CHAPTER TWO
Introduction to Computer Networks

Data Communication and Computer Networks

For - Seng 2051

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Data communication

1. What is a computer network?
2. Applications & Uses of Networks
3. Types of networks
4. Computer network components
5. Computer network design and management

I. What is a computer network?

- A computer network is a system in which a number of independent computers are linked together to:
  - Sharing Information and Resources (file, folder, printer, disk drive)
  - Client-server Configurations
  - E-commerce
  - Communication

2. Applications & Uses of Networks

- Marketing and sales
- Financial services
- Manufacturing
- Electronic messaging
- Directory services
- Information services
- Electronic data interchange (EDI)
- Teleconferencing
- Cellular telephone
- Cable television

2. Applications & Uses of Networks

- **Disadvantages of computer network**
  - **Data security** is therefore an important concern in a networked environment.
  - The danger of **computer viruses** entering the network is greatly increased.
  - **Equipment malfunctions** and system failures are also the risks of computer networks

3. Types of networks

- Depending on one's perspective, we can classify networks in different ways.
  - Based on transmission media: Wired (UTP, coaxial cables, fiber-optic cables) and Wireless
  - Based on network size: LAN and WAN (and MAN)
  - Based on management method: Peer-to-peer and Client/Server
  - Based on topology (connectivity): Bus, Star, Ring …

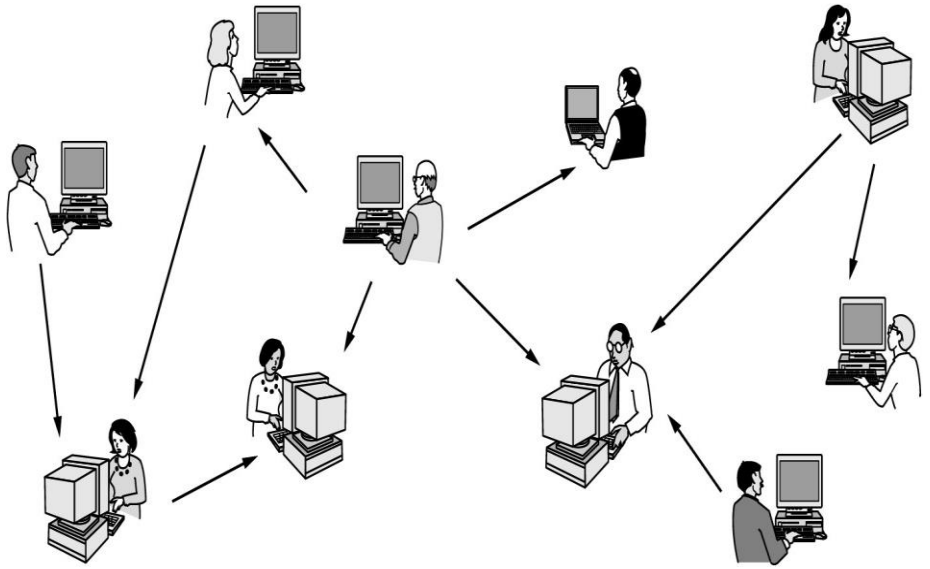
3. Types of networks

- **What are**
  - Wireless Local Area Network (WLAN)
  - Campus Area Network (CAN)
  - Storage-Area Network (SAN)
  - System-Area Network (also known as SAN)
  - Personal Area Network (PAN)

- Types of network based on network size (coverage)
  - Local Area Networks (LANs)
    - Relatively small geographical area such as a home, an office, or a campus.
    - Owned, controlled, and managed by a single person or organization
    - Use certain connectivity technologies, primarily Ethernet and Token Ring.
  - Metropolitan Area Network (MAN)
    - It is a network that transmits data and information over city wide distance.
    - A network that is utilized across multiple buildings.
    - Is larger than a LAN, but smaller than a WAN. interconnection of several LANs
  - Wide area network (WAN)
    - has no geographical limit,
    - Ultimate WAN is the Internet
    - slower and less reliable than a LAN

