Course Outline

WEEK No.	TOPICS
0	Introduction to Data Communication & Network Topologies , Subnets , Circuit and Packet switching, Layers of Communication Protocol ,Connection oriented and Connection less Services
1	Data Link Layer : Framing and Packetization , Error Detection Techniques
2	Data Link Layer: Flow and Error Control , Sliding window protocols
3	Data Link Layer :High Level Data Link Control Protocol , Point to Point Protocol
4	Medium Access Layer : Queuing theory
5	Local Area Networks
6	Network Layer : IP , Flooding & Routing Algorithms
7	Network Layer : Dijkstra Algorithm
8	Network Layer :Distance Vector Routing (RIP)
9	Network Layer : Routing Loops and Count to Infinity Problem , RIP Timers
10	Transport Layer: Quality of Service, Transport Protocol Mechanisms, Flow Control and Congestion Control in TCP, Examples of Transport Protocols (UDP, TCP)

Learning Resources

- Text Books:
  - Data Communications & Networking (4th Edition), Behrouz A. Forouzan - McGraw-Hill
  - Data & Computer Communications (8th Edition) , William Stallings - Prentice Hall

- Reference Book:
  - Computer Networking: A Top-Down Approach (7th Edition) James Kurose , Keith Ross – Pearson

Course Objectives

- To develop understanding of the fundamental concepts of computer networking.

- To develop an understanding of different components of computer networks, various protocols, modern technologies and their applications.

Course Learning Outcomes

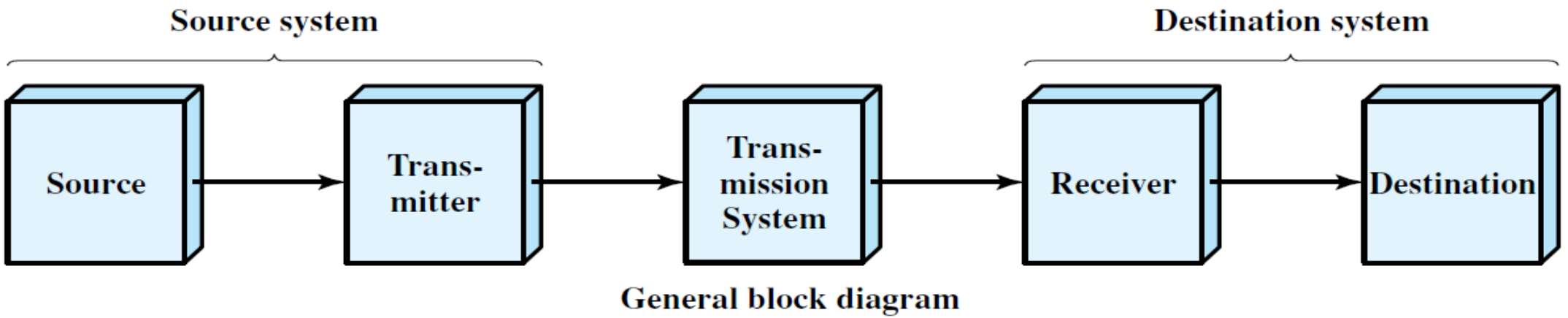
- On successful completion of this course , the student must be able to :
  - Understand basic computer network technology.
  - Understand and explain Data Communications System and its components.
  - Identify the different types of network topologies and protocols.
  - Explain the function(s) of each layer of OSI and TCP/IP reference model.
  - Identify the different types of network devices and their functions within a network.
  - Understand sub-netting and routing mechanisms.
  - Familiarity with the basic protocols of computer networks, and how they can be used to assist in network design and implementation.

A Communication Model

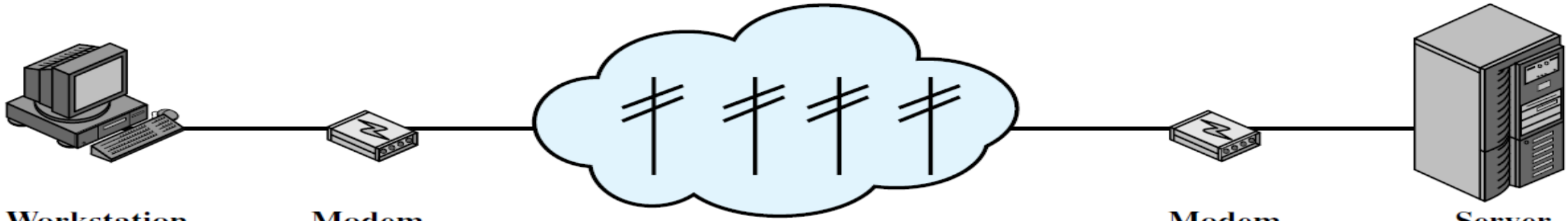
- Exchange of data between two parties.

