Course: Cloud Computing

Week 4: Network in the cloud Computing

Lecturer: Ikwap Flavia Agatha
MSc. Computer Forensic
PHD in IT (Candidate)
University: Kumi University

Lecture learning outcome:

- At the end of the week 4 lecture you will be ale to:
- Define a computer network
- Understand the different networking devices
- Understand the different Types of servers
- Understand the different Transmission medias
- Comprehend the different network types

Lecture learning outcome:

- Understand the internet
- Appreciate the history of the internet
- Understand How the internet works
- Understand the different web technologies
- Understand the architecture of cloud networking
- Comprehend the different challenges in the existing cloud networks

Computer Network

- What is Computer Networking?
- A network refers to two or more connected computers that can share resources such as data, a printer, an Internet connection, applications, or a combination of these resources.

Networking devices

- A network device is a device that receives a message from one resource on a network and determines how to pass the message along the network.
- **HUB:**
- It operates by receiving a message and passing it on to all the resources it connects to. The hub is sometimes referred to as a multiport repeater, because its job is to repeat the incoming message across all its ports (connections).

Networking devices

- **Switch**
- The network switch passes an incoming message onto a single resource. The switch uses the destination address to determine the device to which the message should be passed.
- When a device is connected to a switch, the switch acquires that device's MAC address and retains it in a table. This table is a simple listing that for each port on the switch, the attached device's hardware address is stored.

Networking devices

- **Router**
- Routers are network devices that determine the path to send information from one computer to another or from one network to another network. A router ensures that information reaches its intended destination and nowhere else. The primary function of a router is to connect networks together.

Networking devices

- **Gateway:**
- The gateway is a router that connects different types of networks together. More specifically, the gateway has the ability to translate a message from one protocol into another.
- **Firewalls**
- A firewall is a network device—hardware, software, or a combination thereof.
- Its purpose is to enforce a security policy across its connections by allowing or denying traffic to pass into or out of the network.

Networking devices

- **Bridges**
- A bridge operates at the data link layer, filtering traffic based on MAC addresses.
- **Network Interface Card-NIC**
- A NIC is used to connect a computer to a computer network. Examples; an Ethernet card is used to connect a computer to an Ethernet network, whereas a Token Ring Adapter is used to connect a computer to a Token Ring network.

Load balancers

- They are designed to distribute the processing load over two or more systems.
- They are used to help improve resource utilization and throughput but also have the added advantage of increasing the fault tolerance of the overall system since a critical process may be split across several systems.

Networking devices

- **MODEM**
- The term MODEM stands for MOdulation DEModulation. These two terms express the conversion of digital information into analog information (modulation) and analog information into digital information (demodulation).

Server:

- The server is a combination of the physical device designated to handle the service request and the server software package
- The use of servers in a network suggests that the network is set up as using a client–server model.
- A company's cloud is a collection of servers (sometimes called a server farm) that run virtual machines (VMs).

Types of servers

- **Application Server;**
- Runs application software across the network, there is no need to have the same applications installed on individual networks examples include Coldfusion, Enterprise Server, Glass Fish, net weaver, Tomcat, weblogic, websphere, windows server
- **Database server**: provides networked access to a backend database e.g Mongo Db, Mysql, Oracle
- DHCP Server; Provide dynamic IP addresses to clients in a network for example DHCP Server, dnsmasq, ISC DHCP

Types of servers

- **E-Mail Servers**: transfers emails between local client and email server's examples include Apache James, IBM Lotus Domino, Microsoft exchange server, yahoo server, Gmail server, Novell netmail
- **File servers**: Shared storage utility accessed over the network
- **FTP Server;** supports file transfer protocol so that clients can upload and download files from the server eg. Cerberus FTP Server, Filezilla server, ftpd , freeFTPd, Microsoft internet information services, WS FTP,

