Unit 1: Introduction to Computer Networks

DR MOHAMMAD HAMMOUDEH

6G7Z1004: ADVANCED COMPUTER NETWORKS AND OPERATING SYSTEMS

Contact Details

Dr Mohammad Hammoudeh

Email: M.Hammoudeh@mmu.ac.uk

Room: JD E131

Telephone: +44 (0)161 247 2845

Office hours: See Moodle

Indicative Content

Wide area networks [15%]: Compare the characteristics of WAN technologies, including their switching type, throughput, media, security, and reliability; Describe several WAN transmission and connection methods, including PSTN, ISDN, DSL, broadband cable, ATM, and SONET.

Virtual networking and remote access [15%]: Explain virtualization and identify characteristics of virtual components; Understand VPNs (virtual private networks) and the protocols they rely on; Identify the features and benefits of cloud computing and NaaS.

Advanced wireless and mobile networking [15%]: Wireless links and network characteristics; WiFi: 802.11 Wireless LANs; Cellular internet access; Sensor networks.

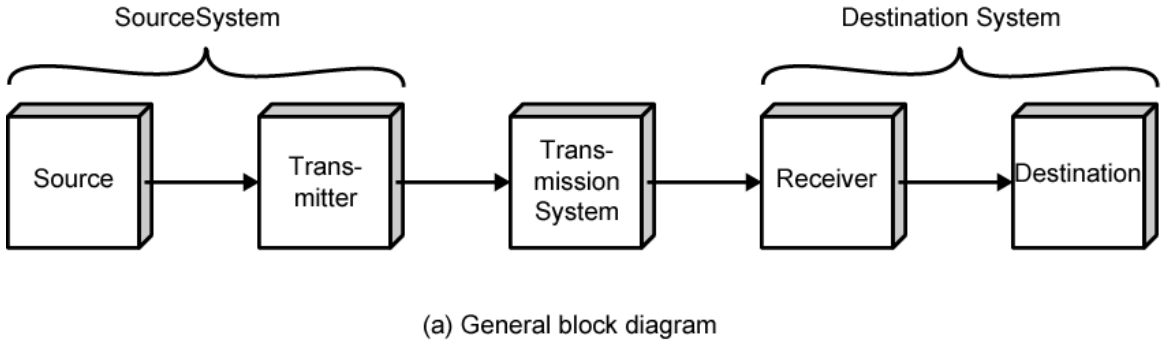
Network Management [5%]: What Is Network Management? The Infrastructure for Network Management; The Internet-Standard Management Framework.

After reading this unit and completing the exercises, you will be able to:

1. List the advantages of networked computing relative to standalone computing
2. Distinguish between client/server and peer-to-peer networks
3. Distinguish between different network topologies
4. Describe several specific uses for a network
5. Describe how Ethernet works

SO LET'S GET STARTED!

Communication Model



(a) General block diagram

(b) Example

Transmission Modes

Simplex

- One direction - e.g. Television

Half duplex

- Either direction, but only one way at a time - e.g. police radio

Full duplex

- Both directions at the same time - e.g. telephone

Communication Types

Unicasting (one-to-one)

Multicasting (one-to-many)

Broadcasting (one-to-all)

Network Classification

Network Classification

By Size or Scale

- LAN
- WAN
- MAN
- CAN
- PAN

Local Area Network (LAN)

- Contains printers, servers and computers
- Systems are close to each other
- Contained in one office or building
- Organizations often have several LANS

Wide Area Networks (WAN)

- Two or more LANs connected
- Over a large geographic area
- Typically use public or leased lines
- The Internet is a WAN

Metropolitan Area Network (MAN)

- Large network that connects different organizations
- Shares regional resources
- A network provider sells time

Campus Area Networks (CAN)

- A LAN in one large geographic area
- Resources related to the same organization
- Each department shares the LAN

Personal Area Network (PAN)

- Very small scale network
- Range is less than 2 meters
- Cell phones, PDAs, MP3 players

Network Classification

By Structure / Functional Relationship

- Client / Server
- Peer to Peer (P2PN)

Client/Server network

- Nodes and servers share data roles
- Nodes are called clients
- Servers are used to control access
- Database software
  - Access to data controlled by server
- Server is the most important computer