- Key Elements:
  - Source – generates data to be transferred
  - Transmitter – converts data into transmittable signals
  - Transmission system – carries the data
  - Receiver – converts received signal into data
  - Destination – takes incoming data

Simplified Communication Model



General block diagram



Example

What is a Network?

- Set of devices (often referred to as nodes) connected by communication links, capable of sending and/or receiving data generated by other nodes on the network.

- Fundamental aim of networks:
  - Resource sharing (computing, printers, peripherals, information)
  - Services (Email, video conferencing, DB access, Client/server applications)

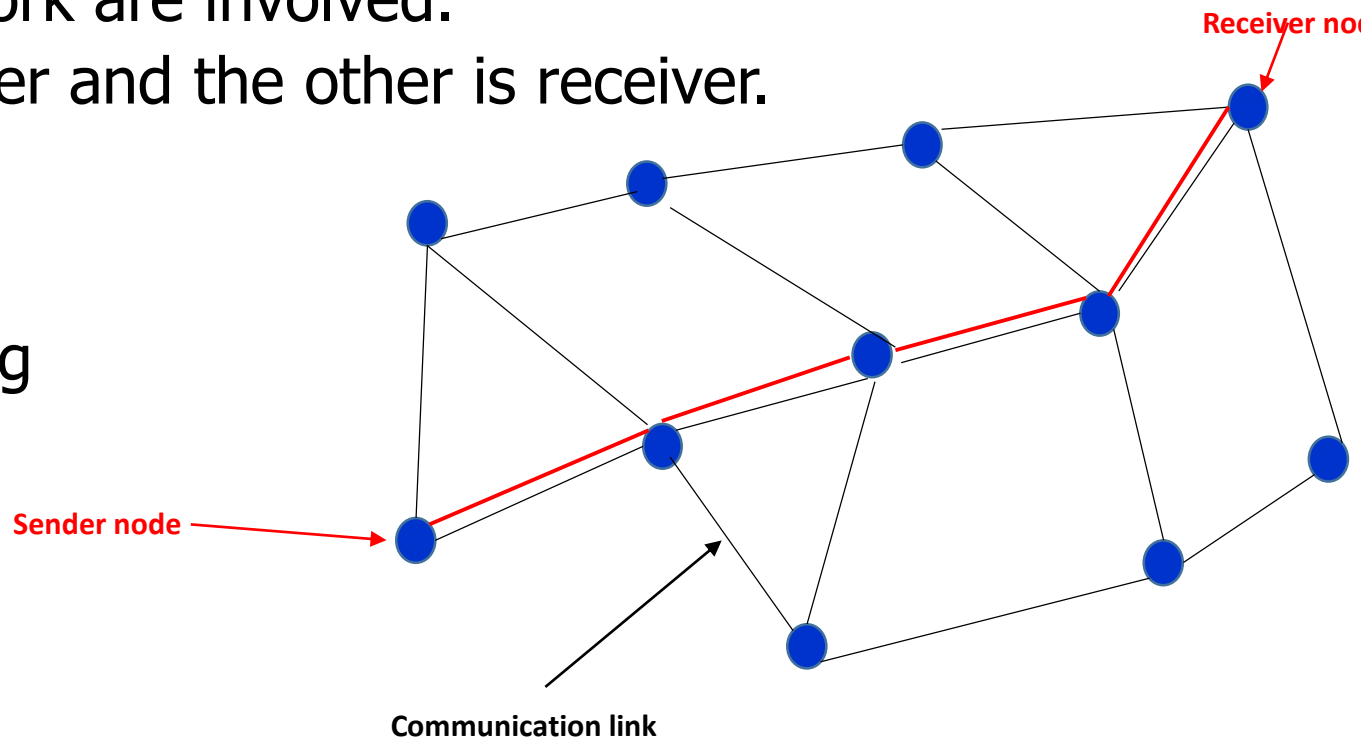
Important Tasks in Networking

- Routing – identify suitable routes subject to constraints on capacity and allowable delays.
- Congestion control – avoid traffic overload situations in specific network areas or at least to react properly to them.
- Flow Control – avoid overflowing receiver with data from sender.
- Error Control – dealing with errors occurred during transmission

Common Communication Patterns

- Unicast
  - Only two nodes in the network are involved.
  - One of the node is the sender and the other is receiver.
  - Nodes can have both roles.