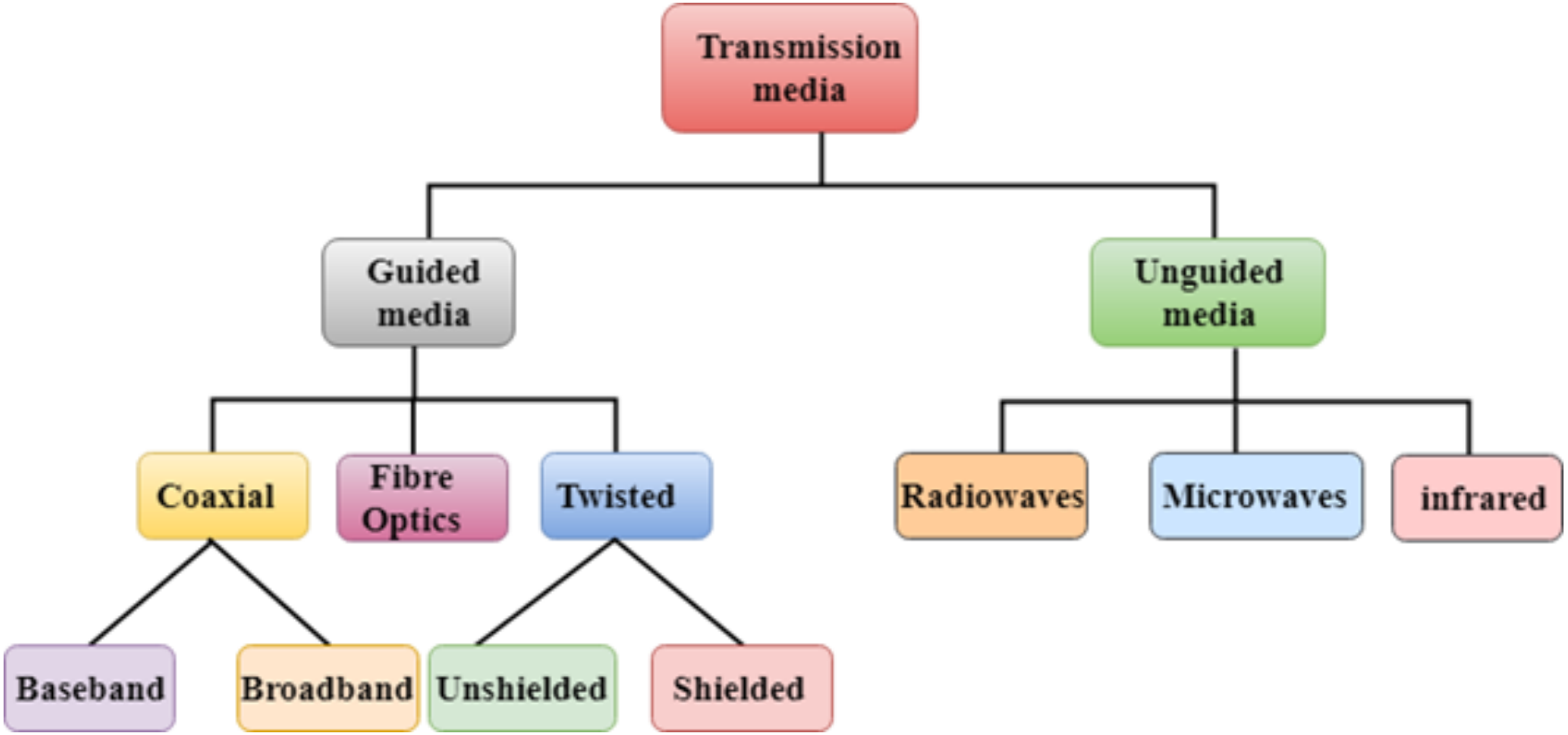
Types of servers

- **Name server (DNS);** Resolves domain namesninto IP addresses and so serves as a cache for example BIND,Cisco Network registrar, dnsmasq, simple DNS Plus, Power DNS
- **Print Server:** Connects clients to a printer to maintain a queue of print jobs for example, CUPS,JetDirect, NetBIO, Net ware
- **Proxy server:** intermediates between web client and web server, for example CC Proxy server, intenet security, Acceleration server, Squid, win Gate

Types of servers

- **SSH Server:** Uses the secure shell protocol to accept connections from remote computers examples include Apache MINA SSHD, Copssh, OpenSSH, Pragma systems SSH Server, Teetia SSH Server
- **VM Server:** creates virtual machines that themselves can be used as computers, web servers, email servers, database servers etc
- **Web server:** Responds to HTTP requests and returns web pages for example AOL server, Apache, Openlitespeed, oracle HTTP Server, Oracle weblogic server

