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Computer Networks

Topic 4:

Network Topology and Architecture

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Topic 4 – Lecture 1:

Network Topology Concepts

Scope and Coverage

This topic will cover:

- Network topology concepts
- Common network topologies and their application
- Topologies and protocols

Learning Outcomes

By the end of this topic, students will be able to:

- Explain the concept of network topology and its design
- Discuss various common network topologies and their application(s)
- Propose a simple network topology in response to detailed requirements

Topology

- To install a network, you need to know how to connect all the elements together.
- A ***network topology*** is the layout of computers, cables and peripherals and also the paths that data travels along on the network.
- There are two forms of network topology:
  - Physical topology
  - Logical topology
- Physical and logical topology may differ.

Network Elements

- There are two main components of a network:
  - Nodes
  - Links
- A ***network node*** is an intersection between links that will contain some equipment:
  - To aid signal transmission (hub, switch, bridge, etc)
  - For data processing (computer, printer, etc)
- A link is the media through which the signals are transmitted (fibre-optic, coaxial cable, RF, etc)

Physical Topology

- Explains how the computers and peripherals are physically connected together
- It is a map showing how each piece of hardware is connected to the other hardware on a network.
- This may be via physical cables or could be wireless.

Logical Topology

- Explains how data passes between network devices
- It is a map showing the logical path of data around the network.
- The logical topology of a network may be different to its physical topology.

Topology Categories

- There are many different topologies.
- There are many different technologies for physical connections.
- There are many different protocols for logical connections.
- We can broadly categorise networks as:
  - Point-to-point networks
  - Broadcast networks

Point-to-Point Networks

- Many connections between individual pairs of machines
- Packets of information may have to pass through intermediate machines.
- Multiple routes of different length are possible, so routing algorithms are used.
- Generally used in larger networks (e.g. Internet)

Broadcast Networks

- Single communication channel that is shared by all the machines on the network
- Packets sent by a machine are received by all the others.
- Address field specifies the recipient
- Generally used for smaller networks (LANs)

Redundancy

- Redundancy involves having more links and/or nodes in a network than are strictly necessary for network operation.
- Redundancy is built into a network as a back-up feature to allow the network to function if one part fails.
- High levels of redundancy are required where network operation is vital.

LAN Physical Topology

- Main factors that determine the choice of physical topology of a LAN are:
  - Office layout
  - Need for redundancy
  - Cost

Office Layout

- Several issues that determine physical topology
- A single room provides more options.
- Multiple rooms may mean cables through walls/ceilings or reduced signal strength for wireless.
- Large building with several floors enhances the problem

Need for Redundancy

- Dependent upon how important guaranteeing network integrity is
- Some topologies isolate breaks in the network so that the rest of the network functions normally.
- Other topologies have built in redundancy so that:
  - If a link breaks, alternative paths are available
  - If a device breaks, there are back up devices available

Cost

- Cost is a function of:
  - The network topology
  - The size of the network
  - The office layout
- Not all topologies have equal cost.
- A bigger network requires more cable, etc.
- The office layout may make laying cables difficult.

Real World Networks

- There is no “one size fits all” solution.
- Must determine topology based upon the specifics of the organisation the network is for
- One private study exercise will involve deciding on a topology for a specific network.

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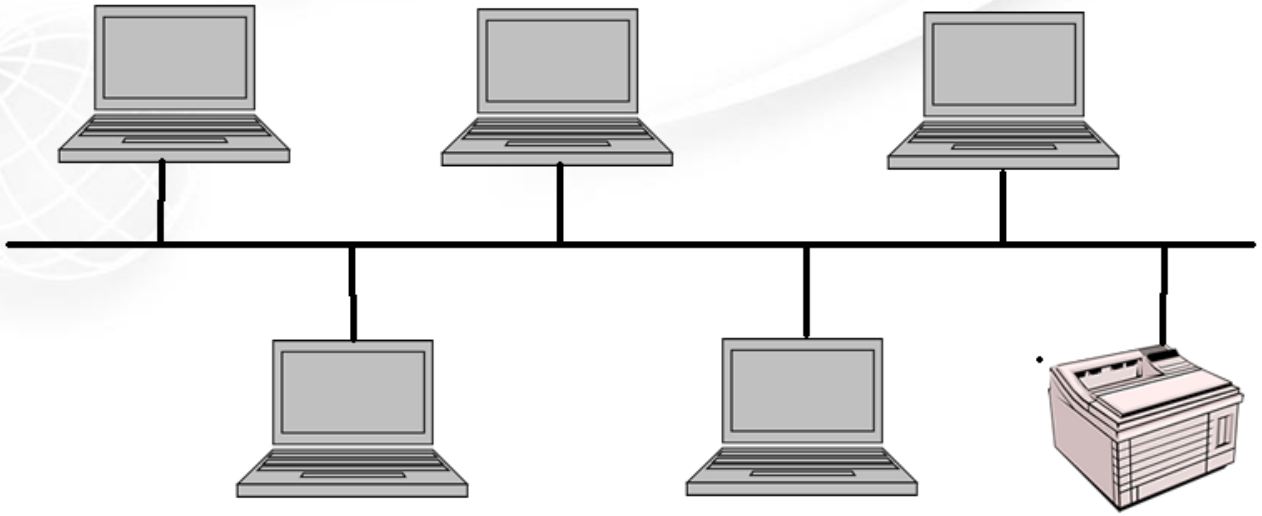
Topic 4 – Lecture 2:

Common Network Topologies

Standard Topologies

- There are three main network topologies in common use:
  - ***Bus*** is a series of computers connected along a single cable segment.
  - ***Star*** is a group of computers connected through a central point (hub).
  - ***Ring*** has computers connected to form a loop.
- There are variations:
  - Extended star
  - Mesh
  - Star combined with bus

Bus Topology - 1



Bus Topology - 2

- E.g. Ethernet
- Devices connected along a single cable
- Electrical pulses (signals) travel along the length of the cable in all directions.
- The signals continue to travel until they weaken enough so as not to be detectable or until they encounter a device that absorbs them.
- At the end of a cable, the signal bounces back unless there is a terminator.

Logical Bus

- Logical topologies describe the path that data travels from computer to computer.
- A physical bus topology is usually also implemented as a logical bus.
- The physical bus has fallen out of use due to technological advances.
- Logical bus topology is used on some physical topologies, in particular a star topology.

Passive Topology

- The bus topology is a ***passive topology.***
- Workstations on the bus are not responsible for regenerating the signal as it passes them.
- The workstations are not required for the bus to function.
- If a workstation fails, the bus does not fail.

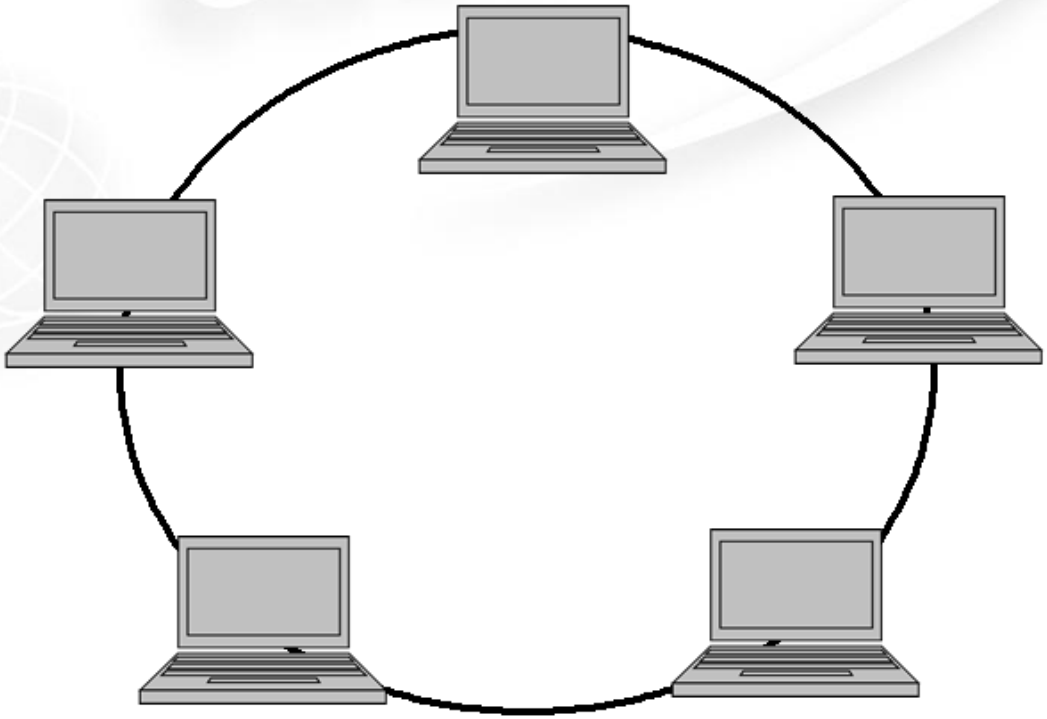
Physical Bus Advantages

- Cost
  - Less cable required than star or mesh
  - No additional devices such as hubs
- Ease of installation
  - Simply connect device to cable segment
- Resistant to workstation failure
  - Network functions if device fails
  - ***NOTE: problems if cable breaks***