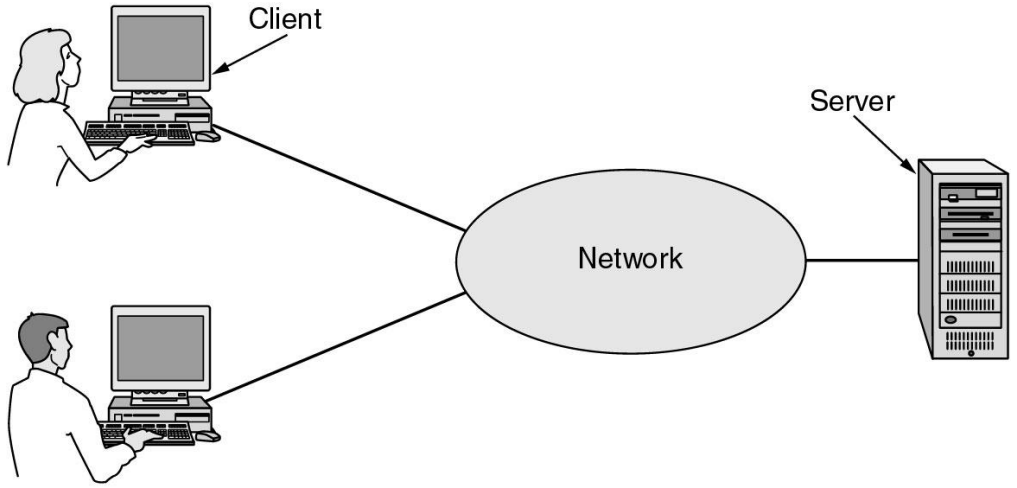
WAN

3. Types of networks



- Types of networks based on node relationship
  - Peer-to-peer networks
  - Server-based networks
- Peer-to-peer networks
  - No dedicated servers, and there is no hierarchy among the computers
  - All the computers are equal, Each computer functions as both a client and a server
  - sometimes called workgroups.
  - are relatively simple, less expensive than server-based networks
  - Users act as their own administrators and plan their own security
  - Peer-to-peer networks are good choices for environments where:
    - There are 10 users or fewer, Users share resources, such as printers, but no specialized servers exist
    - Security is not an issue, only limited growth within the foreseeable future

3. Types of networks



- Server-based networks
  - More than 10, have dedicated servers
  - May have separate servers for file storage, printing, email and for storing and running application software.
  - More complex to install, configure, and manage, a server-based network
  - Centrally administered and controlled , Security is often the primary reason for choosing, backups can be scheduled, support thousands of users

3. Types of networks

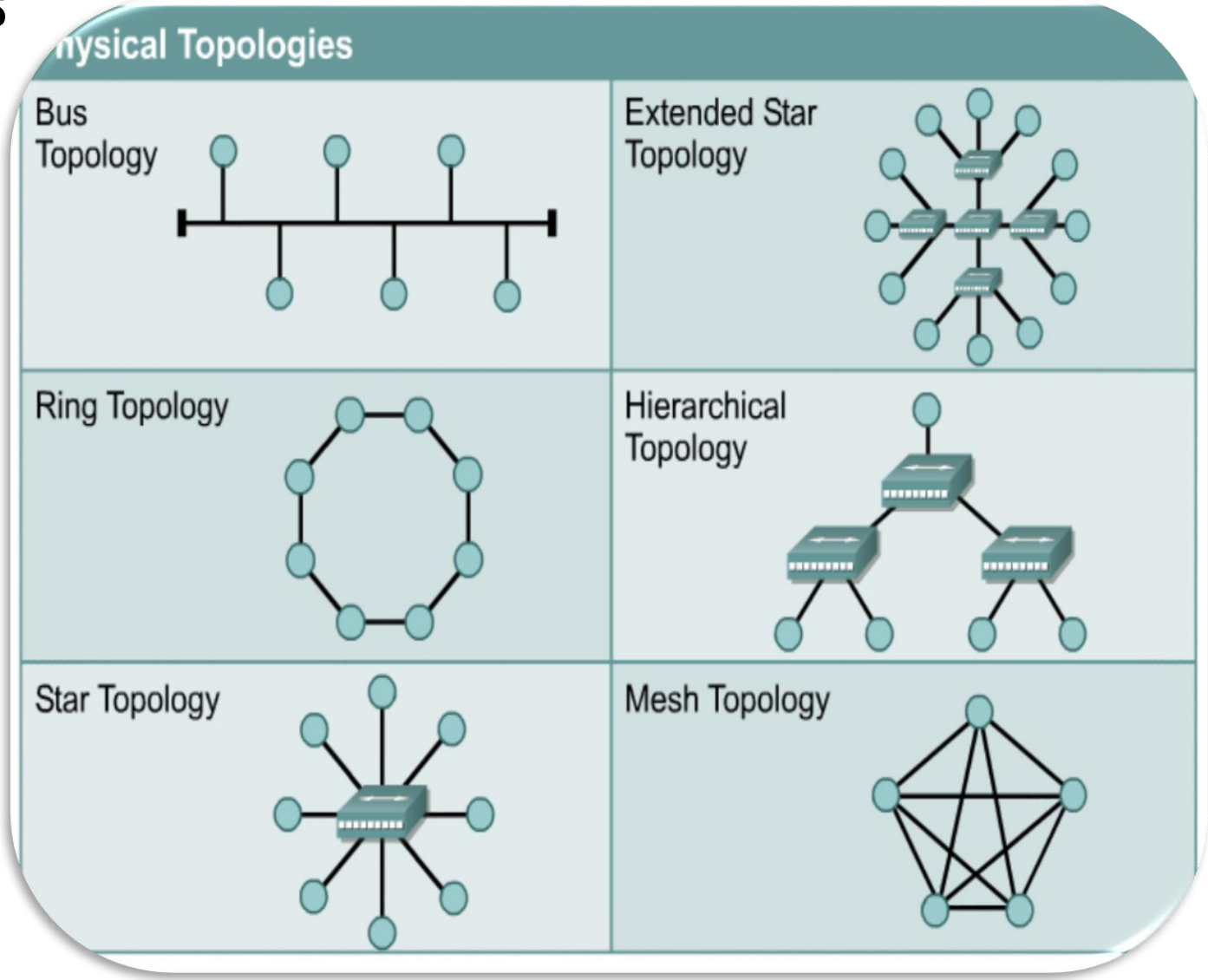
- **Network Topologies**
  - The arrangement or physical layout / structure of computers, cables, and other components on the network,
  - **physical topology** - actual layout of the physical components such as computer, media etc.
    - Also called Physical layout, Design, Diagram or Map.
  - **logical topology –**
    - How the media is accessed by the hosts,
    - How data is transmitted between nodes or
    - How the network message is travel from one node to another

