



 **PMCA506L: Cloud Computing  Module 2 : Cloud Infrastructure  Courtesy : *Ming Lian , Dogules E Comer & Other Sources of Internet***

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Elastic Computing 

• Cloud computing centers on the ability of a customer to lease servers and only pay for the number of servers they need.

• A customer can choose to lease a few servers or many.

• More important, a customer can change the allocation dynamically, adding servers during peak times and decreasing the number of servers during times they are not needed.

• A customer could lease a full rack of servers, a half rack, or a quarter rack, or multiples of the sizes.

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**How Virtualized Servers Aid Providers ?** • From a cloud provider’s point of view, the ability to virtualize servers provides the basis for elastic computing and makes cloud computing economically viable. 

• A cloud provider only needs to use computer software to increase or decrease the number of servers a customer is leasing.

• Furthermore, the use of virtualized servers allows a provider to accommodate the changing needs of many customers.

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**How Virtualized Servers Help A Customer ?** • To a customer, a virtualized server appears to act like a physical server.

• A virtualized server allows apps to communicate over the Internet.

• Like a physical server, each virtualized server is assigned an Internet address.

• A virtualized server can boot a standard operating system and then allow a user to run standard apps, just as if the operating system runs on the physical server.

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**Business Models For Cloud Providers **

• Software as a 

Service (SAAS)

• Platform as a

Service (PAAS)

• Infrastructure as

a Service (IAAS)

***Universal access Guaranteed synchronization*High availability **

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Cloud Services Available 



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Software as a Service(SAAS) • Model-Application hosted as a service • Customer doesn’t maintain it 

• Out of Customer’s hand when hosting service decides to change it

• CRM ,Video Conferencing ,Accounting • Web Analytics, IT Service Management **Benefit**

• Smaller Staff

• Customization

• Security (SSL-Secured Sockets Layer)

• QOS with more bandwidth

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Platform as a Service 

• Application Delivery Model

• Supplies all resources to build application • Design,Development,Testing,Deployment,Hosting • Web service Integration, DB

Integration,Security,Scalability,Storage.



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Infrastructure as a Service 

• Simply offers Hardware

(Servers,Racks,pay for space)

• HAAS-Rent Resources

-> Server Space

-> Network Equipment

-> Memory

-> CPU Cycles

-> Storage Space

• Billed on Utility Computing Basis • Network(Firewalls,Routers,LB..)

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Desktop as a Service(DaaS) • System implements remote desktop access 

• DaaS paints a desktop on the user’s screen and allows the user to click on icons, run apps, browse files, and perform other actions exactly as if the desktop was local.

• The desktop that the user sees, the operating system that supplies the desktop, and the apps a user invokes all run on a server in the cloud instead of the user’s local device.

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****Service Level Agreement (SLA) • The SLA is a contract negotiated and agreed between a customer and a service provider • Service provider is required to execute service requests from a customer within negotiated quality of service requirements for a given price • Due to variable load, dynamically provisioning computing resources to meet an SLA and allow for an optimum resource utilization will not be an easy task

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**Architectural**

▪ Multi-tenancy ▪ Scalability ▪ Security

▪ Performance

**Functional**

▪ Provisioning ▪ Billing

▪ Metering

▪ Monitoring

**Business Model Usage-based pricing** 

• **Per user per month** 

• **Per transaction** 

• **Per GB of storage per month**

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****Service Model Architecture 

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**Types of Cloud(Deployment Models)** 

• Public cloud

– Sold to the public, mega-scale infrastructure – available to the general public

• Private cloud

– single org only,

– managed by the org or a 3rd party,

– on or off premise

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**Types of Cloud(Deployment Models)** • Hybrid cloud

– composition of two or more clouds

– bound by standard or proprietary technology

• Community cloud

– shared infrastructure for specific community – several orgs that have shared concerns, – managed by org or a 3rd party

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Public Cloud 



The Public Cloud Model allows systems and services to be easily accessible to general public. e.g. Google, Amazon, Microsoft offers cloud services via internet.

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**The Advantages Of Public Cloud ** • **Economic** – much lower cost than a private cloud

• **Expertise** –access to a staff with expertise on many topics

• **Advanced services**– offerings not available elsewhere

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**Private Cloud** 

**A private cloud is a cloud computing environment dedicated to a single organization.** 

**A private cloud can be hosted either at an organization's own data center, at a third party colocation facility, or via a private cloud provider who offers private cloud hosting services**

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Private Cloud 

**Retention of control and visibility Reduced latency with on-premises facilities**

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**Community Cloud** 

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The **Community Cloud** allows system and services to be accessible by group of organizations. It shares the infrastructure between several organizations from a specific community. It may be managed internally or by the third-party.