Physical Bus Disadvantages

- Difficult to troubleshoot
  - Faults are usually a break in the main cable and this is difficult to isolate on a large network
- Scalability
  - Increasing network size and layout can be important for productivity
  - Bus topology is not easily scaled up.

Ring Topology



Physical Ring Topology

- All computers are connected in a ring.
- The ring has no start and no end.
  - Does not need a terminator as there are no reflected signals
- Signals travel in one direction.
- Signals are regenerated by each computer in turn
  - ***Active topology***.

Logical Ring Topology

- Data travels from one node to the next device until it reaches its destination.
- Modern ring topologies use “smart hubs” that recognise a computer failure and remove that computer from the ring automatically.
- Shares network resources fairly

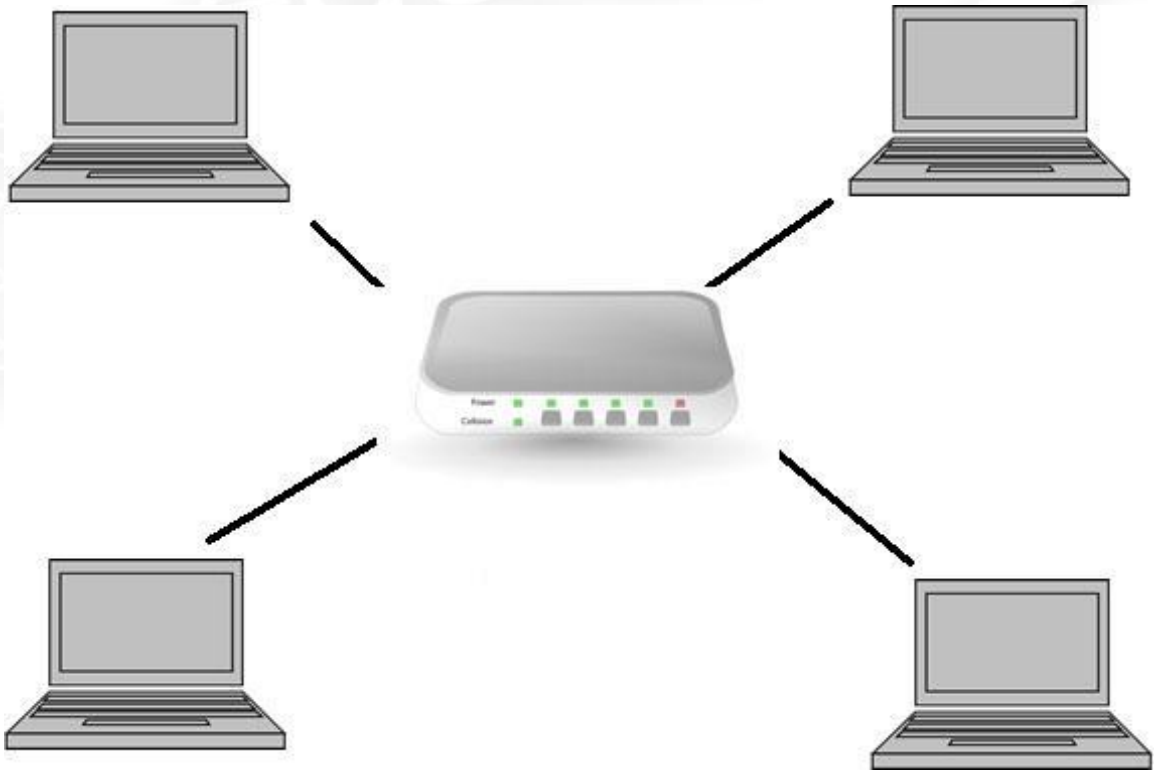
Physical Ring Advantages

- Low signal degeneration
  - Each workstation is responsible for boosting the signal
  - In passive systems, the signal is not boosted and weakens, which limits the size of the network
  - Strong signal means signal seldom needs retransmitting
- Fair allocation of network access to nodes

Physical Ring Disadvantages

- Not resistant to workstation failure
  - Failure of workstation or cable causes network to fail
  - ***Note:*** modern systems and logical rings can isolate failed workstation and maintain network uptime
- Network maintenance
  - Changes to cabling or moving a workstation can cause network downtime.