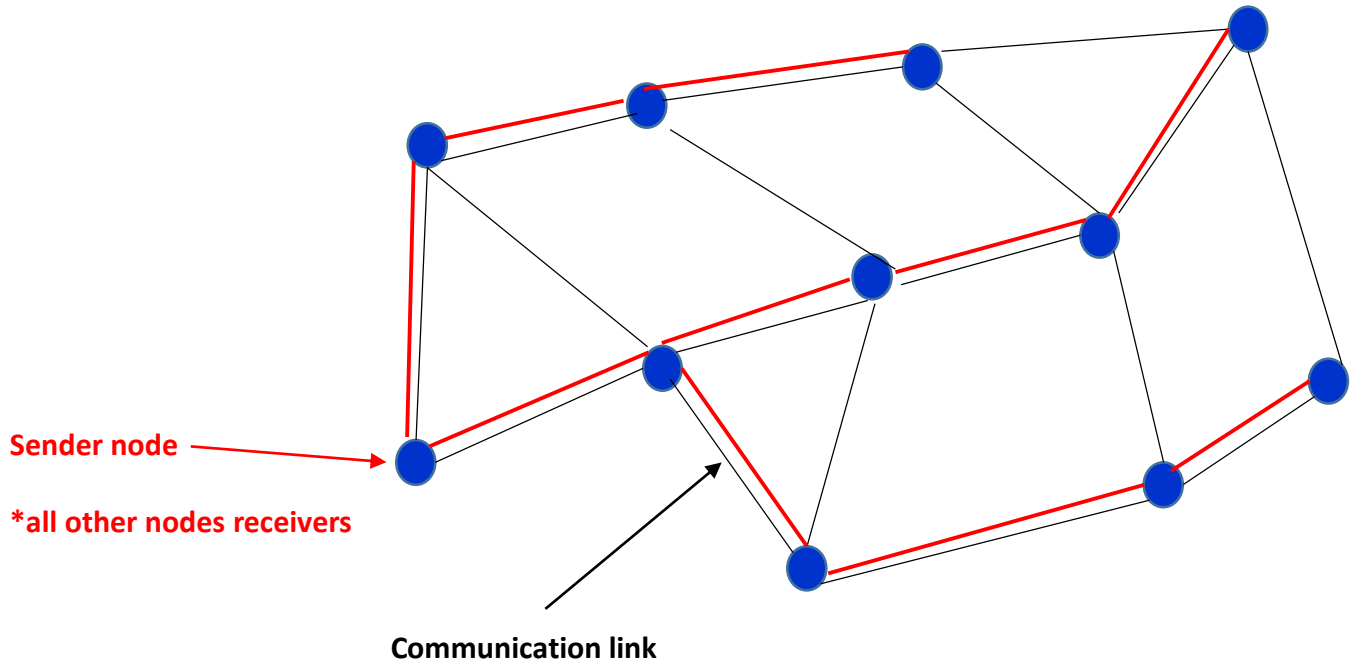
- E.g. Phone connections, viewing a webpage.



Common Communication Patterns

- Broadcast
  - One node as sender , all other nodes as receivers.

