Microsoft online sharepoint and CRM software from Salesforce.com
- Providers such as Google and Microsoft offer integrated IaaS and PaaS services.
- Amazon and GoGrid offer pure IaaS services and expect third parties PaaS providers such as Manjrasoft to offer application development and deployment services on top of their infrastructure services.

Cloud Platforms and Services

Table 4.5 Five Major Cloud Platforms and Their Service Offerings [30]

Model	IBM	Amazon	Google	Microsoft	Salesforce
PaaS	BlueCloud, WCA, RC2		App Engine (GAE)	Windows Azure	Force.com
IaaS	Ensembles	AWS		Windows Azure	
SaaS	Lotus Live		Gmail, Docs	.NET service, Dynamic CRM	Online CRM, Gifttag
Virtualization		OS and Xen	Application Container	OS level/ Hypel-V	
Service Offerings	SOA, E2, TSAM, RAD, Web 2.0	EC2, S3, SQS, SimpleDB	GFS, Chubby, BigTable, MapReduce	Live, SQL Hotmail	Apex, visual force, record security
Security Features	WebSphere2 and PowerVM tuned for protection	PKI, VPN, EBS to recover from failure	Chubby locks for security erforcement	Replicated data, rule-based access control	Admin./record security, uses metadata API
User Interfaces		EC2 command-line tools	Web-based admin. console	Windows Azure portal	
Web API	Yes	Yes	Yes	Yes	Yes
Programming Support	AMI		Python	.NET Framework	

Note: *WCA: WebSphere CloudBurst Appliance; RC2: Research Compute Cloud; RAD: Rational Application Developer; SOA: Service-Oriented Architecture; TSAM: Tivoli Service Automation Manager; EC2: Elastic Compute Cloud; S3: Simple Storage Service; SQS: Simple Queue Service; GAE: Google App Engine; AWS: Amazon Web Services; SQL: Structured Query Language; EBS: Elastic Block Store; CRM: Consumer Relationship Management.*