Star Topology



Physical Star Topology

- All devices connected through a central hub or switch
- Each workstation is connected directly to the hub.
- Very popular topology for modern networks

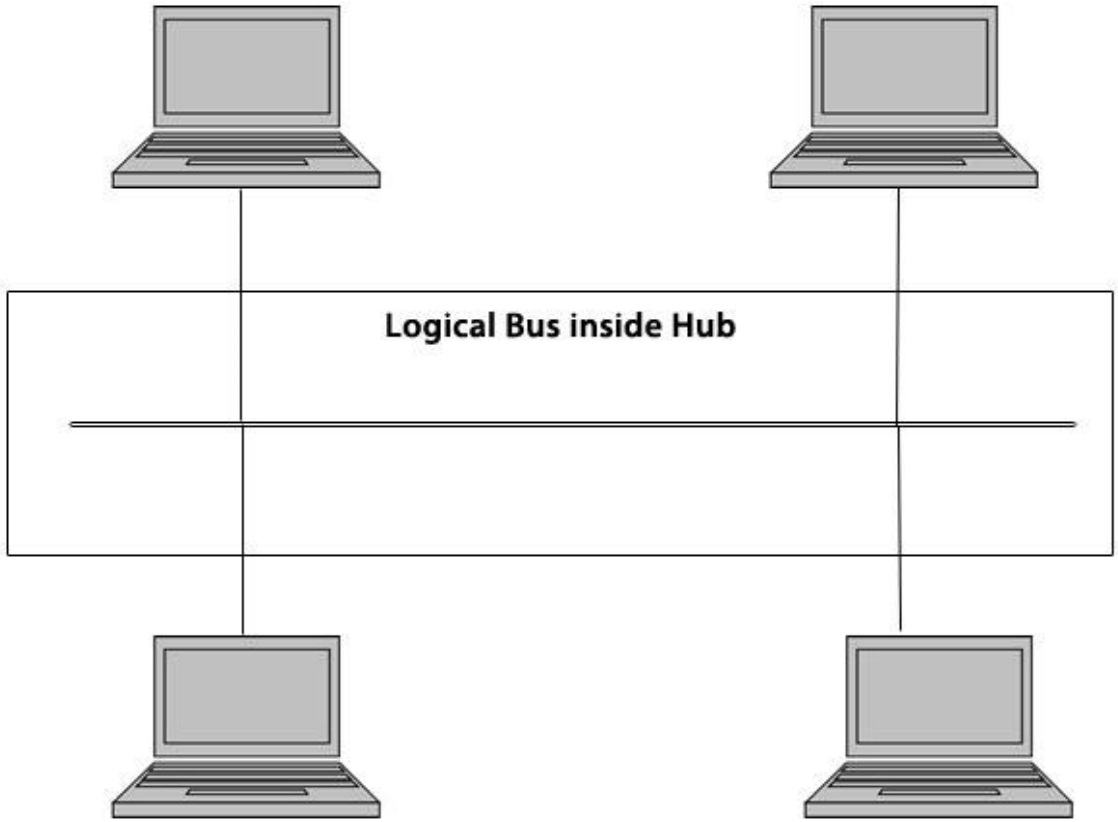
Star Topology Advantages

- Easy to add new devices – just connect to hub
- Cable break only affects one single node.
- Ease of administration
  - Centralised management and monitoring of network traffic simplifies job of network administrator
- Ease of changing configuration