Transmission Media

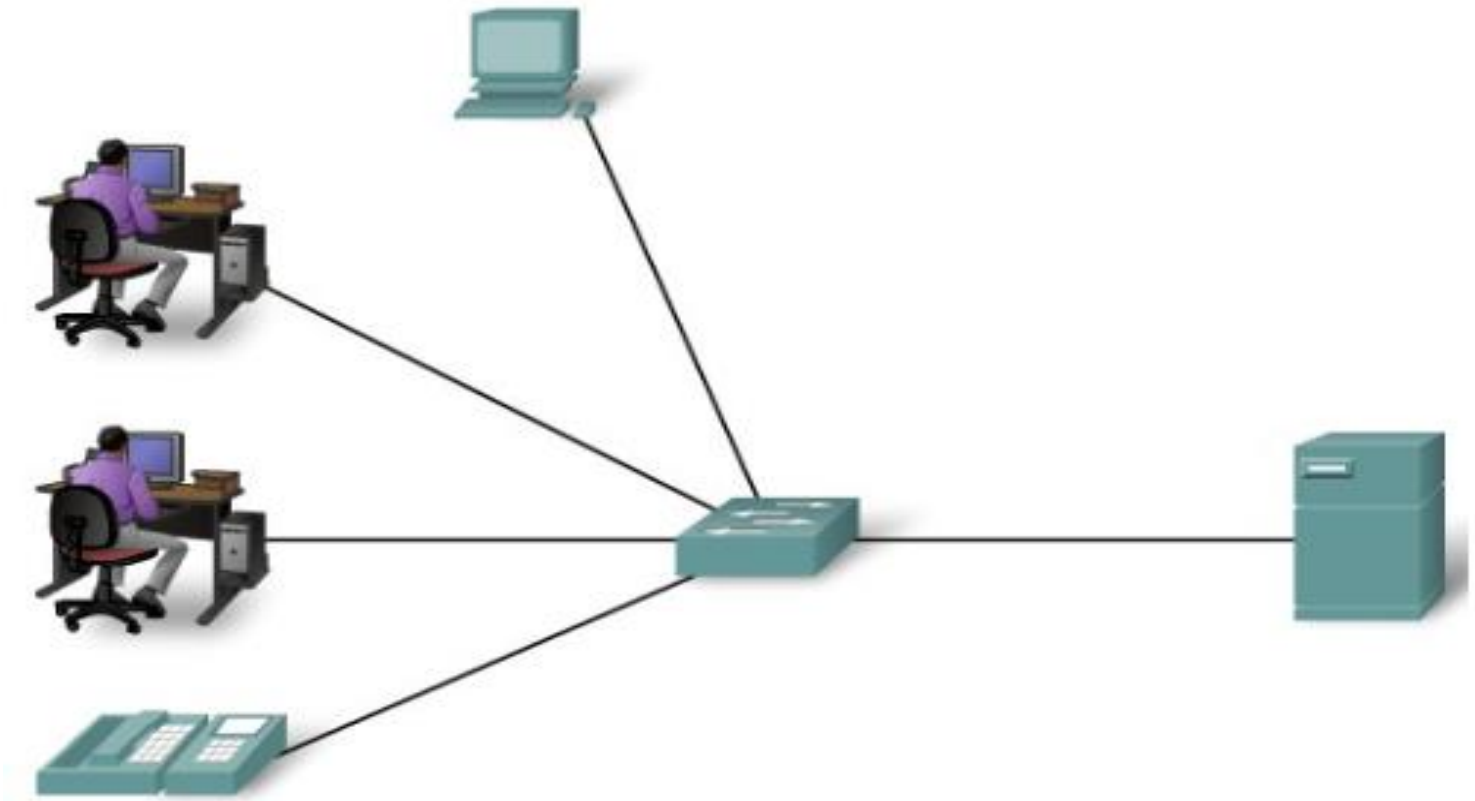


- https://dspmuranchi.ac.in/pdf/Blog/Guided%20Transmission%20media.pdf

Network Types

- Local Area Network (LAN)
- Privately owned small networks that are confined to a localized area (e.g., an office, a building or a factory) are known as Local Area Networks (LANs).

LAN-Serving a home, office, building or a campus



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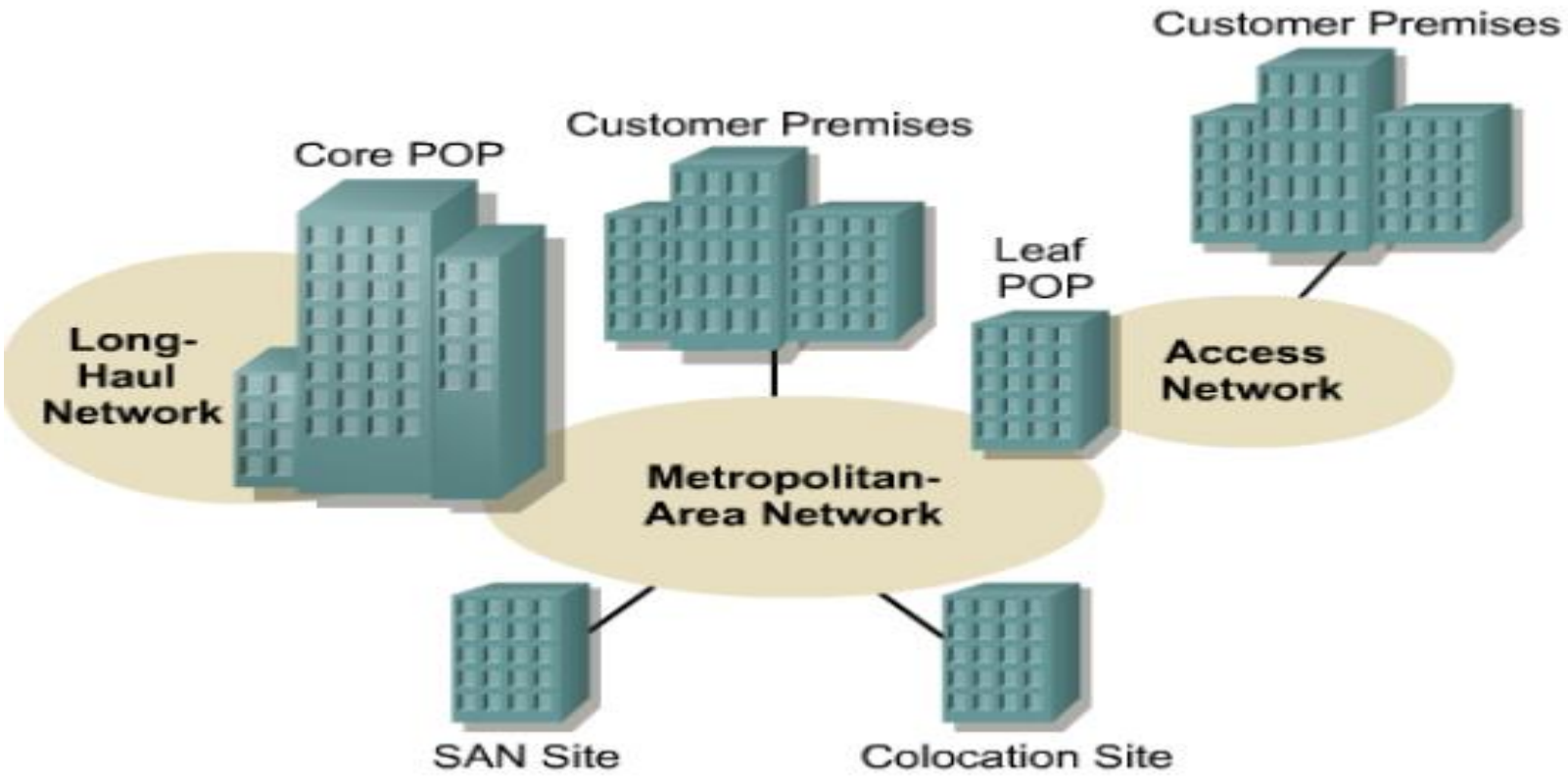
METROPOLITAN AREA NETWORK-MAN