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****Hybrid Cloud **www.nadeshrk.webs.com**

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****Cloud Definition Framework Hybrid Clouds

**Private**

**Community**

Deployment Models

**CloudPublic Cloud Cloud** 

Service Models

Software as a Service (SaaS)

Platform as a

Service (PaaS)

On Demand Self-Service

Infrastructure as a Service (IaaS)

Essential

Broad Network Access Rapid Elasticity

Characteristics

Resource Pooling

Measured Service

Massive Scale Resilient Computing

Common

Homogeneity

Geographic Distribution

Characteristics

Virtualization Service Orientation

Low Cost Software

Advanced Security

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****Essential Cloud Characteristics • On-demand self-service

– Get computing capabilities as needed automatically • Broad network access

– Services available over the net using desktop, laptop, PDA, mobile phone

23

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****Essential Cloud Characteristics (Cont.) • Resource pooling

– Location independence

– Provider resources pooled to server multiple clients • Rapid elasticity

– Ability to quickly scale in/out service

• Measured service

– control, optimize services based on metering

24

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**Cloud computing - Characteristics**

• Agility – On demand computing infrastructure

– Linearly scalable – challenge

• Reliability and fault tolerance

– Self healing – Hot backups, etc

– SLA driven – Policies on how quickly requests are processed

• Multi-tenancy – Several customers share infrastructure, without compromising privacy and security of each of the customer’s data

• Service-oriented – compose applications out of loosely coupled services. One service failure will not disrupt other services. Expose these services as API’s

**Cloud computing - Characteristics**

• Virtualized – decoupled from underlying hardware. Multiple applications can run in one computer

• Data, Data, Data

– Distributing, partitioning, security, and synchronization

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Market Oriented Cloud 



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28

**Conventional Computing** 

**vs.**

**Cloud Computing**

• Conventional Cloud

• Manually Provisioned

• Dedicated Hardware

• Fixed Capacity

• Pay for Capacity

• Capital & Operational Expenses 9/2/2023

• Self-provisioned • Shared Hardware • Elastic Capacity • Pay for Use

• Operational Expenses

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**NIST- Cloud Computing Standards** 

**(National Institute of Standards and Technology )**

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**Provider Lock-In** 

• Cloud providers usually offer a *migration service* that makes it easy for a corporate customer to move their computing into the provider’s public cloud.

• *cloud-to-cloud migration services*.

• Industry uses the term lock-in to refer to the practice of using enticements and obstacles that make it in convenient ore expensive for customers to move to another cloud provider.

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**Multi-Cloud** 

• An organization becomes a customer of more than one public cloud provider.

• The division of computation among providers depends on the structure of the organization and its IT needs.

• An organization can also adopt a multi-cloud approach in which the organization uses multiple public cloud providers.

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**Hyperscalers **

• Companies that own and operate the largest data centers are known as hyperscalers.

• Among public hyperscale cloud providers, Amazon’s AWS, Microsoft’s Azure Cloud, and Google’s GCP have attracted enterprise customers.

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***Data Center Infrastructure And Equipment*** 

**Racks, Aisles, And Pods**

• Physically, racks holding equipment are placed side by side in rows, leaving *aisles* between them.

• Data center is built by replicating a basic set of equipment known as a *pod.*

• A pod or a cluster is simply a set of computers linked by high-speed networks into a single unit

• A point of delivery, or PoD, is "**a module of network, compute, storage, and application components that work together to deliver networking services”**.

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**Pod Size** 

• An early design created pods with over 200 racks per pod.

• The industry has moved to smaller sizes, where a pod with 48 racks is considered “large,” and an average-size pod contains 12 to 16 racks.

✔ Incremental growth

✔ Manageability

✔ Power and cooling

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****Design – Heat Reducing • Raised floor pathways and air cooling • Thermal containment and hot/cold aisles • Exhaust ducts(chimneys)

• Lights-out datacenters



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**Thermal Containment And Hot/Cold Aisles** 

• Hot air leaves each piece of equipment, venting into the data center.

• Overall, air flow in the data center must be designed carefully to move hot air away from the racks.

• Ensuring that it cannot be accidentally drawn back into another piece of electronic equipment.

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**Thermal Containment And Hot/Cold Aisles  **

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**Exhaust Ducts (Chimneys) **

• Despite fans in the ceiling that draw hot air upward, the temperature near racks with high power density can be higher than other areas of a datacenter.

• Designers refer to such areas as *hot spots*.

• For areas that generate inordinate heat, a vertical duct with a fan can be placed over the area with a fan to move hot air upward.

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**Lights-Out Data Centers** 

• An operational paradigm has been invented that helps reduce heat in a data center: minimize any extraneous use of electricity.

• *lights-out datacenter*, the scheme means that entire parts of the data center operate in the dark.

• To minimize the time lights must be on, servers, network switches, and storage equipment are accessed and managed over a network.

• The availability of reliable, automated failure recovery and maintenance systems has further enabled the lights-out approach.

• Automated systems are used for routing, monitoring tasks, and handling fast cut-over during failures.