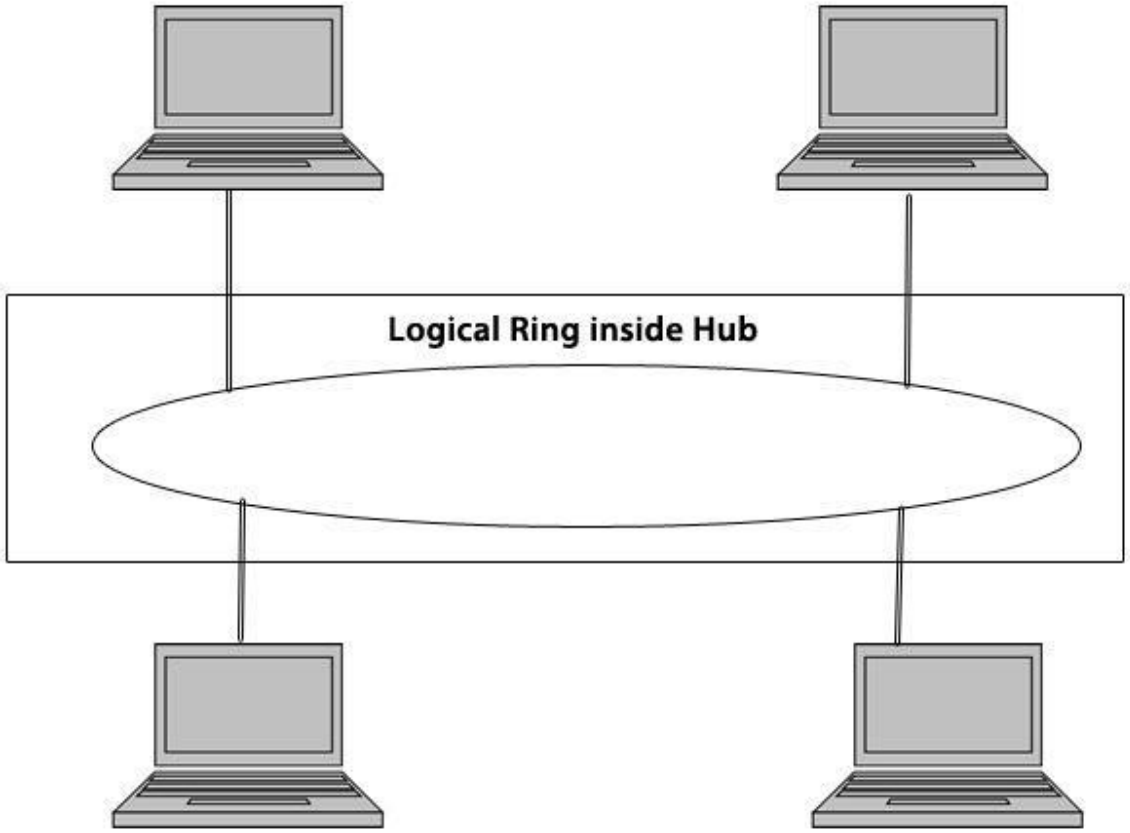
Star Topology Disadvantages

- Hub Failure
  - If the hub fails, the whole system fails.
  - However, this is easy to troubleshoot.
- Cost
  - Cost is higher as extra cabling and devices (hubs) are required.
  - However, this cost is no longer great and therefore not a real barrier to implementing a star topology.

Star as Logical Bus



Star as Logical Ring



Switching as Star Topology

- Switched networks are neither bus nor ring logically, but are implemented as a physical star.
- A switch takes a signal coming from a network device and builds a link to the intended destination computer on the fly.
- Superior to other logical topologies, because multiple computers can communicate simultaneously without affecting each other
- Main method used in most LAN designs

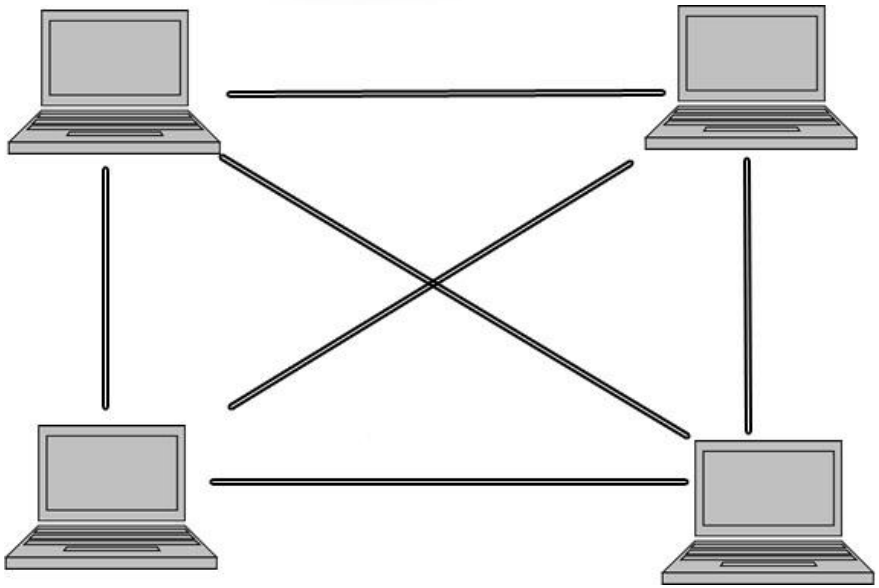
WLAN as Physical Star Topology

- Uses a central device (***access point***) to control communications

- Star physical topology because all the signals travel through one central device