3. Types of networks

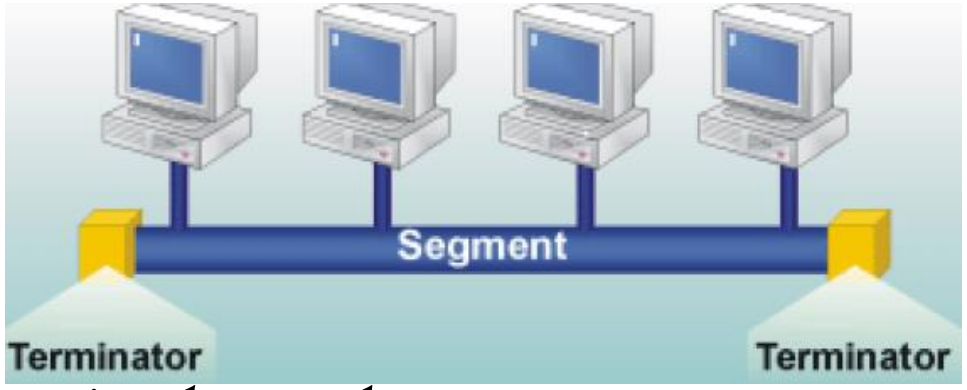
- The choice of topology:
  - Type of equipment that the network needs
  - Capabilities of the network
  - Growth of the network
  - Way the network is managed
  - Different types of cable, different network cards, network operating systems, how the cabling runs through floors, ceilings, and walls. how computers communicate on the network.

3. Types of networks

- Topology
  - Bus Topology
  - Star topology
  - Ring topology
  - Mesh topology
  - Hybrid topologies

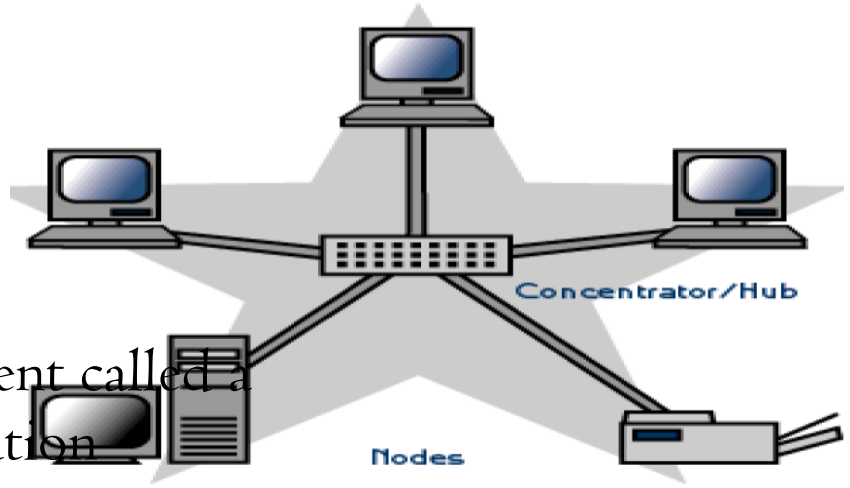


3. Types of networks



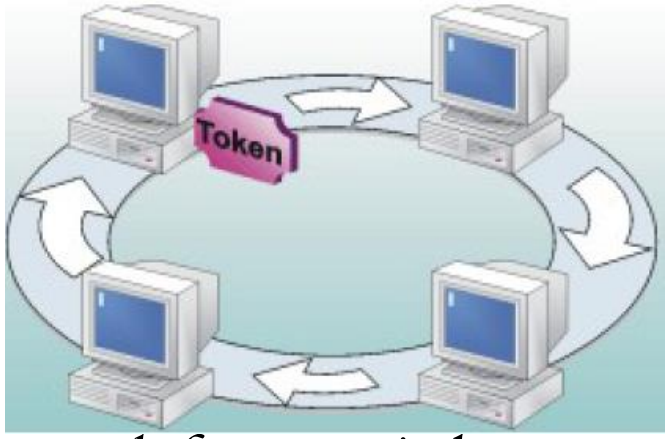
- Bus Topology
  - linear bus , connected in a straight line, Inexpensive, simplest and most common, single cable called a trunk, also called a backbone or segment, Easily extended
  - Three concepts:
    - **Sending the signal** - signals to all the computer. if more computers, others waiting – so slower network, if one computer fails, it does not affect the rest of the network
    - **Signal bounce** - bouncing back and forth along the cable and prevent other computers from sending signals - **collision or noise** - must be stopped
    - **Terminator** - placed at each end of the cable to absorb free signals / To stop bouncing. , if a break in the cable occurs so the signal will bounce, and all network activity will stop
  - Bus topologies use **coaxial cable. T connectors** are often used to connect the computer to the trunk cable.