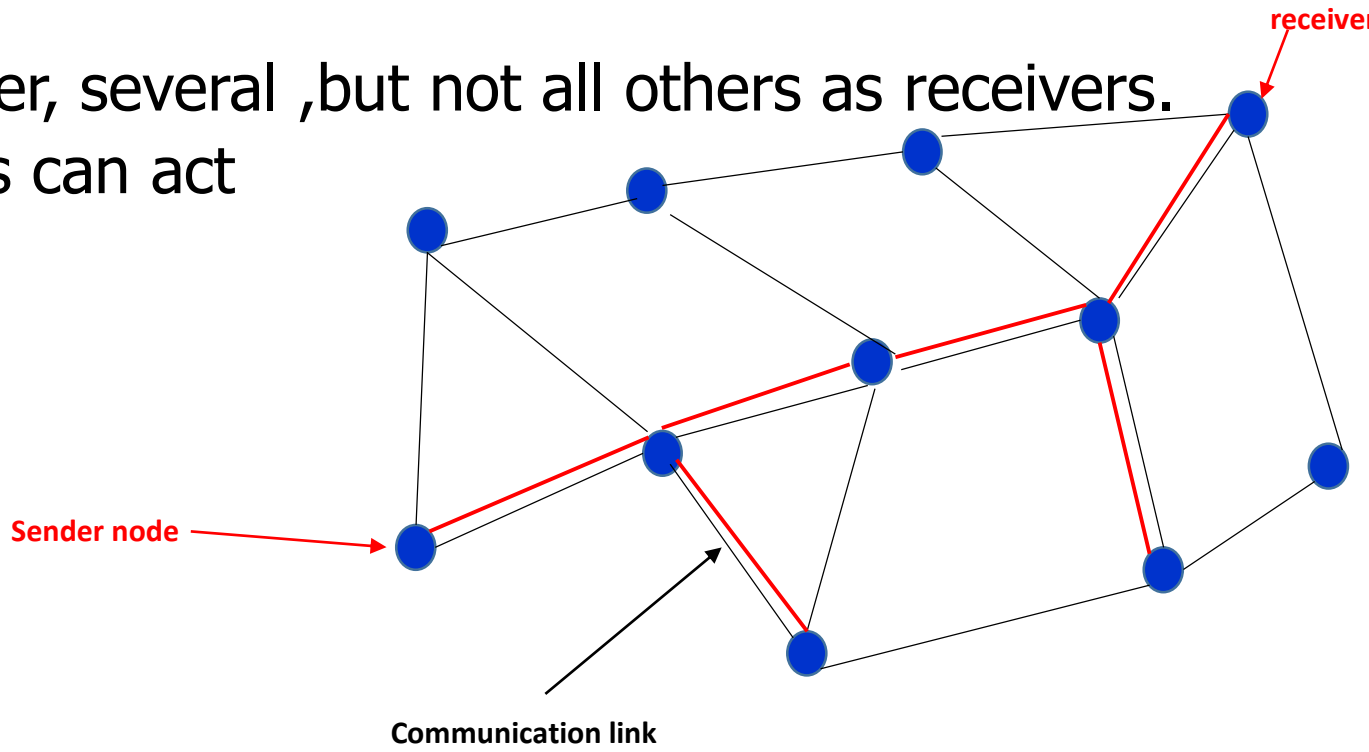
- E.g. Radio , TV



Common Communication Patterns

- Multicast
  - Group communication
  - One of the node is the sender, several ,but not all others as receivers.
  - In multicast group, all nodes can act as sender

- E.g. Internet chat
  phone conferences

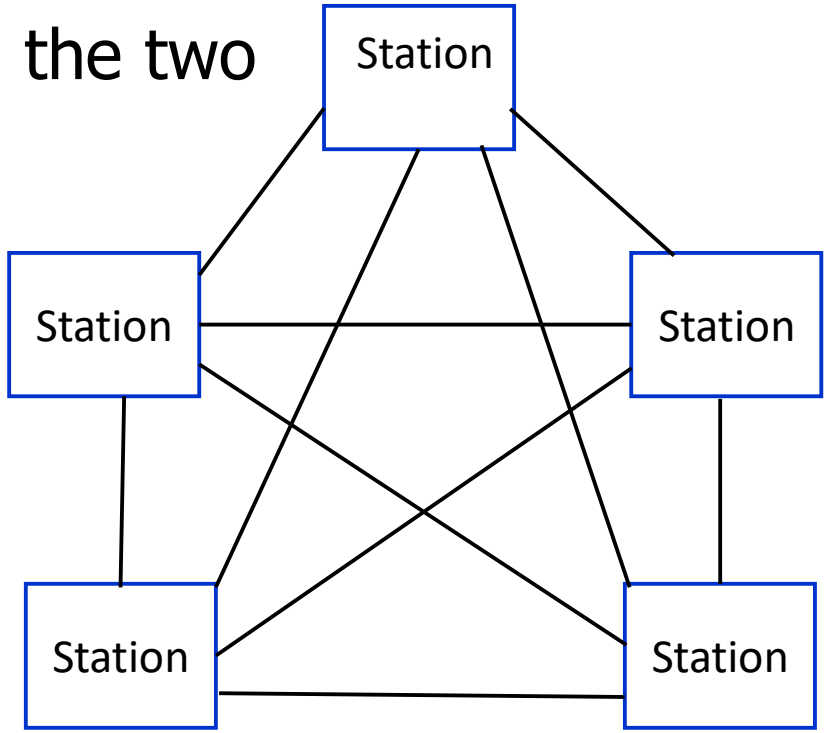


Network Topologies

- Network Topology – arrangement of elements in a communication network.
- A simple model of network is a simple communication graph
  - Nodes represent stations/switching elements
  - Edges represent direct communication links
- Four basic topologies are:
  - Mesh
  - Star
  - Bus
  - Ring

