FUNDAMENTAL CONCEPTS IN COMMUNICATION

Communication Network And Switching

Types of Communication Networks

- Traditional
  - *Traditional local area network (LAN)*
  - *Traditional wide area network (WAN)*
- Higher-speed
  - *High-speed local area network (LAN)*
  - *Metropolitan area network (MAN)*
  - *High-speed wide area network (WAN)*

Characteristics of WAN and LAN

- Characteristics of WANS
  - Covers large geographical areas
  - Consists of interconnected switching nodes
  - Traditional WANs provided modest capacity
  - Higher-speed WANs use optical fiber and transmission technique known as asynchronous transfer mode (ATM)
    - 10s and 100s of Mbps common
- Characteristics of LANS
  - LAN interconnects a variety of devices and provides a means for information exchange among them
  - Traditional LANs
    - Provided data rates of 1 to 20 Mbps
  - High-speed LANS
    - Provide data rates of 100 Mbps to 1 Gbps

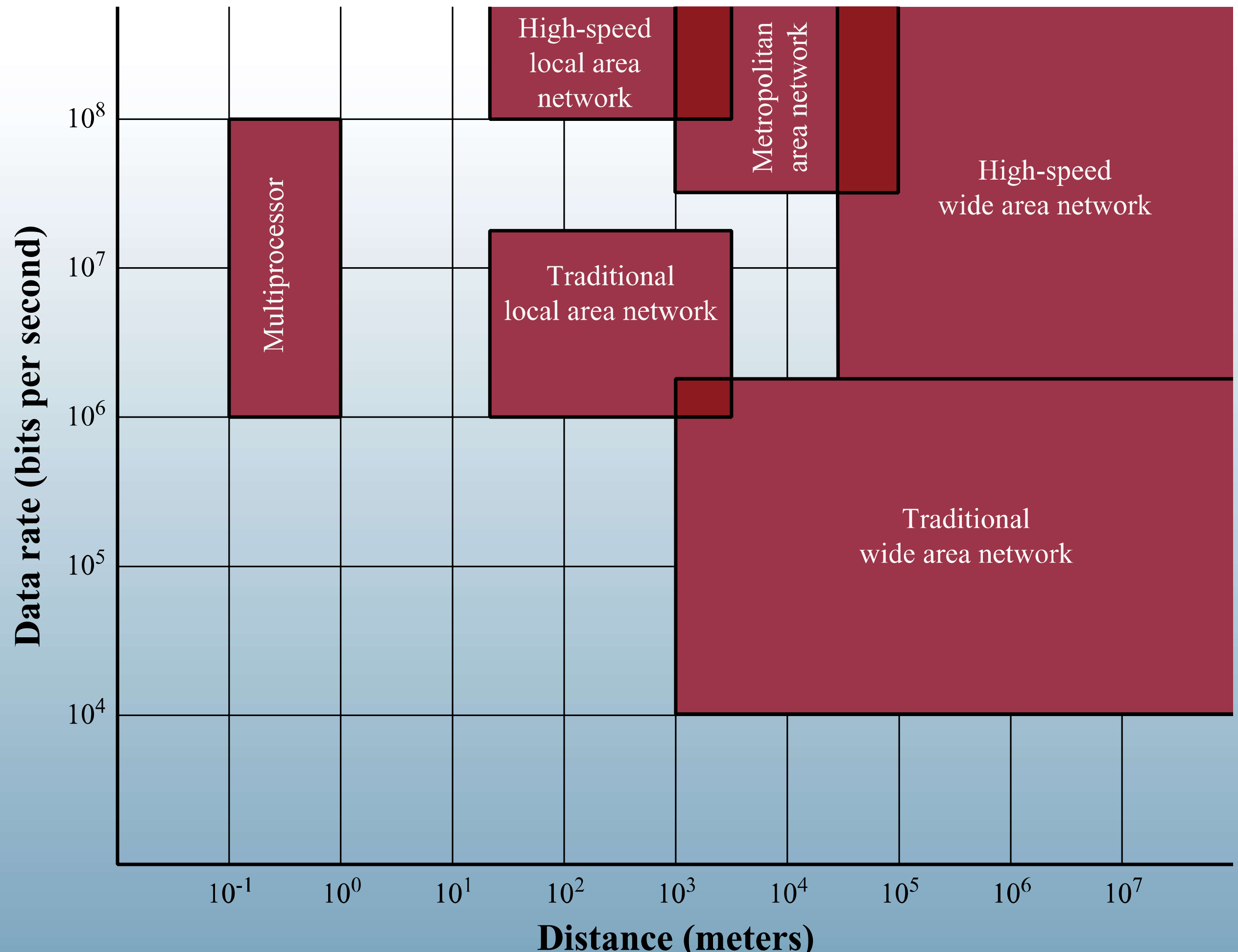
Differences between LANs and WANs

- Scope of a LAN is smaller
  - *LAN interconnects devices within a single building or cluster of buildings*
- LAN usually owned by organization that owns the attached devices
  - *For WANs, most of network assets are not owned by same organization*
- Internal data rate of LAN is much greater