Cloud Computing as A Service

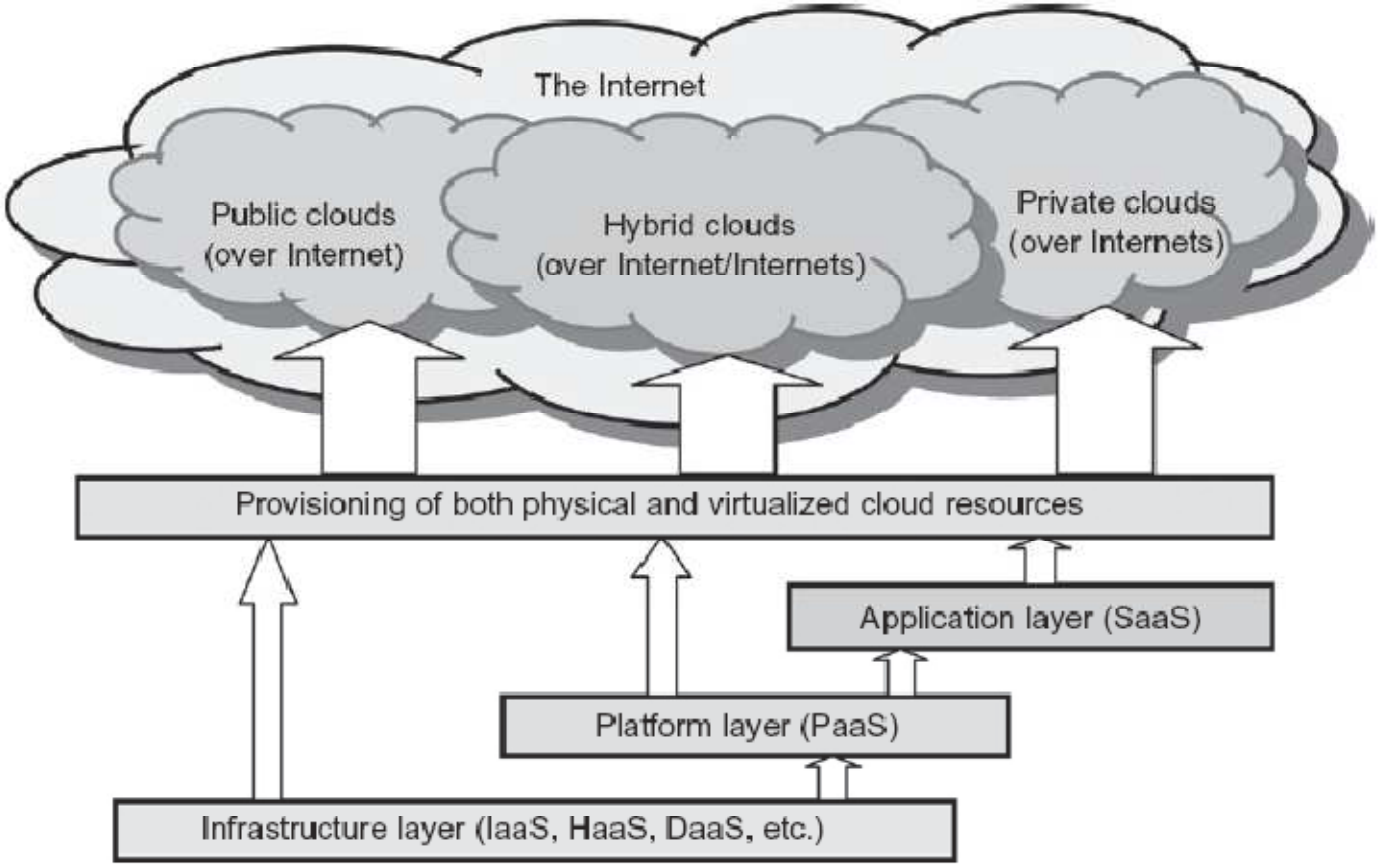


FIGURE 4.15

Layered architectural development of the cloud platform for IaaS, PaaS, and SaaS applications over the Internet.