Mesh Topology

- Every workstation is connected to every other workstation.
- Not very common



Mesh Topology Advantages

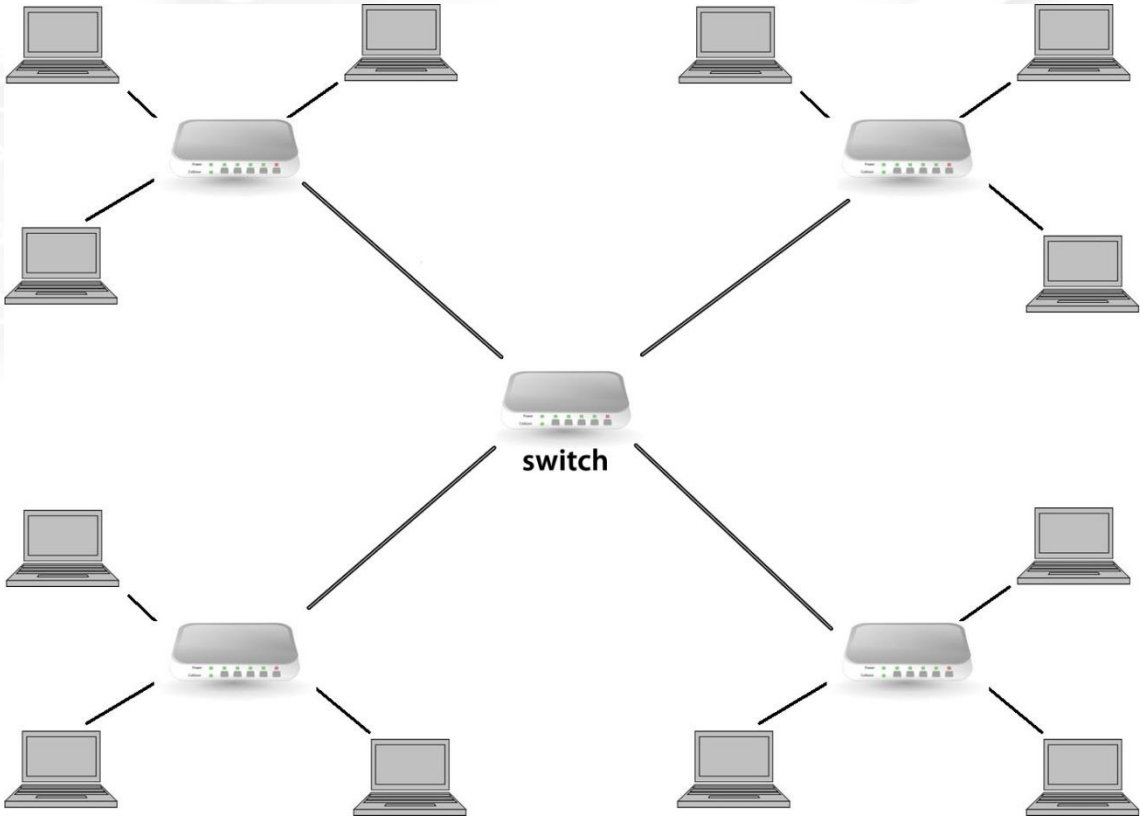
- Resilience
  - Multiple pathways for sending data
  - Cable fault is not a problem as data can go via another path
  - Almost impossible for network to fail due to cable failure as there are so many routes available

Mesh Topology Disadvantages

- Cost
  - Additional cabling
  - Additional interfaces
- Difficult to administer
  - Due to the number of connections