The Need for MANs

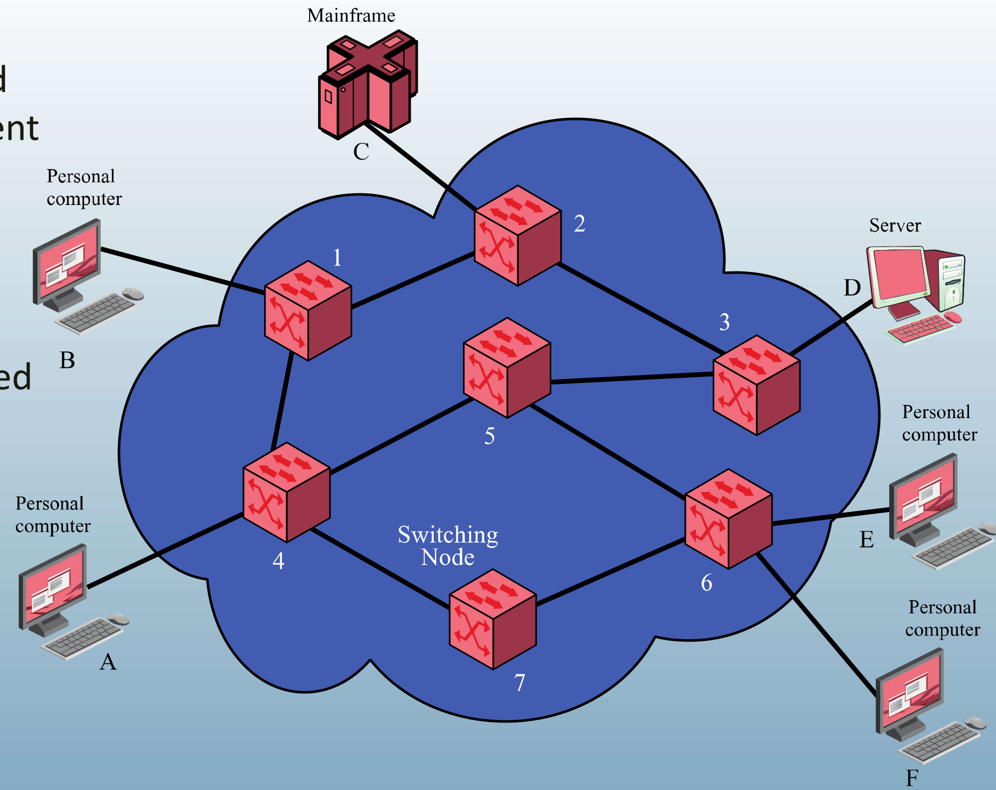
- Traditional point-to-point and switched network techniques used in WANs are inadequate for growing needs of organizations
- Need for high capacity and low costs over large area
- MAN provides:
  - Service to customers in metropolitan areas
  - Required capacity
  - Lower cost and greater efficiency than equivalent service from telephone company

Comparison of LAN, MAN, and WAN : Illustration



Switching Concept

- Switching Nodes:
  - Intermediate switching device that moves data and doesn’t concern with content of data
- Stations:
  - End devices that wish to communicate and connected to a switching node
- Communications Network:
  - A collection of switching nodes



Observation of the Figure

- Some nodes connect only to other nodes (e.g., 5 and 7)
- Some nodes connect to one or more stations
- Node-station links usually dedicated point-to-point links
- Node-node links usually multiplexed links
  - Frequency-division multiplexing (FDM)
  - Time-division multiplexing (TDM)
- Not a direct link between every node pair