Peer to peer networks (P2PN)

- All nodes are equal
- Nodes access resources on other nodes
- Each node controls its own resources
- Most modern OS allow P2PN

Network Classification

By Topology / Physical Connectivity

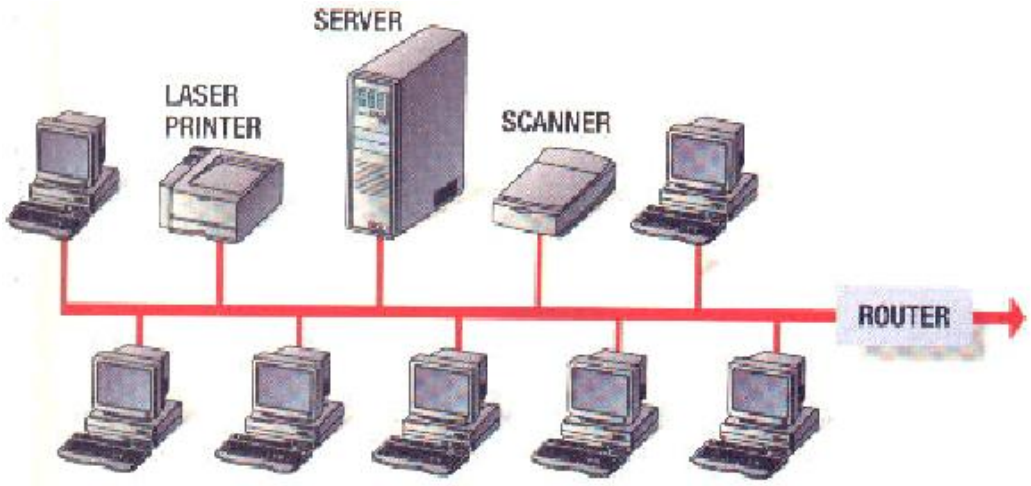
- BUS
- STAR
- RING
- MESH
- TREE

Network Topology

- Physical layout of wires and equipment
- Choice affects
  - Network performance
  - Network size
  - Network collision detection

BUS

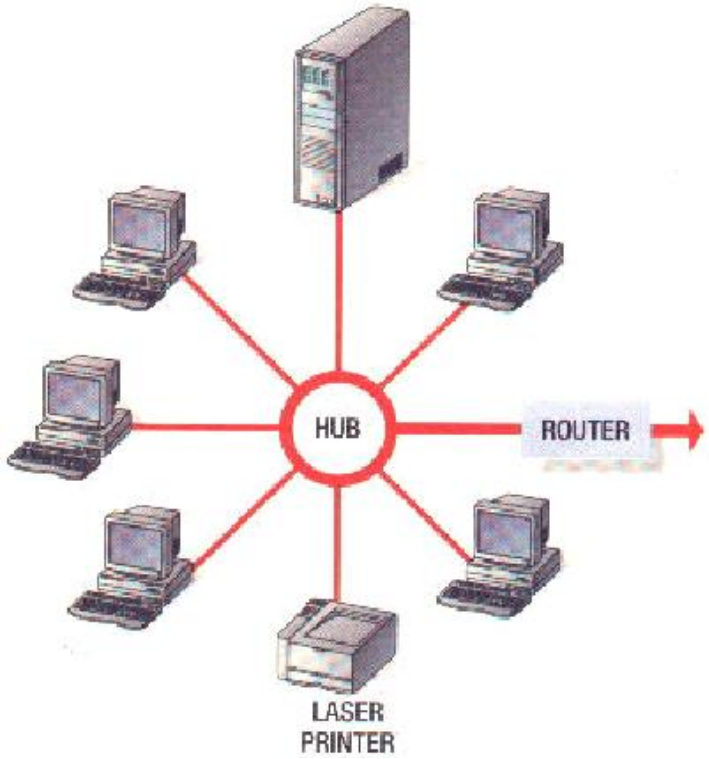
- Also called linear bus
- One wire connects all nodes
- Terminator ends the wires
- Advantages
  - Easy to setup
  - Small amount of wire
- Disadvantages
  - Slow
  - Easy to crash