3. Types of networks



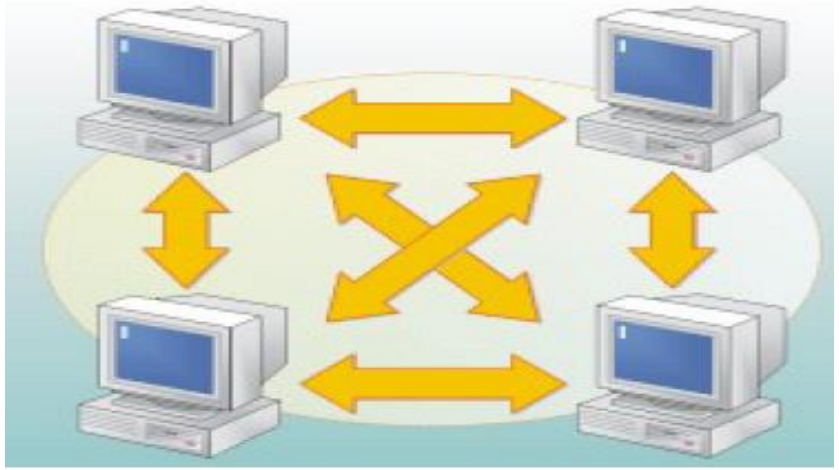
- Star topology
  - Each computer are connected to a centralized component called a concentrator, making it very easy to add a new workstation
  - requires a great deal of cable
  - **Most common network configuration in use today**
  - if the central point/device fails, the entire network goes down
  - If one computer or the cable fails. The rest of the network continues to function normally.
  - are more expensive to install than bus networks, because there are several more cables
  - plus the cost of the concentrator / hubs

3. Types of networks



- Ring topology
  - Connects computers on a single circle of cable
  - Each node is connected to the two nearest nodes so the entire network forms a circle.
  - Signals travel around the loop in one direction and pass through each computer (act as a repeater).
  - failure of one computer can have an impact on the entire network
  - One method for passing data on ring networks is token passing.
  - Easier to manage
  - Easier to locate a defective node or cable problem
  - In short ring topology enables reliable communication
  - Expensive, requires more cable and network equipment at the start, not used as widely as bus topology
  - **only one computer** at a time **can send**

3. Types of networks



- Mesh topology
  - Offers superior redundancy and reliability
  - Each computer is connected to every other computer by separate cabling.
  - If one cable fails, another will take over the traffic
  - Ease of troubleshooting and increased reliability
  - Are expensive to install because they use a lot of cabling
  - Used in conjunction with other topologies to form a hybrid topology
  - The simplest logical topology in terms of data flow, but it is the most complex in terms of physical design
  - If there are x computers, there will be $(x \times (x-1)) \div 2$ cables

3. Types of networks

- Hybrid topologies
  - Star bus topology
    - If one computer goes down, it will not affect the rest of the network. The other computers can continue to communicate.
    - If a hub goes down, all computers on that hub are unable to communicate
  - Star ring topology
    - The star ring (sometimes called a star-wired ring) appears similar to the star bus.
    - Both the star ring and the star bus are centered in a hub that contains the actual ring or bus

3. Types of networks

- Logical Topologies
  - Defines how the hosts communicate across the medium
- The two most common types of logical topologies are:
  - **Broadcast topology / Ethernet**
    - means that each host sends its data to all other hosts on the network medium.
    - It is first come, first serve.
    - Commonly supported by networks that use a bus, a star, or a star-wired bus physical topology
  - **Token passing**
    - Controls network access by passing an electronic token sequentially to each host.
    - When a host receives the token, that host can send data on the network.
    - Two examples of networks that use token passing are Token Ring and Fiber Distributed Data Interface (FDDI).

4. Computer network components

- Two basic components
  - Hardware
  - Software
- **Hardware** - all physical parts that we can see and touch
  - Server
  - Workstation / Client / dump Terminals
  - Transmission media / Medium
  - Network Interface Cards (NIC) - transmitter" and "receiver" – transceiver. It use MAC address can be wired or wireless. **PCI slot** (desktop) and **ExpressCard slots** (laptop)
  - A concentrator / network connectivity devices / internetworking devices, or wiring center

4. Computer network components

- A concentrator / network connectivity devices
  - **Hub –**
    - **Hubs can be:** A passive hub, An active hub, A switched hub
    - Currently Hubs are becoming obsolete and replaced by more advanced communication devices such as **Switches and Routers**
  - **Switch –**
    - amplify the signal as it moves from one device to another
    - Managed switch and unmanaged switch
  - **Repeaters -** amplifies the signal it receives and rebroadcasts it
  - **Bridges -** segment a large network into two smaller, more efficient networks
  - **Routers -** translates information from one network to another; it is similar to a super intelligent bridge
  - **Gateway -** A gateway is a translation tool. It is a server that acts as an intermediary for some other server.