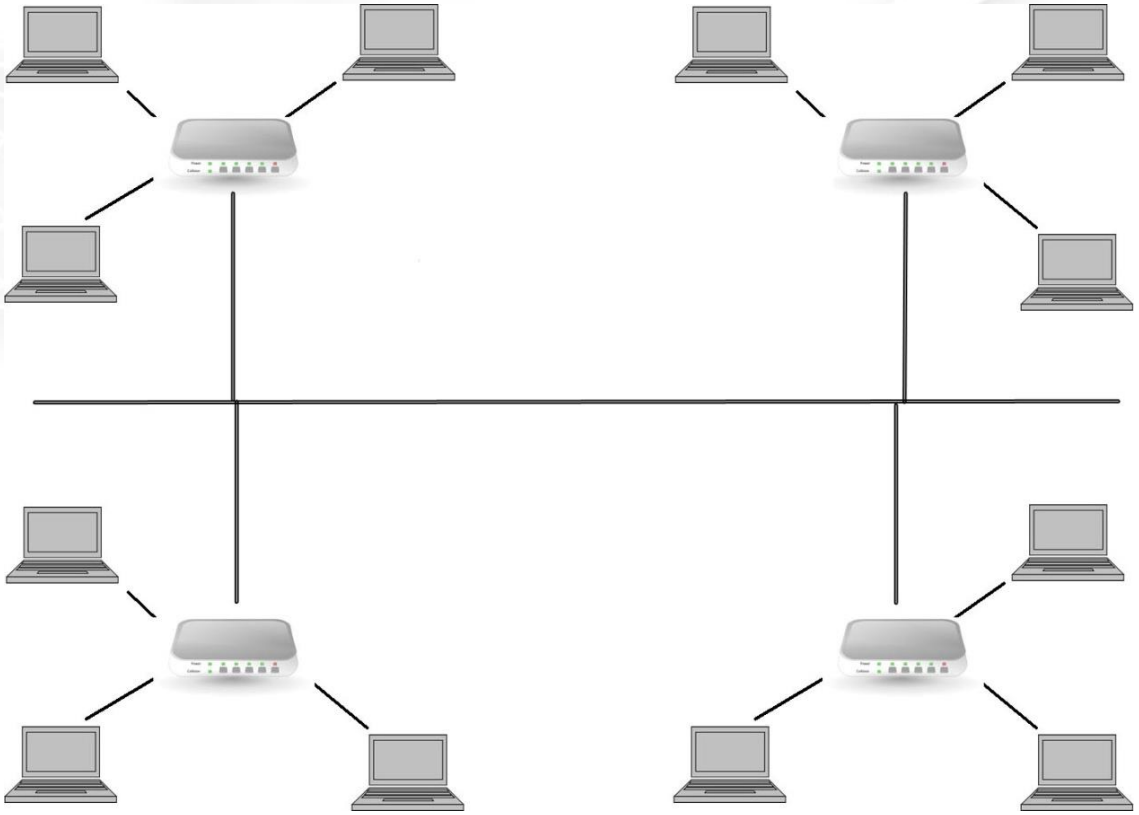
Extended Star

- Several stars connected in a star from a switch



Combination of Star & Bus

- Several stars connected along a bus



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Topic 4 – Lecture 3:
Topologies & Protocols

Star Topology

- The most common physical topology in modern LANs
- Requires a device at the centre of the network that controls traffic
- Both hubs and switches can act as the centre of a star topology.

Hubs

- Active hubs are the most common type of hub.
- Regenerate or repeat the signals
  - Needs electrical power
  - Has many ports
  - Also called multiport repeaters or repeating hubs
  - Signal comes in on one port
  - Cleans the signal (filters out noise)
  - Strengthens the signal
  - Sends the regenerated signal out to all other ports

Switches

- Central connecting point in a star topology network
- Does more than regenerate signals
- Has several ports for connecting workstations in a star topology
- Determines which port the destination device connects to and forwards the message to that port
- Handles several conversations at a time
- Provides the full network bandwidth to each device rather than requiring bandwidth sharing

Network Access

- In any network, providing access for nodes to transmit messages is a key element.
- It must be assumed that any node may require access at any time.
- Controlling access to networks becomes more difficult for larger networks and faster data speeds.
- Access is controlled by a combination of topology, wiring and protocols that combine into network standards.

Non-contention Techniques

- Designed to prevent conflict between nodes wishing to transmit
- Does not allow two nodes to transmit at the same time
- Each node is given exclusive access to the network.
- This right to access is passed throughout the network.
- ***Token passing*** is a common form.

Contention Techniques

- Allow conflicts and collisions to occur
- Dealing with collisions is part of the design
- No order of access to transmit
- Any node can transmit at any time.

Common Contention Technique

- CSMA/CD
- As used in Ethernet
- When a collision occurs, each node waits a random time before retransmitting, why?