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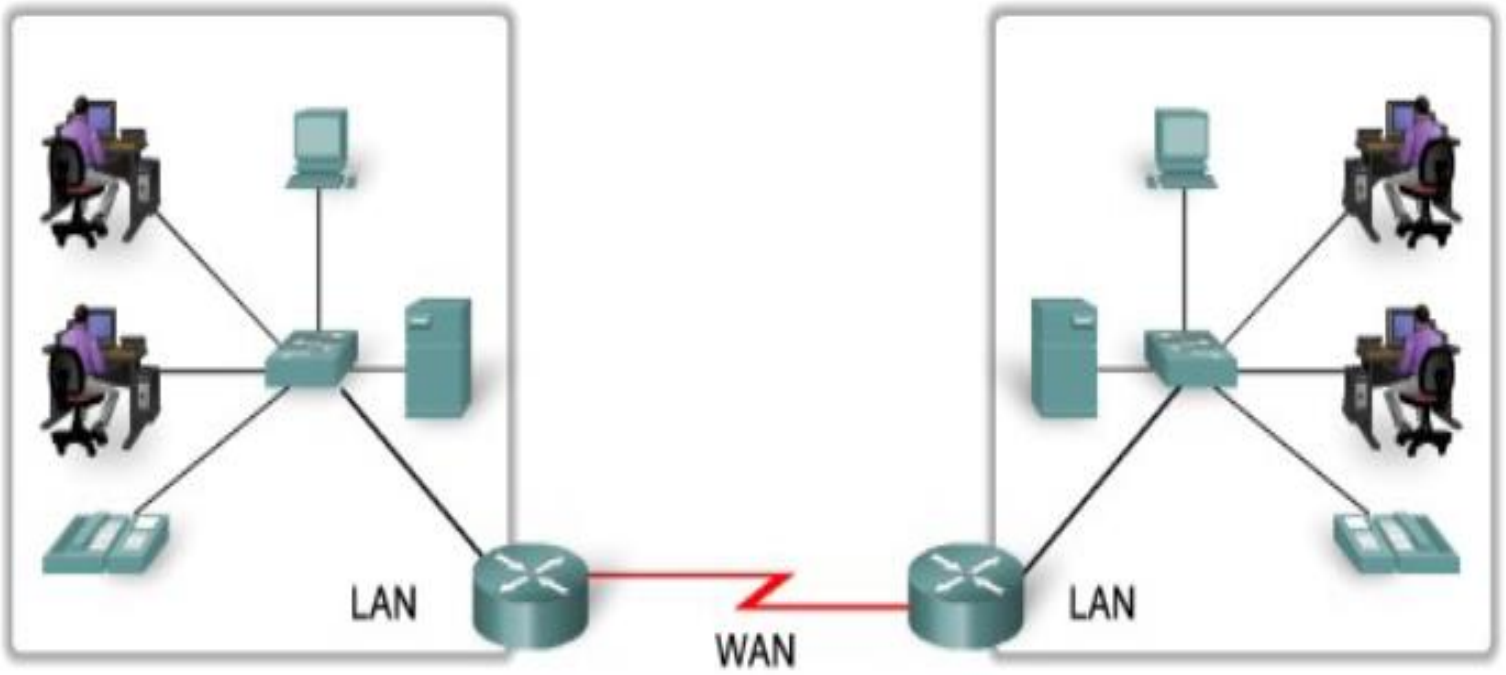
Wide Area Network (WAN)

- The networks spreads across countries are known as WANs.
- A wide Area Network (WAN) is a group of computers that are separated by large distances and tied together.
- The largest WAN in existence is the internet.
- It can even be a group of LAN that are spread across several locations and connected and together to look like one big LAN.
- The WANs link computers to facilitate fast and efficient exchange of information at lesser costs and higher speeds

WIDE AREA NETWORK LINKING DIFFERENT LANS



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THE INTERNET

- The internet is a large connection of multiple TCP/IP networks, connecting millions of computers around the world. Every networked computer is a part of it (Internet).
- HISTORY OF INTERNET
- The term “Internet” was first used in the Requests for Comments (RFC) document published on the TCP protocol (RFC 675)

HISTORY OF INTERNET

- The internet has evolved over the last five decades connecting networks using TCP/IP. Packet switching led to the growth of multiple networks that could be linked together to share data and other recourses.
- Department of Defense's Advanced Research Projects Agency (DARPA) established ARPANET in 1969.
- In the UK, the SERCnet (JANET) was set up in 1974 providing network connectivity to British academic and research sites using packet switching technology.

HISTORY OF INTERNET

- With growth of many networks to provide a standard of communication across the various needs; Hence leading to Design of the TCP/IP as a common inter-network protocol widely adopted in 1983.

HOW DOES INTERNET WORK?

- The internet enables the transfer of information in a very short time (seconds)
- Data is able to travel across the internet by the support of the internet infrastructure, tools, protocols and technologies that interconnect various Internet devices.
- The Internet provides several different basic tools for data sharing. These are: Email, Chat, Instant Messaging (IM), File Transfer Protocol (FTP), Voice over Internet Protocol (VoIP), World Wide Web, Blog, Social Media and Telnet (remote login).