STAR

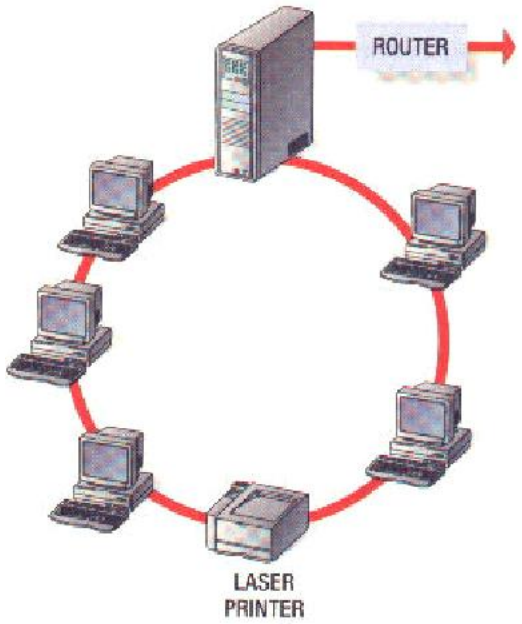
- All nodes connect to a hub
  - Packets sent to hub
  - Hub sends packet to destination
- Advantages
  - Easy to setup
  - One cable can not crash network
- Disadvantages
  - One hub crashing downs entire network
  - Uses lots of cable

Most common topology



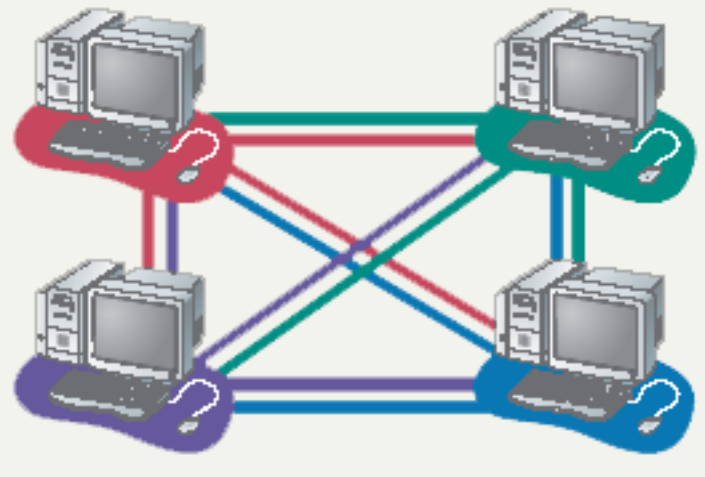
RING

- Nodes connected in a circle
- Tokens used to transmit data
  - Nodes must wait for token to send
- Advantages
  - Time to send data is known
  - No data collisions
- Disadvantages
  - Slow
  - Lots of cable



MESH

- All computers connected together
- Internet is a mesh network
- Advantage
  - Data will always be delivered
- Disadvantages
  - Lots of cable
  - Hard to setup



The Ethernet

The Ethernet History

- Designed and tested in 1973, at Xerox Corporation's Palo Alto Research Center (PARC)
- Developed the physical method of cabling that connected devices on the Ethernet as well as the standards that governed communication on the cable
- The most popular and most widely deployed network technology in the world

Ethernet Basic Design

- The original Ethernet described communication over a **single cable** shared by all devices on the network.
- Once a device attached to this cable, it had the ability to communicate with any other attached device.

Ethernet Basics

- A local area technology
- At most, Ethernet devices could have only a few hundred meters of cable between them, making it impractical to connect geographically dispersed locations. Modern advancements have increased these distances considerably, allowing Ethernet networks to span tens of kilometres.

Ethernet Terminology

Protocols: A set of rules that govern communications. For two devices on a network to successfully communicate, they must both understand the same protocols.

Medium - Ethernet devices attach to a common medium that provides a path along which the electronic signals will travel.