4. Computer network components

- Modems – for internet connection over **the existing telephone line**.
  - Like NIC, **Modem is not integrated with a computer motherboard**. It comes as separate part which can be installed on the PCI slots found on motherboard.
  - It is not necessary for LAN, but required for internet connection such as dial-up and DSL.
- **Software**
  - Network operating system (NOS)
    - Peer-to-peer (such as Windows for Workgroup) and client server (Windows 2012 Server)
  - The operating system of the workstation – (such as windows 10)
  - Server software - web server, mail server, print server, file server, database server
  - Client software - web browsers, e-mail clients

5. Computer network design and management

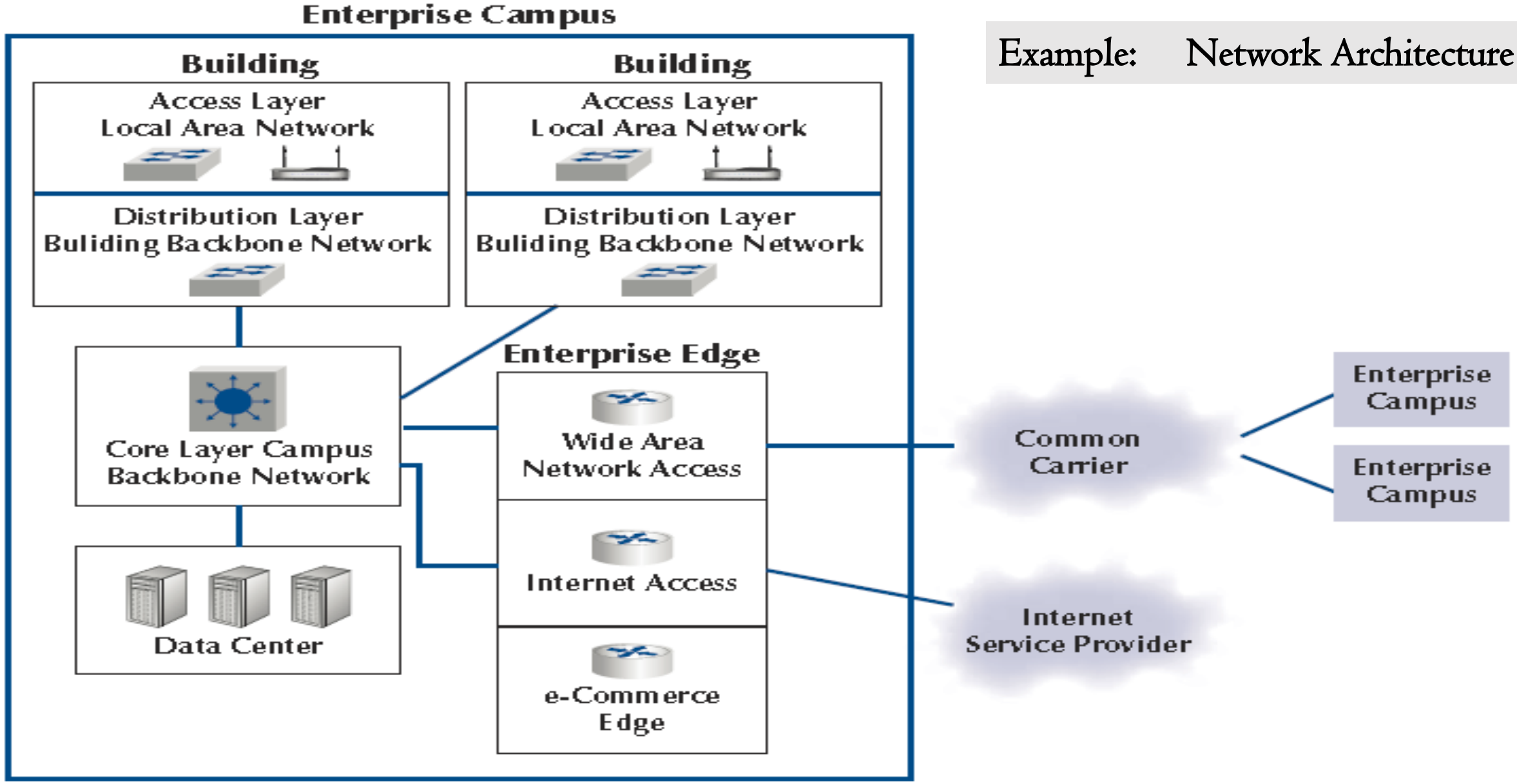
- **Network Design**
  - Identify the **organizational objective** and the **goal of the network** to be developed
- The most typical technical goals in an enterprise LAN/WAN design
  - **Scalability** – appropriate size or volume, minimal cost
  - **Availability** - 7 / 24 or according to need. Fast User Interface, Application availability
  - **Performance** / Reliability - capacity utilization, throughput, and delay
  - **Security** – policy, Roles and Privileges
  - **Flexibility** - Easy User Management, Handling Multiple Time-zones, Maintenance scheduling

5. Computer network design and management

- First decide whether a peer-to-peer or a server-based network. factors:
  - Size of the network.
  - Level of security.
  - Type of business.
  - Level of administrative support available.
  - Amount of network traffic.
  - Needs of the network users.
  - Network budget.