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****Lights out Approach

• In addition to reducing energy costs, The lights-out approach has three advantages. •

• Using automated systems to monitor a data center offers owners cost savings by reducing the staff size; automation is less likely than human operators to misconfigure equip ment; and restricting personnel in the data center reduces the threat of malicious attacks.

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**A Possible Future Of Liquid Cooling** 

• When it changes from air cooling to liquid cooling, a data center must install hydraulic equipment to circulate cold liquid refrigerant to the racks and return heated refrigerant to the cooling unit.

• In addition, all servers and network equipment must be replaced with units that have hydraulic fittings to accommodate liquid cooling.

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**Network Equipment And Multi-Port Server Interfaces ** • Servers (Physical machines)

• Storage

• Network devices (switch, router, cables) • Topology

• Routing / switching equipment

• Protocols

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**Top-Of-Rack Architecture**

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Rapid Data Transfer 

• The connections between the ToR switch and each server must operate at high speed (Gbps) • Data centers - 10 Gbps and 40 Gbps

• To further increase the rate at which data can be sent, each server can use a ***multi-port network interface card*** (*multi-port NIC*).

• Each of the ports connects to the ToR switch, and each operates independently and in parallel. • A multi-port NIC works well with a multi-core server because it allows the server to send and receive more data.

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****Traditional DC Topology

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Layer 2 vs. Layer 3? 

**Ethernet switching (layer 2)**

◆ Cheaper switch equipment

◆ Fixed addresses and auto-configuration ◆ Seamless mobility, migration, and failover

**IP routing (layer 3)**

◆ Scalability through hierarchical addressing ◆ Efficiency through shortest-path routing ◆ Multipath routing through equal-cost multipath

• **Data centers often connect layer-2 islands by IP routers** 

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****Conventional Topology 

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**Standard Data Center Routing**

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**North-South And East-West Network Traffic** 

• How should the ToR switches in all the racks be interconnected to form a network in the data center?

• How should the data center network connect to the Internet?

• A variety of network architectures have been used in data centers

North-south traffic

East-west traffic

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North-South traffic 

• Industry uses the term north-south traffic to describe traffic sent between arbitrary computers on the Internet and servers in a datacenter.

• For example, that early data centers focused on large-scale web sites. Web traffic falls into the category of north-south traffic.

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East-west traffic 

• Consider a company using cloud computing. When the company fills an order, software may need to access both a catalog of products as well as a customer database.

• Similarly, when a manager approves time off, software may need to access an employee’s record, payroll data, and the company’s accounting system.

• Communication within the company means network traffic will travel among the servers the company has leased.

• Communication proceeds left and right, which leads to the name east-west traffic.



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****Network Hierarchies, Capacity, And Fat Tree Designs • Hierarchical / staged/layered/fat tree

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****Clos Topology



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*Leaf-Spine Architecture* 

• ***How can a data center network be designed that handles large volumes of east-west traffic without using a hierarchical design?***

• The answer lies in parallelism and a form of load balancing.

• The specific approach used in data center is known as a *leaf-spine network architecture* • In leaf-spine terminology, each Top-of-Rack switch is called a *leaf*.

• An additional set of *spine* switches and connects each leaf switch to each spine switch.

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*Leaf-Spine Architecture* 

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Leaf-Spine Architecture 

• **Higher capacity for east-west traffic**

• **Redundant paths to handle failures**

Because both the source and destination racks connect to all four spine switches, four independent paths exist between each pair of racks, one path through each spine switch

A leaf switch equipped with *Equal Cost Multipath Routing* (*ECMP*) technology can be configured to divide traffic equally among the paths.

ECMP means one- fourth of the data will travel through spine 1, another fourth of the data will travel through spine 2, and so on

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**Redundant paths to handle failures  **

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**Scaling A Leaf-Spine Architecture With A Super Spine **

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**Storage In A Data Center** 

• Data center providers follow the same basic approach for storage facilities as they do for computational facilities: parallelism.

• Modern data centers use *Solid State Disks* (*SSDs*).

• Virtualized disk.

• Industry uses the term *block storage* to refer to virtualized disks.

• As software on a virtualized server accesses or stores data on its disk, requests travel across the data center network to the storage facility, and replies travel back over the network.

• The higher reliability of solid state disks has lowered failure rates, making replacement much less frequent.

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**Unified Data Center Networks** 

• Early data center storage facilities used specialized network hardware that was designed to optimize remote storage access. The specialized hardware was expensive and required running extra cables.

• Data centers are now using a single network for storage access as well as other communication.

• *The availability of low-cost Ethernet hardware and a leaf spine network architecture has allowed data centers to eliminate special- purpose storage networks and move to a single, unified network that carries storage access traffic as well as other traffic.*

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Summary 

• Elastic Computing

• Business Model

• Types of Cloud

• Data Centers

• Leaf-Spine Architecture • Storage

• Unified Datacenter Networks **www.nadeshrk.webs.com**

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