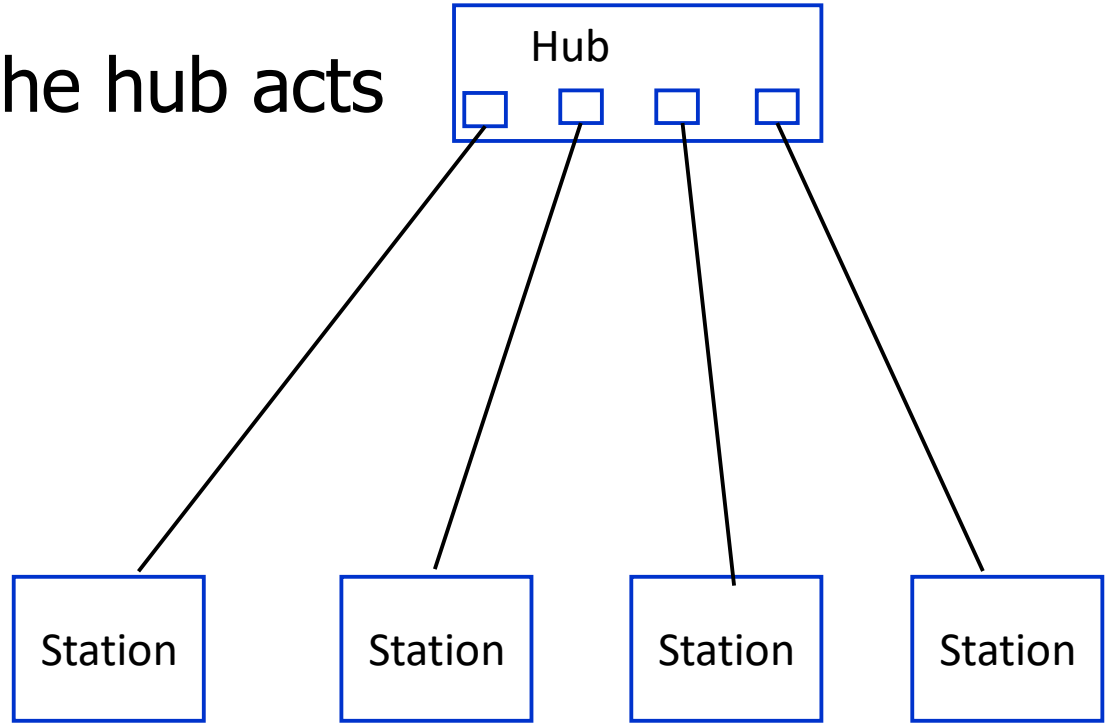
Mesh Topology

- Mesh Topology – every device has a dedicated link to every other device.
- Dedicated link carries traffic only between the two devices it connects.
- Total no. of links = $\frac{n(n-1)}{2}$
- Advantages:
  - Robust
  - Privacy or security
- Disadvantages:
  - Increased cost of installation
  - Poor scalability