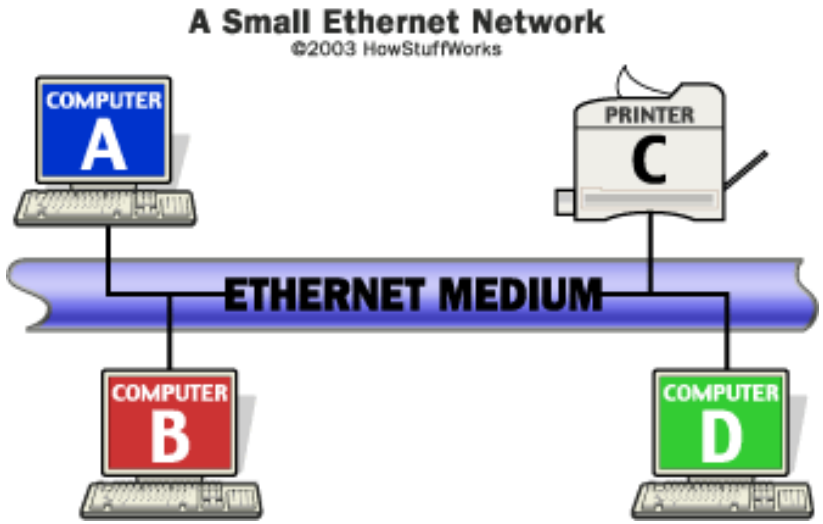
Segment - We refer to a single shared medium as an Ethernet segment.

Node - Devices that attach to that segment are stations or nodes.

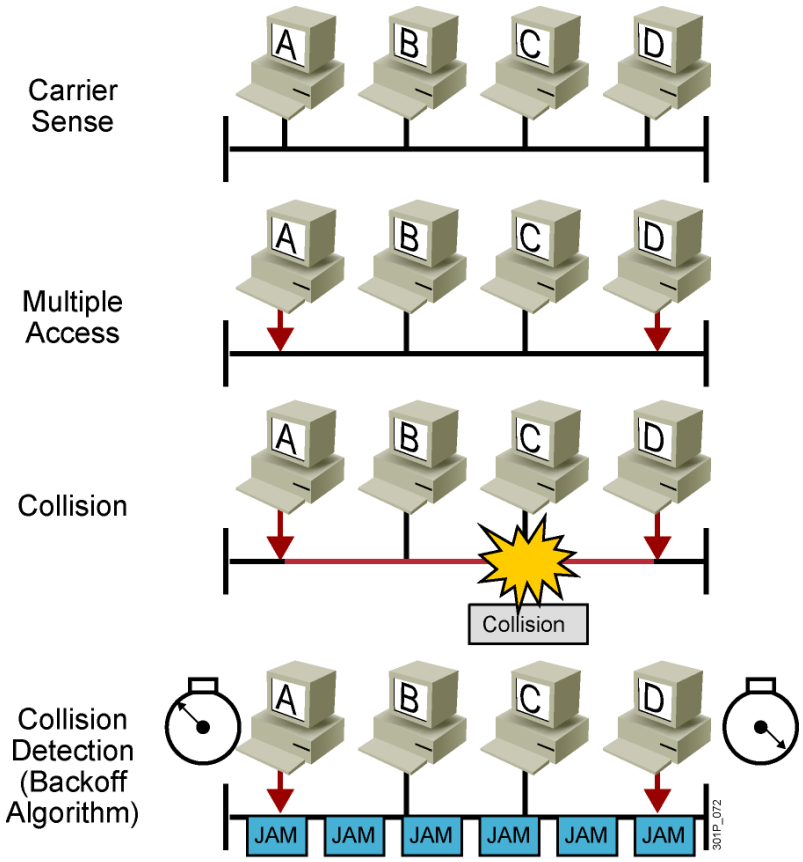
Frame - The nodes communicate in short messages called frames, which are variably sized chunks of information.

Ethernet Medium

Since a signal on the Ethernet medium reaches every attached node, the destination address is critical to identify the intended recipient of the frame.



CSMA/CD



Carrier Sense Multiple Access Collision Detection (CSMA/CD)

CSMA/CD

1. monitor carrier sense signal before transmission (listen before transmitting).
2. if busy, delay transmission.
3. should a collision occur
   a. stop transmission (listen while transmitting).
   b. send out short jam sequence.
   c. reschedule a retransmission after a random interval (binary exponential backoff).