5. Computer network design and management

Example: Network Architecture

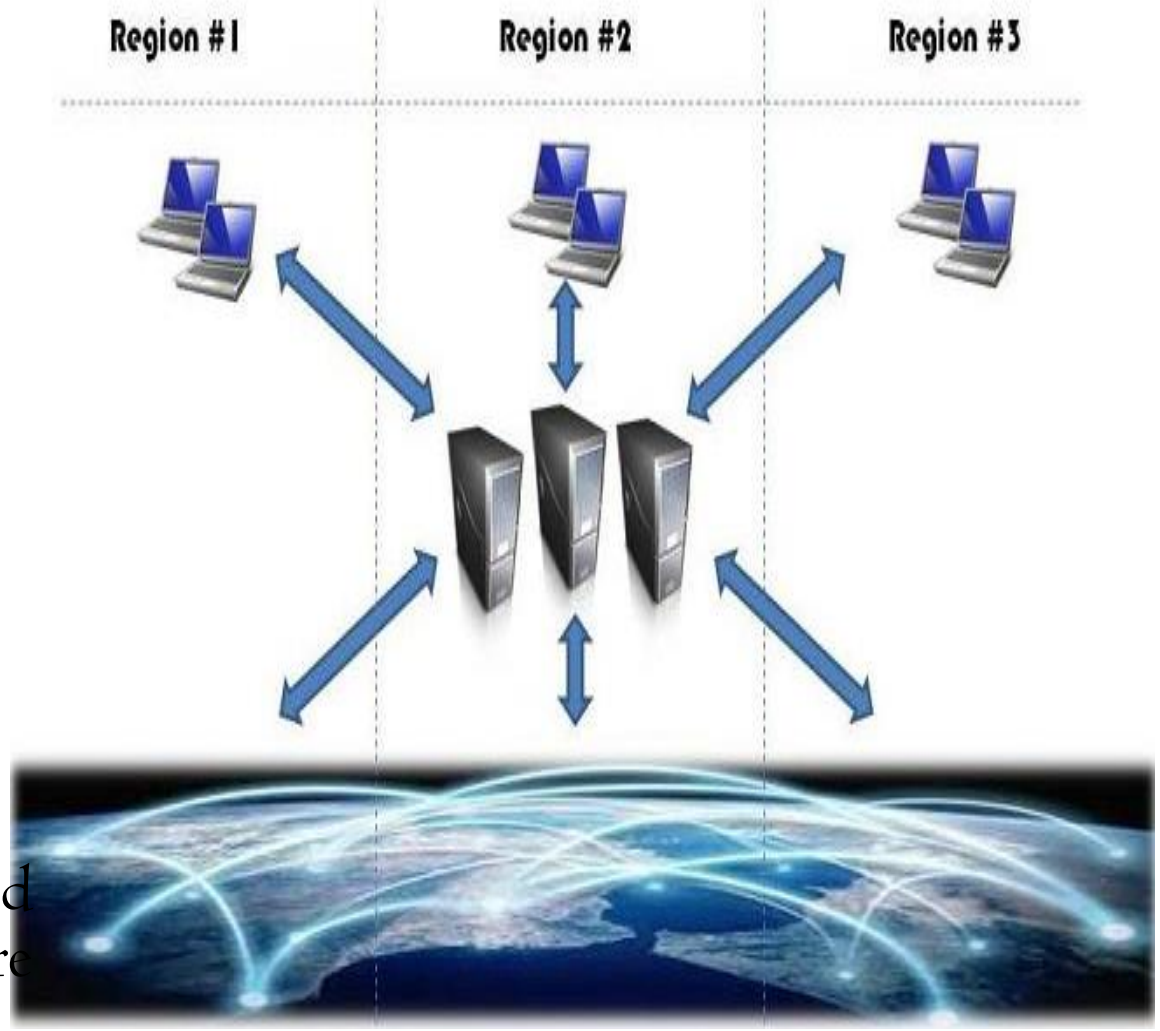


5. Computer network design and management

- **Components in the above Architecture**
- **The first** is the **local area network (LAN)**, which enables users to access the network. Some vendors call this component the **access layer** because it provides access to the network
- **The second** is the **building backbone network**, which some vendors call the **distribution layer**, because it distributes network traffic to and from the LANs
- **The third** is the **campus backbone** (sometimes called the **core layer**), which connects all the buildings on one campus.
- **The fourth** is the **data center**, which contains the organization's servers (e.g., database servers, email servers). The data center is essentially a LAN, but because so much traffic goes to and from the data center, it is typically designed and managed very differently than the LANs intended for user access.
- **The last three** components of the network architecture make up the **enterprise edge**, the parts of the network that are at the edge of an enterprise campus and connect that campus to the rest of the world.
  - The **wide area network (WAN)**. A WAN is a private network that connects its different campus locations, usually leased from a **common carrier** such as AT&T.
  - The **Internet access** component, which enables the organization to connect to the Internet.
  - The **e-commerce edge**. The e-commerce edge is a special LAN with a group of servers that enables electronic data exchange between the organization and the external entities with which it does business (such as its customers or suppliers).