HOW DOES INTERNET WORK?

- **Internet Infrastructure** – The Internet has an infrastructure at the backend which include; Network Access Points, backbones and thousands of ISPs (Internet Service Providers.
- The backbones (Backbones are fiber optic trunk lines with multiple fiber optic cables) connect together through network access points (NAPs).
- **Internet Topology** –Built in a Tiered model. From bottom to-top it consists of end systems (PCs, workstations, etc.) connected to local Point of Presence (PoP) of the Internet Service Providers (ISPs). The local ISPs are in turn connected to regional ISPs, which in turn connect to the backbone through NAPs.

HOW DOES INTERNET WORK?

- **Architecture** Internet uses client/server model for running its basic tools such as Telnet, FTP, Gopher, E-mail and World Wide Web and others. In the client/server model, all computers on the Internet are either clients or servers.
- **ISP (Internet service provider)** is an organization that provides connectivity/access to the Internet.
- The role of an ISP is to take a local customer from the Point of Presence of the ISP to a network access point (NAP).

What is TCP/IP

- **What is TCP/IP? -** Communication between computers and networks on the Internet takes place in TCP/IP protocol, a set of technical standards that govern the transmission of data over the network. IP means Internet Address. Because Internet is a network of global computers, every computer must have an address called IP address.

What is TCP/IP

- What is IP address? The IP number is called an “address” is used to uniquely identify each device on the Internet and its location to help direct Internet traffic. IP address is a unique number given to identify a host computer on the Internet on the network

What is TCP/IP

- What is DNS? With Fewer network sites remembering an IP address and connecting it to host was easy; However with the ever growing network sizes IP Address usage has grown. It became important to map address names to IP addresses;- this is the role of a Domain Name System (DNS) making it possible to address a Web site on TCP/IP networks by name and not by IP address.

DNS

- A Digital Object Identifier (DOI) is a permanent identifier given to a Web file or other Internet resources. It helps a user to find a lost Internet resource when its URL changes.
- Internet tools: To use Internet you need basic tools such as e-mail, telnet, FTP,
- World Wide Web; all of these tools comply with suite of TCP/IP protocols.

Web Technology

- Cloud computing largely depends on Internet and Web technologies.

  1. Basic web technology:

- The World Wide Web is a system of interconnected IT resources accessed through the Internet. Its two fundamental components are the Web browser client and the Web server.
- Other components, such as proxies, caching services, gateways, and load balancing, are used to improve Web application features such as scalability and security.

Basic web technology:

- Web technology architecture consists of three basic elements.
- **Uniform Resource Locator (URL):** A standard syntax used to point to Web resources' identifier. URLs usually consist of logical network locations
- **Hypertext Transfer Protocol (HTTP):** The basic communication protocol for exchanging content and data through the World Wide Web. The URL is transmitted via HTTP. At a clients request, the browser will send a webpage request to the website corresponding to the URL, using HTTP, and the website will return the requested webpage to the browser after receiving the request.

Basic web technology:

- **Markup Language-Markup Language:** It provides a lightweight method to represent Web-centric data and Metadata. At present, Hyper Text Markup Language (HTML) is commonly used in webpages, and the meaning of its tags is fixed.

2. Web applications

- Distributed applications based on Web technology (usually displaying the user interface through a Web browser) are generally considered Web applications. Due to their high accessibility, these applications appear in all types of cloud based environments.

Web applications

- Web application may have a three-tier model.
- The first layer is the Presentation Layer, which is used to represent the user interface.
- The second layer is the Application Layer, which is used to implement application logic.
- The third layer is the Data Layer, which consists of persistent data storage; this pattern is also commonly referred to as the Model-View Controller (MVC) pattern. The MVC pattern model is the part of the application used to process the data logic of the application. The model objects are responsible for accessing data in the database.