Collision Detection

- Ethernet segment is called a **collision domain** because no two stations on the segment can transmit at the same time without causing a collision.
- When stations detect a collision, they cease transmission, wait a random amount of time, and attempt to transmit when they again detect silence on the medium.
- The random delay makes it unlikely that any two stations will collide more than a few times in a row.

Limitations of Ethernet (1)

Length of the shared cable (**network diameter**)

- Electrical signals propagate along a cable very quickly, but they weaken as they travel, and electrical interference from neighbouring devices can scramble the signal.
- A network cable must be short enough that devices at opposite ends can receive each other's signals clearly and with minimal delay.

Limitations of Ethernet (2)

Communication delay

- In CSMA/CD only a single device can transmit at a given time, there are practical limits to the number of devices that can coexist in a single network. Attach too many devices to one shared segment and contention for the medium will increase. Every device may have to wait an inordinately long time before getting a chance to transmit.

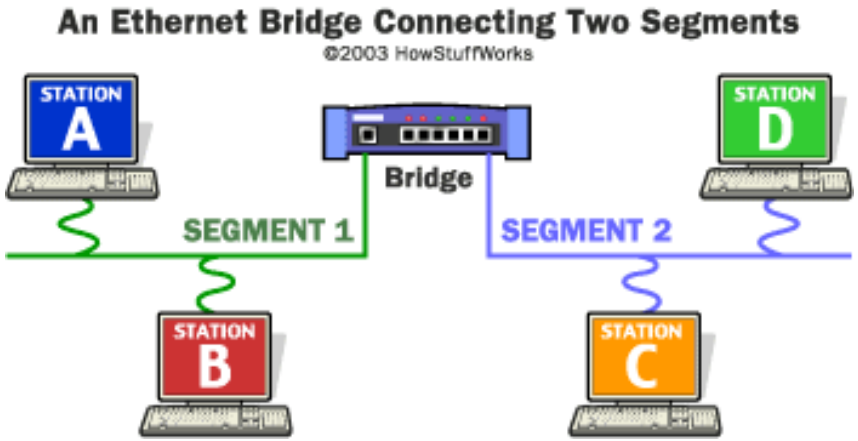
Segmentation

Ethernet networks face **congestion** problems as they increased in size.

One way to reduce congestion would be to split a single segment into multiple segments, thus creating **multiple collision domains**. This solution creates a different problem, as now these now separate segments are not able to share information with each other.

Bridges (1)

Bridges connect two or more network segments, increasing the network diameter as a repeater does, but bridges also help **regulate traffic**.



Bridges (2)

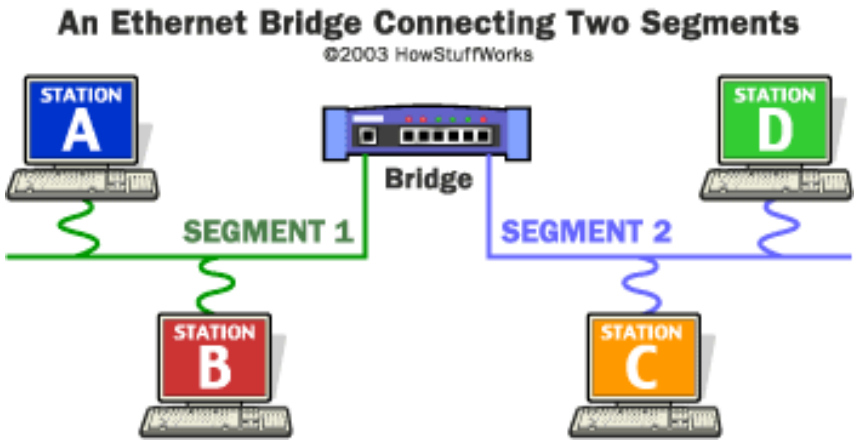
One goal of the bridge is to **reduce unnecessary traffic** on both segments.

It does this by examining the destination address of the frame before deciding how to handle it.

- If the destination address is that of station A or B, then there is no need for the frame to appear on segment 2. In this case, the bridge does nothing. We can say that the bridge **filters** or drops the frame.
- If the destination address is that of station C or D, or if it is the broadcast address, then the bridge will transmit, or **forward** the frame on to segment 2. By forwarding packets, the bridge allows any of the four devices in the figure to communicate.