Designing a Network

- The main steps are as follows:
  - Determine what the network will be used for – this will be a major factor in deciding the topology you use.
  - Choose the types of devices that will be used for interconnecting computers and sites.
  - Consider the type of devices the network will employ and the usage of network resources – this will determine how many servers are required and where servers should be placed.

Selecting a Topology

- Modern networks have one key factor in this choice - how fast should the network be?
- ***Physical topology*** will almost certainly be a star
- ***Logical topology*** is usually a switched network
- Ethernet switches are used on most LANs
- Other logical topologies can be the result of:
  - Use of legacy equipment
  - Network size
  - Cost restrictions
  - Difficulty of running cables

Planning a Logical Topology - 1

- Can either start from scratch or upgrade an existing network?
- You should have sufficient information about:
  - Networking components
  - Hardware
  - Protocols
  - Physical topologies

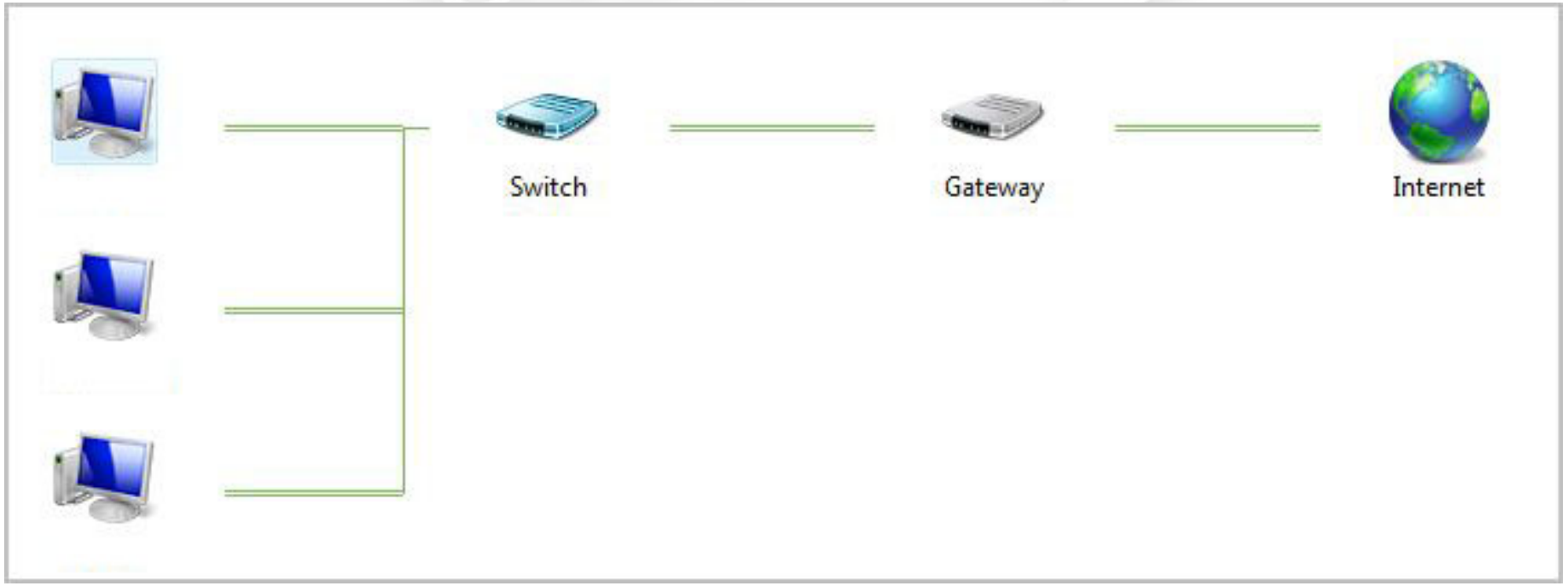
Planning a Logical Topology - 2

- Analyse the following:
  - Security needs
  - Traffic patterns
  - Need for future expansion
  - Server capabilities
  - Internet access requirements
- You should also make a plan for disaster recovery, data recovery and troubleshooting techniques.

Creating a Network Layout - 1

- A network layout must be documented in a diagram.
- Factors to consider
  - Number of client computers
  - Number of servers
  - Will there be an Internet connection?
  - The architecture of the building
  - The best topology or topologies
- Any diagram must be updated if the layout changes
  - Version control.

Creating a Network Layout - 2



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- Price, B. (ed) (2003). *Networking Complete,* 3rd edition. Sybex.
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Topic 4 – Network Topology and Architecture

Any Questions?

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