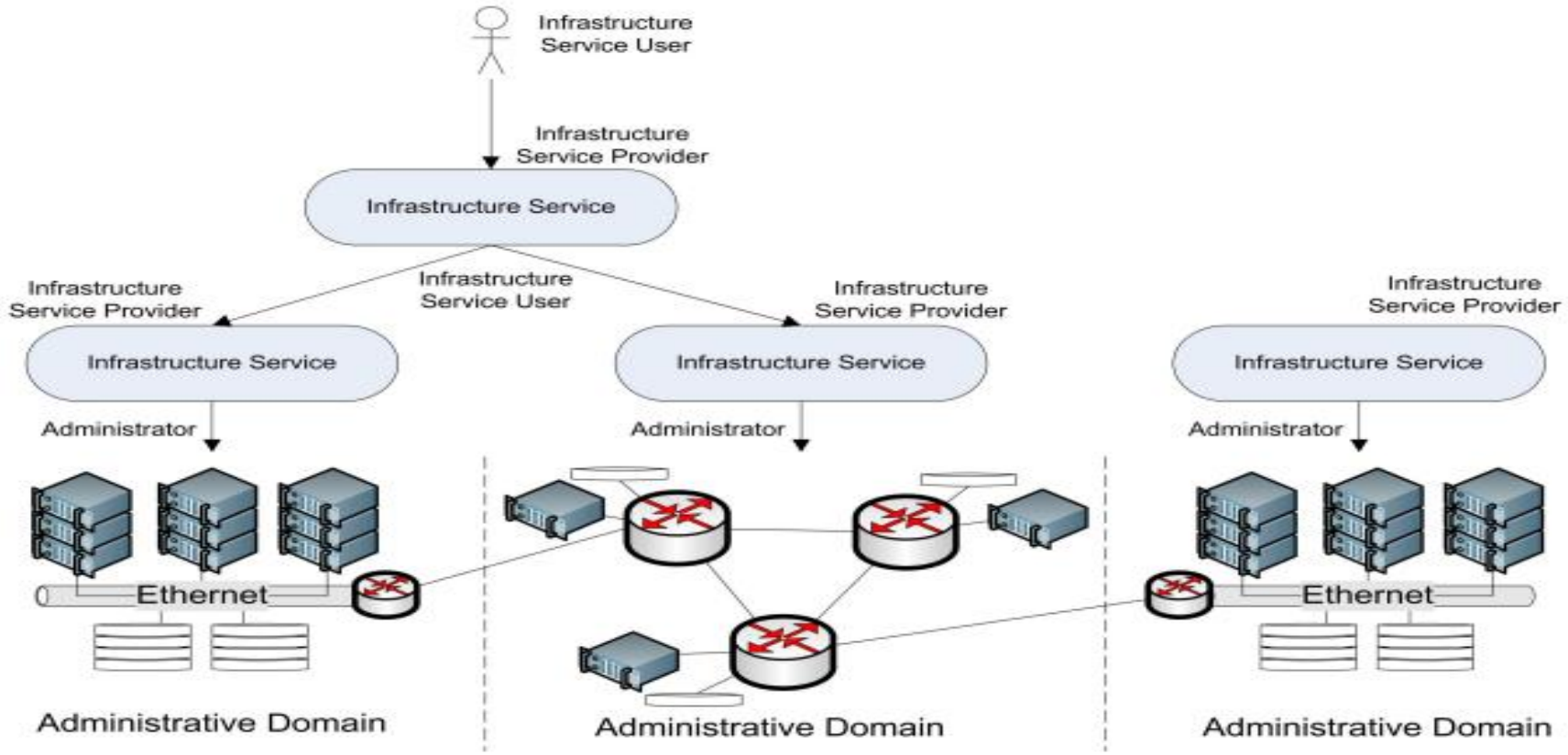
Architecture of cloud networking

- **Components**
- Administrator: has administrative authority over underlying virtual or physical equipment (the administrative domain) used to implement resources. The administrator uses management systems to configure and manage resources within the administrative domain.
- Infrastructure Service User such as an enterprise, an application service provider or communication service provider accesses an infrastructure service in order to obtain, examine, modify and destroy resources.

Architecture of cloud networking

- The interaction between the user and provider represents delegation; the provider is responsible for implementing and managing the virtual infrastructure on behalf of the user
- Infrastructure Service Provider offers an infrastructure service that may be used by an infrastructure service user to obtain, examine, modify and destroy resources, has access to their own administrative domain and can manage individual virtual resources directly.