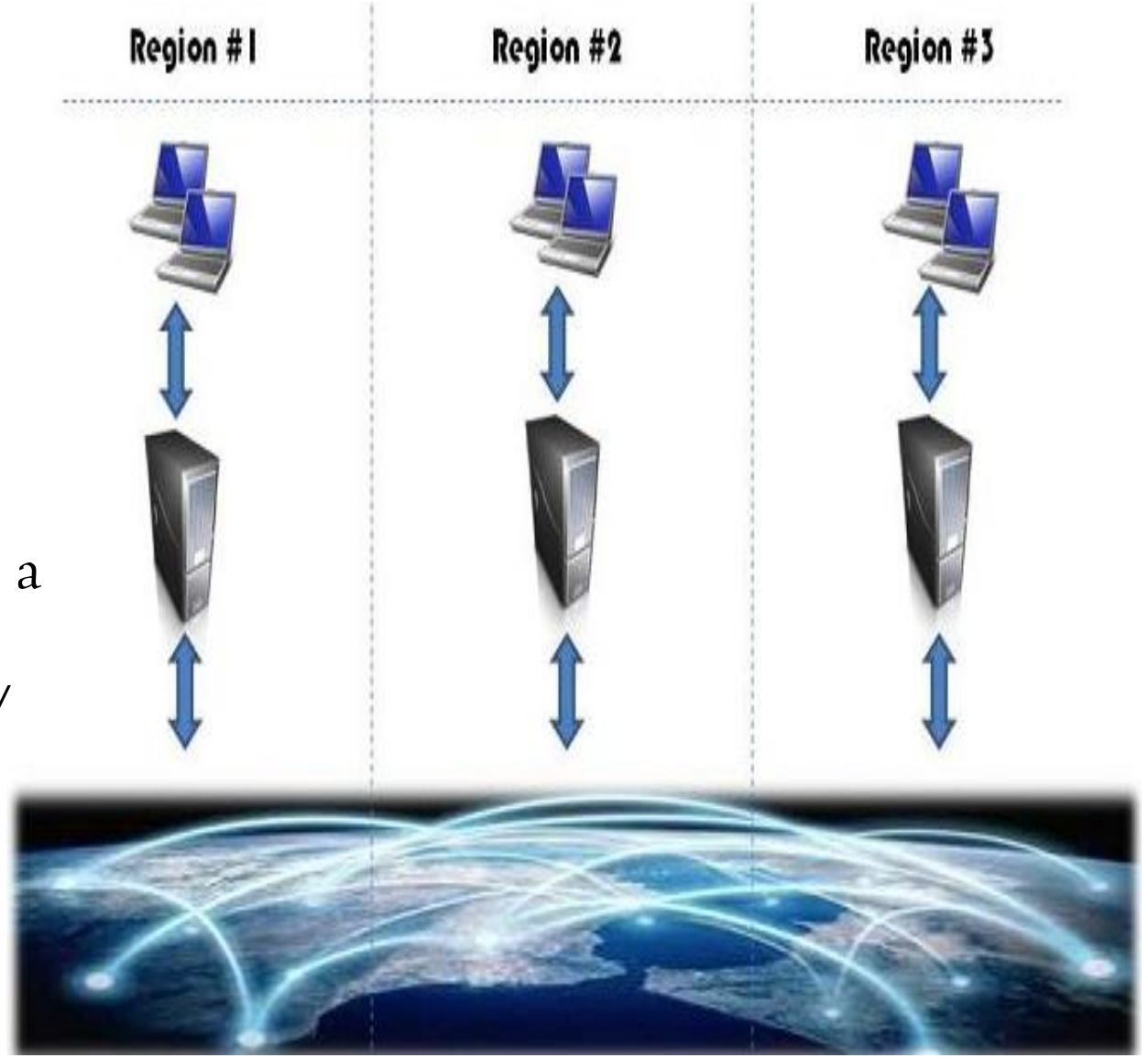
5. Computer network design and management

- Network Management Architecture
  - Centralized
  - Distributed
  - Hierarchical
- Centralized Network Management Architecture
  - A **single management system installation** monitors the whole network.
  - This installation may consist of **one or more** servers due to hardware limitations.
  - If more than one server is used, it is considered as a centralized architecture when all servers are located at the same NOC.



5. Computer network design and management

- **Distributed Network Management Architecture**
  - **Multiple installations of management systems** are used to monitor the whole network.
  - Each management system is installed at a NOC that is responsible to monitor a geographical or administration region / domain, i.e. it is a *Domain Manager*.



5. Computer network design and management

- Hierarchical Network Management Architecture
  - **Multiple installations of management systems** are used to monitor the whole network.
  - Each management system is installed at a NOC that is responsible to monitor a geographical or administration region / domain, i.e. it is a *Domain Manager*.
  - It adds an additional layer, the **Manager of Managers (MoM)**.
  - MoM sits at a higher level and requests information from domain managers.
  - There is no communication between domain managers, information flow follows the hierarchy.
  - The hierarchy can be further expanded by adding additional layers of MoMs and therefore is quite scalable.