Public Clouds and Service Offerings

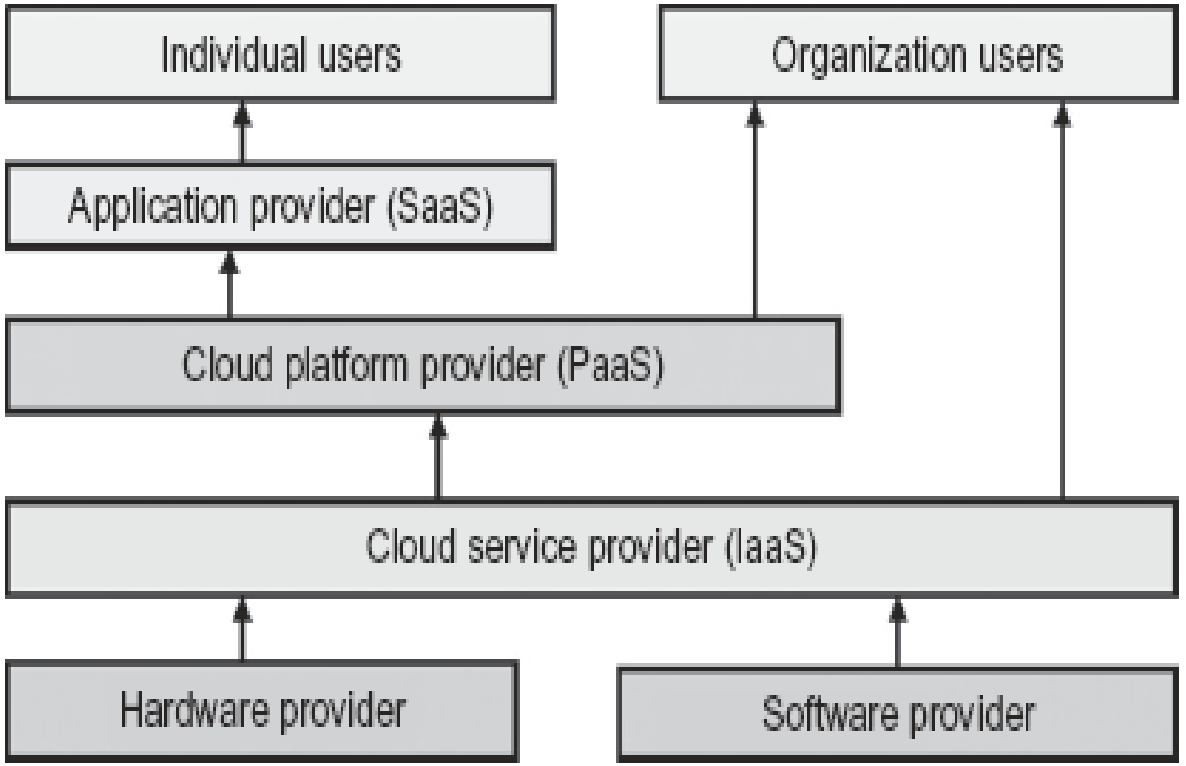


FIGURE 4.19

Roles of individual and organizational users and their Interaction with cloud providers under various cloud service models.

Challenges in Cloud Computing (1)

- Concerns from The Industry (Providers)
  - Replacement Cost
    - Exponential increase in cost to maintain the infrastructure
  - Vendor Lock-in
    - No standard API or protocol can be very serious
  - Standardization
    - No standard metric for QoS is limiting the popularity
  - Security and Confidentiality
    - Trust model for cloud computing
  - Control Mechanism
    - Users do not have any control over infrastructures

Challenges in Cloud Computing (2)

- Concerns from Research Community :
  - Conflict to legacy programs
    - With difficulty in developing a new application due to lack of control
  - Provenance
    - How to reproduce results in different infrastructures
  - Reduction in Latency
    - No specially designed interconnect used
    - Very low controllability in layout of interconnect due to abstraction
  - Programming Model
    - Hard to debug where programming naturally error-prone
    - Details about infrastructure are hidden
  - QoS Measurement
    - Especially for ubiquitous computing where context changes

Security and Trust Barriers in Cloud Computing

- Protecting datacenters must first secure cloud resources and uphold user privacy and data integrity.
- Trust overlay networks could be applied to build reputation systems for establishing the trust among interactive datacenters.
- A watermarking technique is suggested to protect shared data objects and massively distributed software modules.
- These techniques safeguard user authentication and tighten the data access-control in public clouds.
- The new approach could be more cost-effective than using the traditional encryption and firewalls to secure the clouds.

Inter-Cloud or Mashup Services

(Cloudbus Project at the University of Melbourne)