Architecture of cloud networking

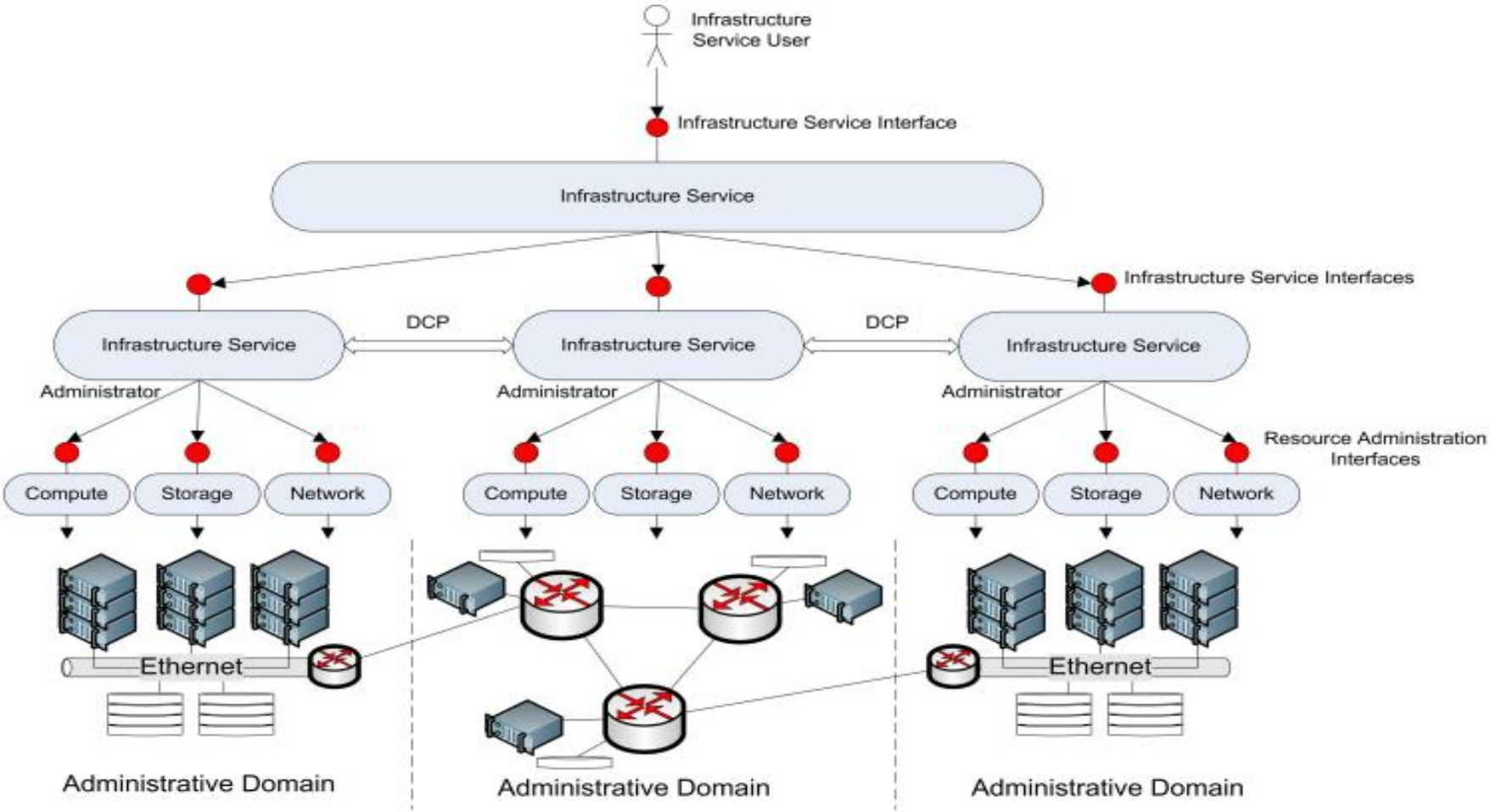


- (Edwall, 2011)

Architecture of cloud networking

- **Interfaces**
- Three interfaces are identified between the different roles of the architecture;
- Resource administration interface,
- Distributed control plane
- Infrastructure service interface

Architecture of cloud networking



- (Edwall, 2011)

Architecture;- Resource Administration

- The resource administration interfaces correspond to the management functions that are used by the administrator role to create, manage and destroy virtual resources within an administrative domain.

Resource Administrative interface include;

- Compute interface, a storage device controller or a network administration interface. They must provide information about the underlying infrastructure including the network topology and technologies used, so that the administrator can make a decision on how to manage the resources and what information needs to be passed through these interfaces.

Architecture;- Resource Administration

- ***Compute Resource Interface;*** Provides more advanced capabilities than pure virtual machine control (e.g. load balancing through virtual machine migration and distribution of compute tasks onto various machines). This interface provides access and ability to invoke a number of essential functions in handling resources such as: • Creation/Deletion/Start/Suspend/Stop of VMs

Architecture of cloud networking

- ***Storage Resource Interface***,
- Relies on standards such as Cloud Data Management Interface (CDMI) and Amazon Simple Storage Service (S3) to provide access to virtual storage spaces as well as physical storage. Compatibility with such standard is essential as they are widely adopted in the cloud community. Additional needs emerge when network providers also provide storage within the network nodes such as caching and even storage of files, documents or multimedia files or data.

Architecture of cloud networking

- ***Network Resource Interface***: Compute and Storage can be allocated and managed as cloud resources via well-defined web interfaces and Application Programming Interfaces (APIs).These kinds of interfaces and APIs are cloud computing and storage specific.
- Cloud networking interfaces and APIs; The objective is to define these missing interfaces and APIs so that cloud networking can be achieved like traditional network configuration for Network

Architecture of cloud networking

- Interface Cards (NICs), Virtual Local Area Networks (VLANs), Open Flow, Open v Switch, Dynamic VPNs. This interface will highly depend on the capabilities of the underlying network and existing network management systems. This interface supports with;- configure parameters like bandwidth and jitter, Mobility, fault monitoring, and redundancy.

Architecture of cloud networking

2. Distributed Control Plane: The Distributed Control Plane (DCP) describes a category of protocols, interfaces and control operations that enable two or more infrastructure service providers to interact and exchange cross administrative domain information

3. Infrastructure as Service Interface

Networking in IaaS

- Most cloud computing infrastructures are built with virtualized servers. Within a virtualized environment, some of the networking functionalities (e.g., switching, firewall, application-delivery controllers, and load balancers) can reside inside a physical server.
- The Virtual switch inside the same physical server can be used to switch the traffic between the VMs and aggregate the traffic for connection to the external physical switch. The Virtual Switch is often implemented as a plug-in to the hypervisor.

Networking in IaaS

- Network architecture is one of the key building blocks of cloud computing. A cloud user connects to the network to access the cloud resources. The cloud is accessible through a public network (the Internet) or through a private network infrastructure (e.g., MPLS or dedicated links). The most significant effect of cloud computing on network is in the data center. The data center consists mainly of servers in the racks interconnected through a Top-of-Rack (TOR)
- Ethernet switch which in turn connects to an aggregation switch, also known as End-of-Rack (EOR) switch.