Bridges (3)

By filtering packets when appropriate, the bridge makes it possible for station A to transmit to station B at the same time that station C transmits to station D, allowing two conversations to occur simultaneously!



Switches are the modern counterparts of bridges, functionally equivalent but offering a **dedicated segment** for every node on the network

Routers: Logical Segmentation (1)

Bridges forward Ethernet broadcasts to all connected segments

This poses problems for bridged networks that grow too large.

- When a large number of stations broadcast on a bridged network, congestion can be as bad as if all those devices were on a single segment.

Routers: Logical Segmentation (2)

Routers are advanced networking components that can divide a single network into two logically separate networks.

While Ethernet broadcasts cross bridges in their search to find every node on the network, they do not cross routers, because the router forms a logical boundary for the network.

Network Separation (1)

- Imagine a small company that have 10 employees, each with a computer. Four of the employees are animators, while the rest are in management. The animators will need to send lots of very large files back and forth to one another as they work on projects. To do this, they'll use a **network**.
- When one animator sends a file, it will use up most of the network's capacity, making the network run very slowly for other users.

Network Separation (2)

- This keeps the basic plan of the network simple, but has performance consequences as the size of the network or level of network activity increases
- To keep the animators' work from interfering with that of the folks in the front office, the company sets up two separate networks, one for the animators and one for the rest of the company.
- A router links the two networks and connects both networks to the Internet.

Network Separation (3)

As the number of networks attached to one another grows, the configuration table for handling traffic among them grows, and the processing power of the router is increased.

Switched Ethernet

- Modern networks can operate at 100 or even 1,000 Mbps
- Switched networks replace the shared medium of legacy Ethernet with a dedicated segment for each station
- These segments connect to a switch
- The switch picks up every transmission before it reaches another node
- The switch then forwards the frame over the appropriate segment, just like a bridge, but since any segment contains only a single node, the frame only reaches the intended recipient

Full-duplex Ethernet

- Legacy Ethernet is half-duplex
- In a totally switched network, nodes only communicate with the switch and never directly with each other. Switched networks also employ either twisted pair or fiber optic cabling, both of which use separate conductors for sending and receiving data
- In this type of environment, Ethernet stations can forgo the collision detection process and transmit at will, since they are the only potential devices that can access the medium
- This allows end stations to transmit to the switch at the same time that the switch transmits to them, achieving a **collision-free** environment

Ethernet or 802.3?

- Ethernet originally referred to a networking implementation standardized by Digital, Intel and Xerox. (**DIX** standard.)
- The 802.3 group standardized the operation of a CSMA/CD network that was functionally equivalent to the DIX Ethernet
- Ethernet and 802.3 differ slightly in their terminology and the data format for their frames, but are in most respects identical
- Today, the term Ethernet refers generically to both the DIX Ethernet implementation and the IEEE 802.3 standard

Alternative Network Technologies: Token Ring (1)

- Developed by IBM
- It implements a strict, orderly access method
- It arranges nodes in a logical ring
- The nodes forward frames in one direction around the ring

Alternative Network Technologies: Token Ring (2)

1. The ring initializes by creating a **token**, which is a special type of frame that gives a station permission to transmit
2. The token circles the ring like any frame until it encounters a station that wishes to transmit data
3. This station then "captures" the token by replacing the token frame with a data-carrying frame, which encircles the network
4. Once that data frame returns to the transmitting station, that station removes the data frame, creates a new token and forwards that token on to the next node in the ring

Alternative Network Technologies:
Fiber-distributed data interface (FDDI)

- Is another token-passing technology
- Operates over a pair of fiber optic rings, with each ring passing a token in opposite directions
- FDDI networks offered transmission speeds of 100 Mbps, which initially made them quite popular for high-speed networking
- With the advent of 100-Mbps Ethernet, which is cheaper and easier to administer, FDDI has waned in popularity.

Alternative Network Technologies:
Asynchronous Transfer Mode (ATM)

ATM networks blur the line between local and wide area networking, being able to attach many different devices with high reliability and at high speeds, even across the country

ATM networks are suitable for carrying not only data, but voice and video traffic as well, making them versatile and expandable.