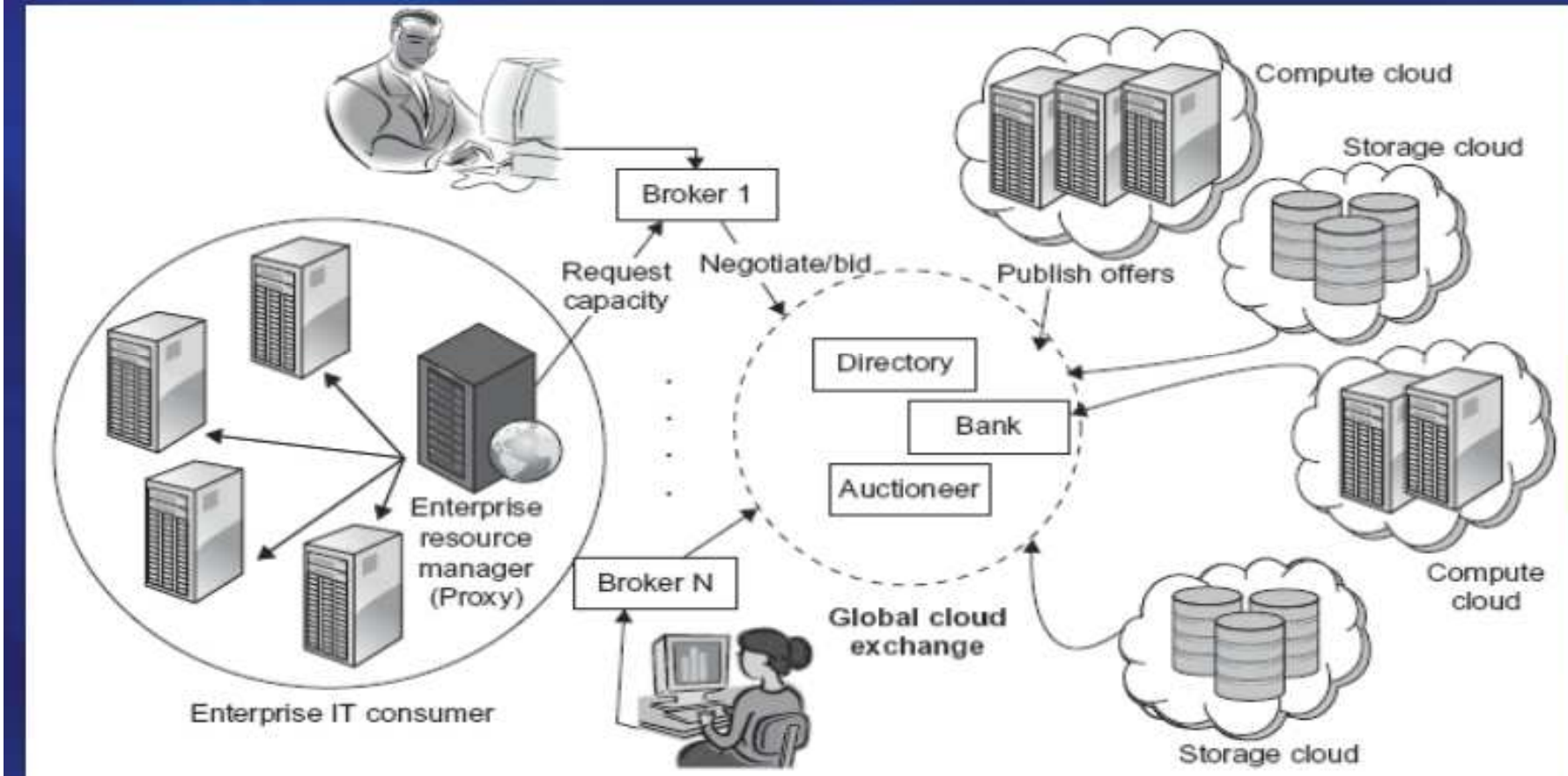


FIGURE 4.30

Inter-cloud exchange of cloud resources through brokering.

(Courtesy of R. Buyya, et al., University of Melbourne [12])

Summary

- Cloud Deployment Models
  - Public Cloud
  - Private Cloud
  - Hybrid Cloud
  - Community Cloud
- Cloud Ecosystem
- Cloud Service Models
  - Infra-structure as a Service (IaaS)
  - Platform as a Service (PaaS)
  - Software as a Service (SaaS)
- Cloud Computing Challenges

References

1. R. Buyya, J. Broberg, A. Goscinski (Eds.), Cloud Computing: Principles and Paradigms, Wiley Press, 2011
2. Cloud Computing Tutorial, www. thecloudtutorial.com, January 2010.
3. David Lloud Johnson and Daniel Vucci. Auto scaling and cloud bursting service for Eucalyptus. In Virtualization and cloud computing technologies Fall 2011.
4. Eucalyptus Private Cloud. http://www.eucalyptus.com/eucalyptus-cloud/get-started
5. Amazon Elastic Compute Cloud. http://aws.amazon.com/ec2


THANK YOU
SSN