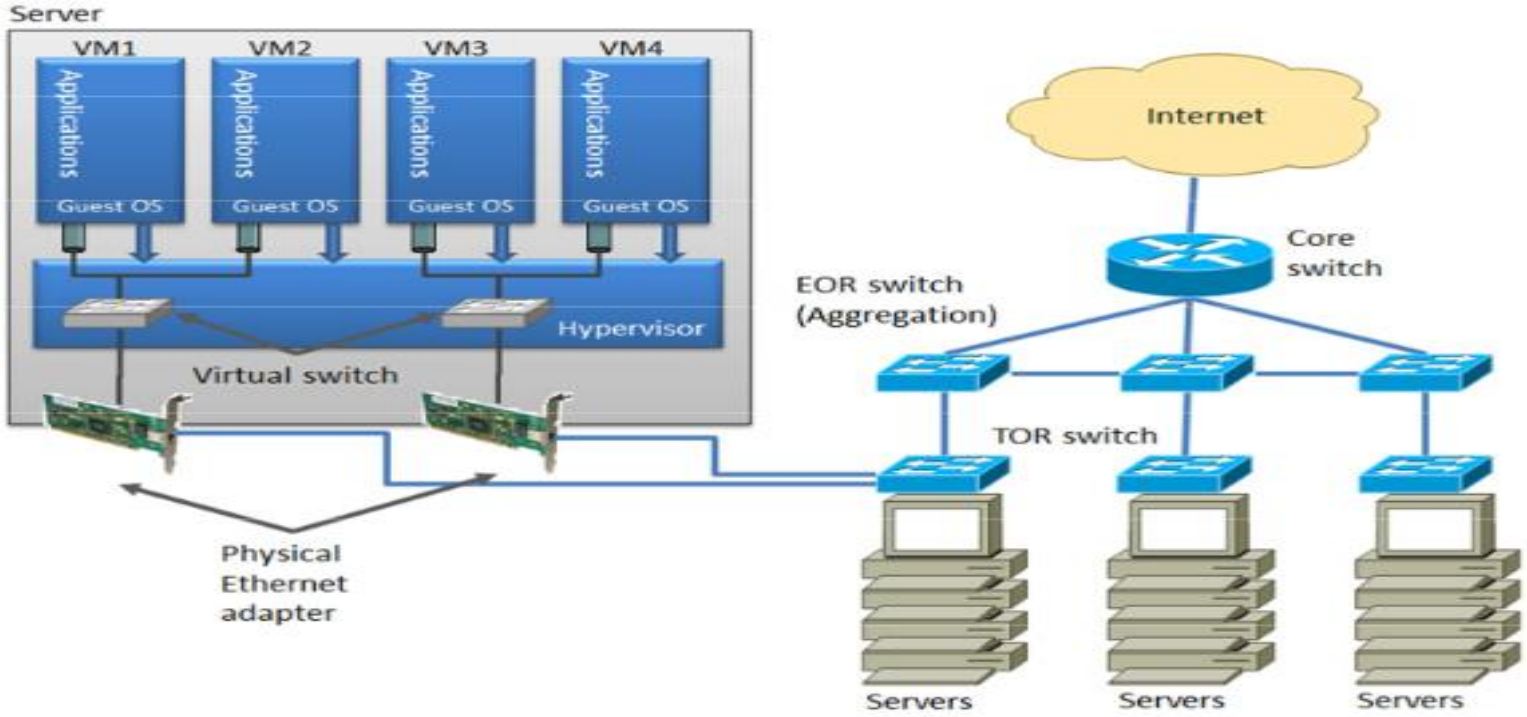
Networking in IaaS

- The aggregation switch connects to other aggregation switches and through these switches to other servers in the data center. A core switch connects to the various aggregation switches and provides connectivity to the outside world, typically through Layer 3(IP).

The presence of virtualized servers

- Network connections to physical servers will need to involve “bigger pipes” because traffic for multiple Virtual Machines (VMs) will be multiplexed onto the same physical Ethernet connection compared to the case in which the network connection is just used for standalone server.
- Data transfer and network bandwidth, WAN acceleration for the cloud, and VM migration are some of the perspectives on cloud computing networking

Data-Center switched network architecture



- (Chao, 2016)

Challenges in the existing cloud networks

- Application performance: Specification for Bandwidth requirements for applications hosted in the cloud ; Insufficient bandwidth between these servers will impose significant latency on user interactions. Therefore without explicit control, variations in cloud workloads and oversubscription can cause delay and drift of response time beyond acceptable limits.

Challenges in the existing cloud networks

- Flexible deployment of appliances: Enterprises deploy a wide variety of security appliances in their data centers, such as Deep Packet Inspection (DPI) or Intrusion Detection Systems (IDS), and firewalls to protect their applications from attacks. When deployed in the cloud, an enterprise application should be able to continue exploiting the functionality of these appliances.

Challenges in the existing cloud networks

- Policy enforcement complexities: Traffic isolation and access control to the end-users are among the multiple forwarding policies that should be enforced. These policies directly impact the configuration of each router and switch. making it extremely challenging to build, operate and inter-connect a cloud network at scale.

Challenges in the existing cloud networks

- Topology dependent complexity: For example, a network topology, designed to carry traffic among servers in a data center, is not the as one designed to carry traffic to/from the Internet. The topology design also depends on how the Layer 2 and/or Layer 3 are utilizing the effective network capacity.

Challenges in the existing cloud networks

• Location dependency: Network appliances and servers (e.g., hypervisors) are typically tied to a statically configured physical network, which implicitly creates a location dependency constraint. For instance the IP address of a sever is determined based on the VLAN or subnet it belongs to.

Challenges in the existing cloud networks

- Application rewriting: Applications may need to be rewritten or reconfigured before deployment in the cloud to address several network related limitations. Two key issues are: 1) lack of a broadcast domain abstraction in the cloud network and 2) cloud-assigned IP addresses for virtual servers.

Challenges in the existing cloud networks

- Multi-layer network complexity; This multi-layer architecture imposes significant complexities in defining boundaries of L2 domains, L3 forwarding networks and policies, and layer-specific multi-vendor networking equipment.

Next Lecture

- Virtualization

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