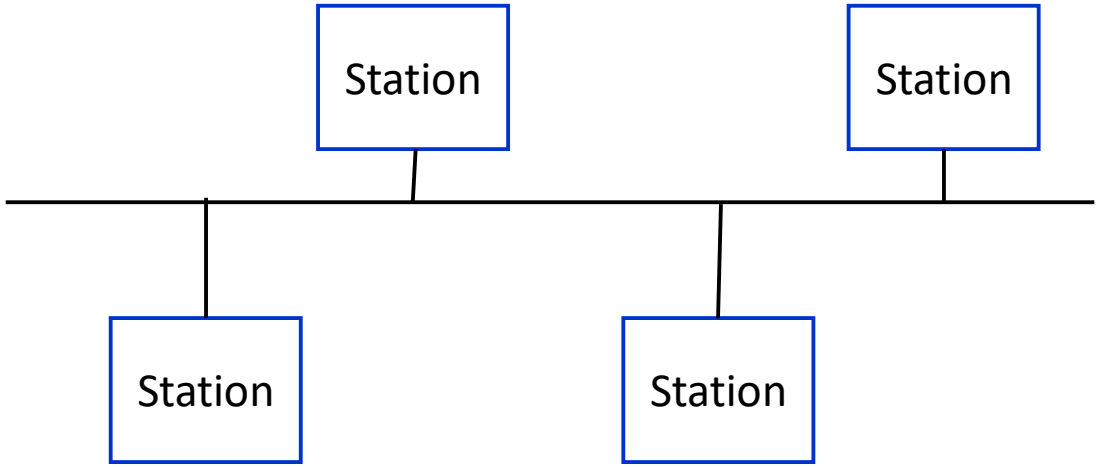
Star Topology

- Star Topology – every device has a dedicated link to central controller(hub).
- No direct traffic between devices, the hub acts as an exchange.
- Total no. of links = n
- Advantages:
  - Robust
  - Less expensive
- Disadvantages:
  - Hub is the single point of failure



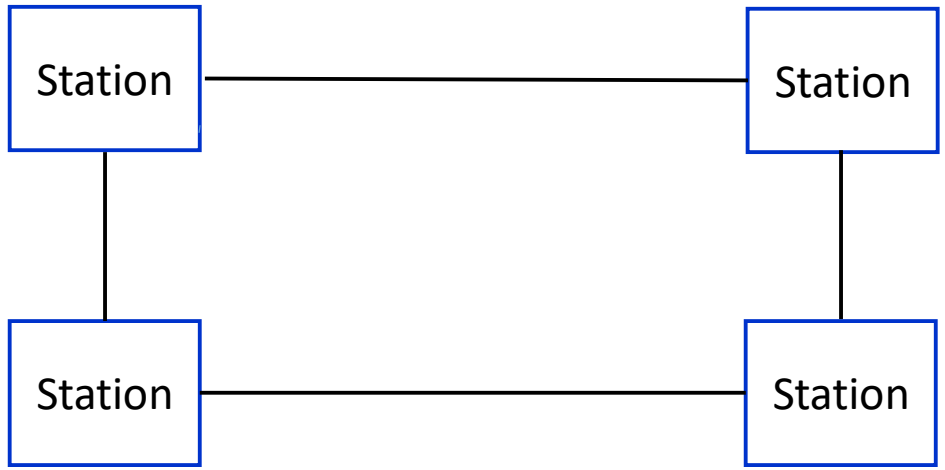
Bus Topology

- Bus Topology – every device is connected to a common bus.
- Bus is a broadcast medium.
- Advantages:
  - Ease of installation
- Disadvantages:
  - Difficult to scale
  - Bus is a common point of failure



Ring Topology

- Ring Topology – every device has a dedicated connection to the two devices on either side of it.
- Signal is passed along the ring in one direction only, from one device to other, until it reaches the destination.
- Advantages:
  - Ease of installation
- Disadvantages:
  - Difficult to scale
  - A single break in the link can bring entire network down.



Network Coverage Areas

- Local Area Network(LANs)
  - Have limited geographical extension, usually ≤ 1 Km(spans office or building)
  - Controlled by only one owner/ administrative entity
  - Offer a shared transmission medium to multiple stations
- Most common LANs are switched (Ethernet) LAN and wireless LAN.
- E.g.
  - Connect desktop computers to share files , emails
  - Allow several computers to share printers , file servers.

Network Coverage Areas

- Wide Area Network(WANs)
  - Spans large area (countries, continents , world)
  - Controlled by several administrative entities
  - Internet is an example of WAN
- In internet, LANs are an elementary unit.
  - Internet = Network of Networks
  - LANs are attached to Routers, Routers are interconnected via other LANs
- WANs can be implemented using one of the two technologies:
  - Circuit Switching
  - Packet Switching