Criteria	Centralized	Distributed	Hierarchical
Reliability	Depends on Data Communications Network infrastructure (DCN), due to connectivity between regions.	Very Reliable, no single point of failure. Regions are independent.	Very Reliable and scalable. Regions are independent but also centrally monitored.
Scalability	Depends on DCN: as the network expands the DCN bandwidth between regions increases	Very Good, just add servers to increase the managed network size	Excellent, add servers to increase the managed network size and Manager of Managers for control
Flexibility	Limited, only one time-zone is possible per server, regions must follow the central region maintenance schedule	Very Flexible, can handle different time-zones; each region can schedule independent maintenance actions	Very Flexible, can handle different time-zones; each region can schedule independent maintenance actions
User Experience	Depends on DCN, as DCN performance affects client's remote access to servers	Very Good, local access to servers ensures UI speed and responsiveness	Excellent, local access to servers ensures User Interface speed and responsiveness. MoM gives end-to-end visibility
Overall	Good	Better	Best

5. Computer network design and management

- **Selecting a Logical Network Topology**
  - Identify the network segments and interconnection points between segments, size and scope of networks, and the types of required internetworking devices
  - develop a layered and hierarchical design model
  - A typical hierarchical network topology includes the following three layers:
    - **A core layer** consisting of high-end routers and switches that are optimized for availability and performance
    - **A distribution layer** of routers and switches that implement network policies
    - **An access layer** that connects users via hubs, switches, and other interconnection devices

5. Computer network design and management

- **Requirements of the Network**
- Define requirements to the existing hardware, software, and telecommunications. At a minimum, you should consider the following:
  - The size of the facility (located on a single floor vs. multiple floors)
  - The number of users
  - Whether the LAN will be extended to several buildings
  - The environment (office, manufacturing, out-of-doors)
  - The current network media, if any
  - The technical competence of users
  - The amount of network traffic (initially, and anticipated for the future)
  - The level of security

5. Computer network design and management

- Network Management
  - **Network administrators** need tools to monitor the **functionality** of the network **devices**, the **connections** between them, and the **services** they provide. SNMP is de facto standard with RMON and BIM
- Network Management Architecture
  - **Network management system (NMS)**: A system that executes applications that monitor and control managed devices. NMSs provide the bulk of the processing and memory resources that are required for network management.
  - **Network management protocol**: A protocol that facilitates the exchange of management information between the NMS and managed devices, including SNMP, MIB, and RMON.
  - **Managed devices**: A device (such as a router) managed by an NMS.
  - **Management agents**: Software, on managed devices, that collects and stores management information, including SNMP agents and RMON agents.
  - **Management information**: Data that is of interest to a device's management, usually stored in MIBs.

5. Computer network design and management

- *Protocols and Standards*
  - **SNMP -** how management information is exchanged between network management applications and management agents
    - **Manager** - there is a trade-off between polling frequency and bandwidth usage
    - **Protocol** - SNMP is a protocol for message exchange, It uses the UDP
    - **Managed device** - A device (such as a router) managed by the manager.
    - **Management agents** - SNMP management agents reside on managed devices to collect and store a range of information about the device and its operation
    - **MIB** - a database of objects about the device. Is a collection of managed objects
    - **RMON** - allows packet and traffic patterns on LAN segments to be monitored
  - **NetFlow**
  - **CDP**
  - **Syslog**

5. Computer network design and management

- MIB
  - A MIB is a collection of managed objects.
  - A MIB stores information, which is collected by the local management agent, on a managed device for later retrieval by a network management protocol.
  - Each object in a MIB has a unique identifier that network management applications use to identify and retrieve the value of the specific object.
  - The MIB has a tree-like structure in which similar objects are grouped under the same branch of the MIB tree.
  - For example, different interface counters are grouped under the MIB tree's interfaces branch.

5. Computer network design and management

- RMON
  - RMON is a MIB that provides support for proactive management of LAN traffic.
  - The RMON standard allows packet and traffic patterns on LAN segments to be monitored. RMON tracks the following items:
    - Number of packets
    - Packet sizes
    - Broadcasts
    - Network utilization
    - Errors and conditions, such as Ethernet collisions
    - Statistics for hosts, including errors generated by hosts, busiest hosts, and which hosts communicate with each other
  - Without RMON, a MIB could be used to check the device's network performance
  - RMON agents can reside in routers, switches, hubs, servers, hosts, or dedicated RMON probes

5. Computer network design and management

- **NetFlow**
  - Cisco NetFlow is a measurement technology that measures flows that pass through Cisco devices
  - Answers the questions of what, when, where, and how traffic is flowing in the network
  - NetFlow-collected data serves as the basis for a set of applications, including
    - Network traffic accounting
    - Usage-based network billing
    - Network planning
    - Network monitoring

5. Computer network design and management

- CDP
  - is a Cisco-proprietary protocol that operates between Cisco devices at the data link layer.
  - CDP information is sent only between directly connected Cisco devices; a Cisco device never forwards a CDP frame.
  - CDP provides a summary of directly connected switches, routers, and other Cisco devices.

5. Computer network design and management

- Syslog
  - It alerts you when something goes wrong or down in your network. Syslog is an excellent tool for system monitoring and is almost always included in your distribution

Level	Keyword	Description
0	emergencies	System is unusable
1	Alerts	Immediate action is needed
2	Critical	Critical conditions exist
3	Errors	Error conditions exist
4	Warnings	Warning conditions exist
5	Notification	Normal, but significant, conditions exist
6	Informational	Informational messages
7	Debugging	Debugging messages