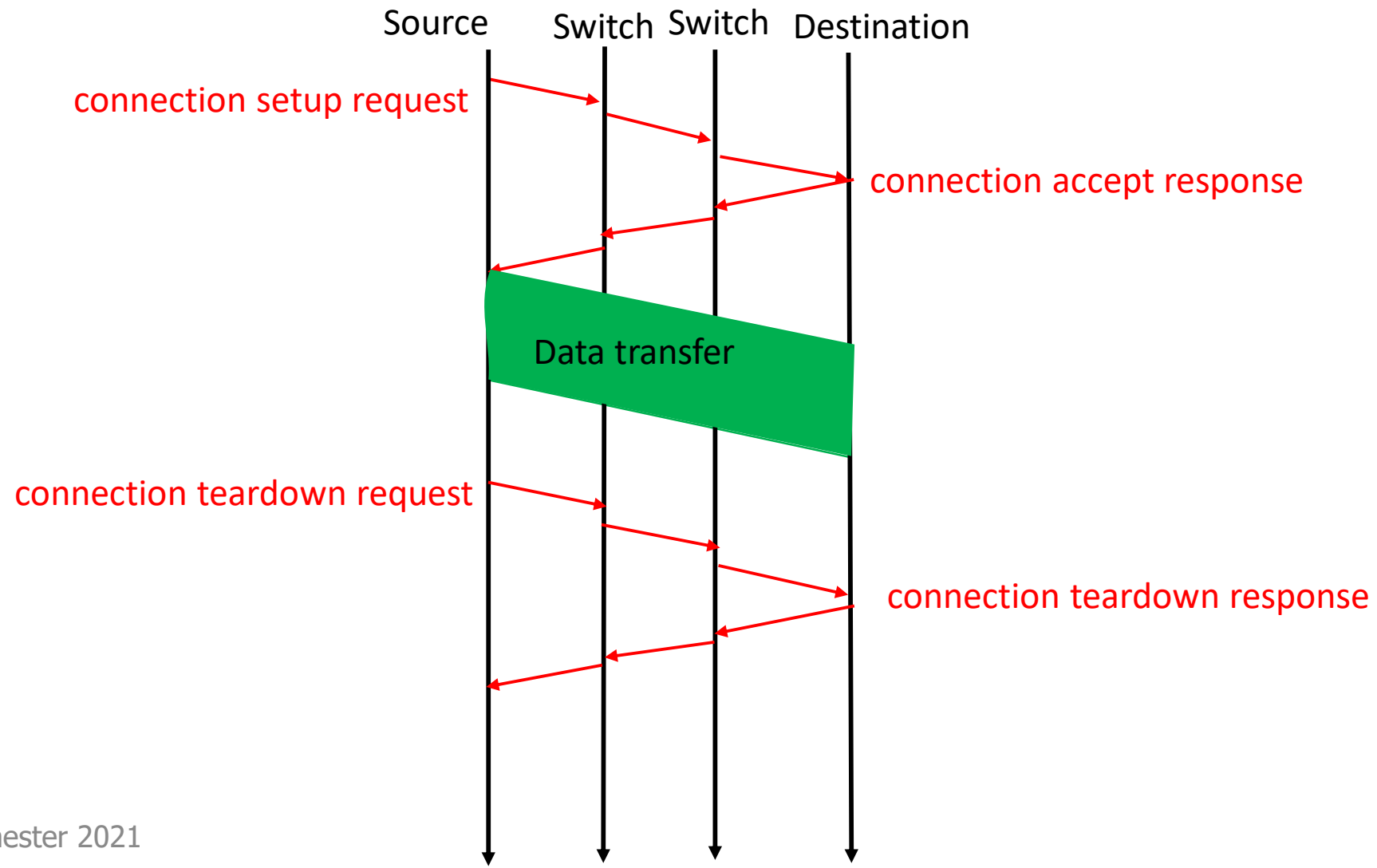
Circuit Switching

- Circuit Switching Networks– dedicated connection or circuit is established between nodes for the duration of the connection.
- The lifetime of connection has three phases:
  - Connection setup : identify the routes , set aside resources so that they are guaranteed.
  - Connection usage : use the established connection to transmit the data. The pre-reserved resources guarantee that this connection is not influenced by other connections
  - Connection teardown: free the reserved resources
- Data generated by the source station are transmitted along the dedicated path as rapidly as possible.
- At each node, incoming data are routed or switched to the appropriate outgoing channel without delay.
- Switching elements are called switches.
- Example: The telephone network

Circuit Switching

- A routing decision is made only once (at connection setup) and never/rarely modified.
- A connection has its resources guaranteed.
- Any bandwidth not used by a connection cannot be reused by other connections, this can result in poor utilization.
- Connection setup takes time, if messages are much shorter than the connection setup time then circuit switching is not economical.
- Connection setup may fail when no route or not enough resources are available in the network.
- Admission Control: Switching elements check whether enough resources are available for the new connection without compromising the resources already granted to existing connections.

Event Timing of Circuit Switching



Packet Switching

- Packet Switching Networks - Data flows are segmented into small chunks called packets.
- Packets are basic unit of transmission.
- A packet consists of:
  - A packet header containing meta-information about the packet, e.g. address fields
  - The packet payload
  - a packet trailer for error detection / correction
- Packets are transmitted individually and independently from one node to the other.
- At each node, the entire packet is received, stored briefly, and then transmitted to the next node.
- There is no concept of a connection, packets can be sent immediately without having to set up resource reservation in the network.
- Switching elements are called routers.
- Analogy: letter transfer in postal network, envelopes correspond to packet headers.
- Example: The Internet.

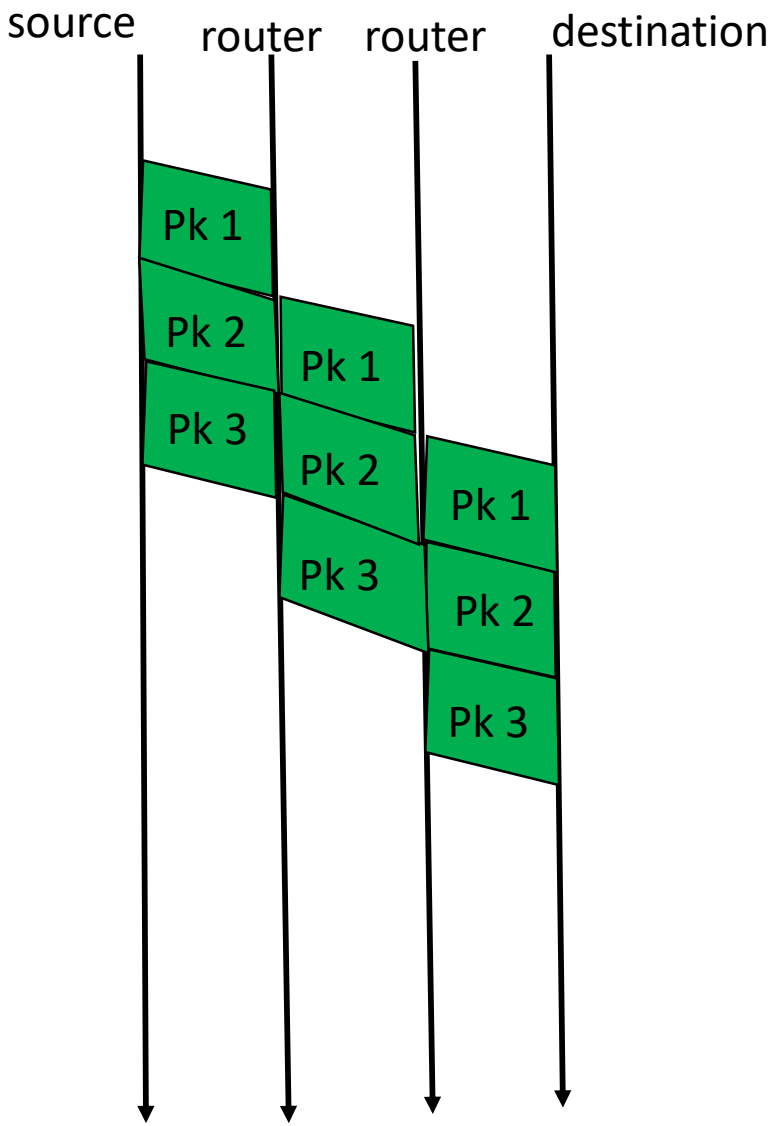
Packet Switching

- Sequence of packets between the same source destination pair is called a flow.
- Each packet is routed individually, different packets in the same flow can take different routes.
- Each router makes a routing decision for each packet.
- Each packet must include information facilitating routing, e.g. header fields for source and destination addresses.
- Packets do not necessarily arrive in the same order as they have been sent. Packets are reordered at the destination.
- Many flows can share a link, bandwidth not utilized by one flow can be used by others.

Packet Switching

- No guarantee for packet delivery – lack of resource reservation.
  - Internet/IP "best effort" service: packet is delivered – maybe
- Since flow data rates and routes often cannot be predicted in advance, routers buffer some packets to prevent packet dropping in temporary overload situations.
- Routers only have a finite amount of memory, and when overload situation sustains, packet dropping is inevitable, this is called congestion.
- Which packets to drop?
  - Congestion control schemes either try to avoid congestion or to deal with it.

Event Timing of Packet Switching



Circuit Switching Vs Packet Switching

- Circuit-switching:
  - Can give guaranteed bandwidths
  - No reuse of resources
  - Data forwarding is low-complexity operation for switches
  - Routing is done only once
- Packet-switching:
  - Cannot give any guarantees
  - Allows reuse of resources
  - Data forwarding is higher-complexity operation for routers
  - Routing is done for every packet