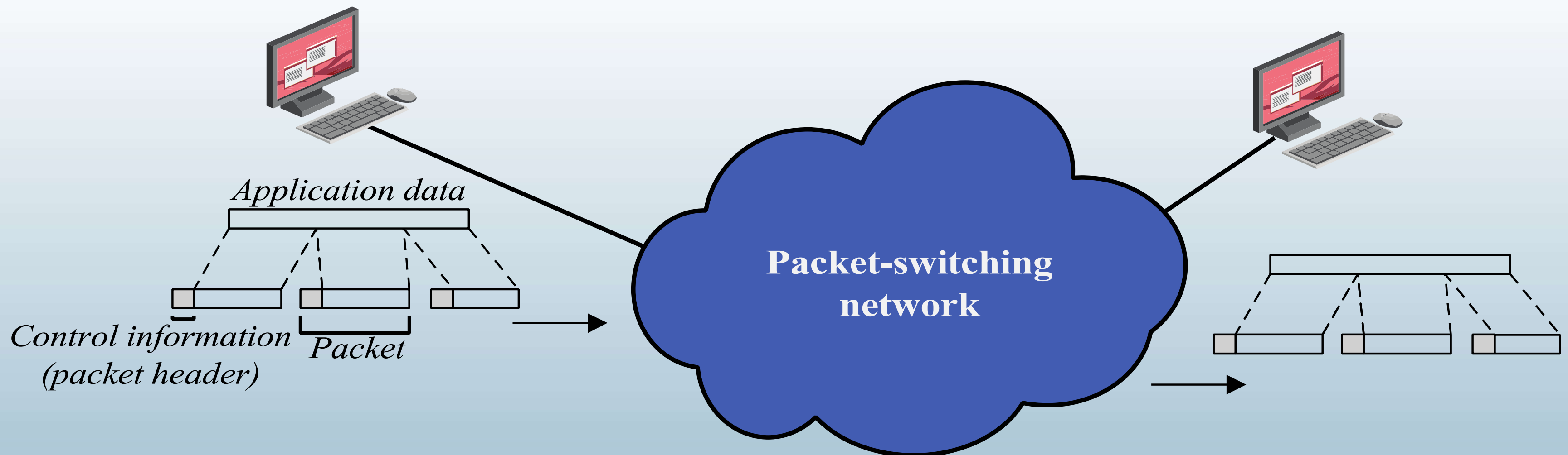
Techniques Used in Switched Networks

- Circuit switching
  - Dedicated communications path between two stations, E.g., public telephone network
  - Phases :
    - Circuit establishment
      - *An end to end circuit is established through switching nodes*
    - Information Transfer
      - *Information transmitted through the network*
      - *Data may be analog voice, digitized voice, or binary data*
    - Circuit disconnect
      - *Circuit is terminated*
      - *Each node deallocates dedicated resources*

Techniques Used in Switched Networks

- Packet switching
  - Message is broken into a series of packets before being sent
    - Typical packet length is 1000 octets (bytes)
    - Packets consists of a portion of data plus a packet header that includes control information
  - Each node determines next leg of transmission for each packet
    - At each node en-route, packet is received, stored briefly and passed to the next node

Techniques Used in Switched Networks

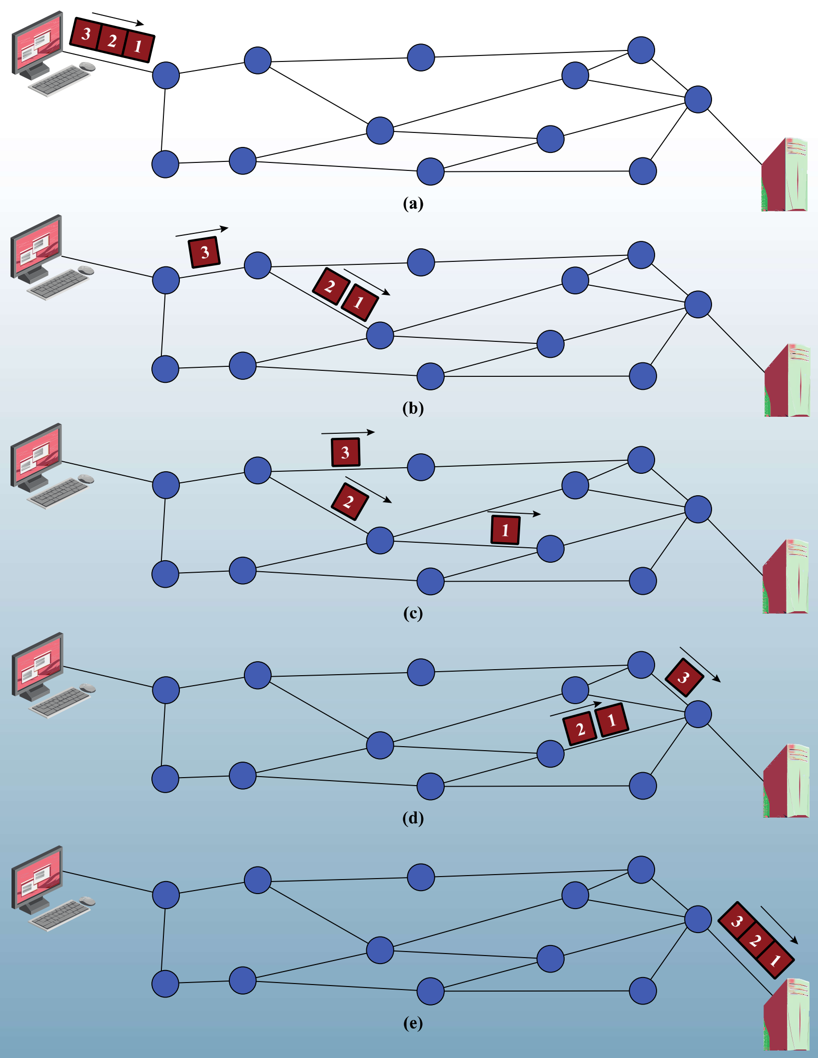


The Use of Packets

Packet Switching- Datagram Network

- Each packet treated independently, without reference to previous packets
- Each node chooses next node on packet’s path
- Packets don’t necessarily follow same route and may arrive out of sequence
- Exit node restores packets to original order
- Responsibility of exit node or destination to detect loss of packet and how to recover

Packet Switching- Datagram Network



Circuit Switching

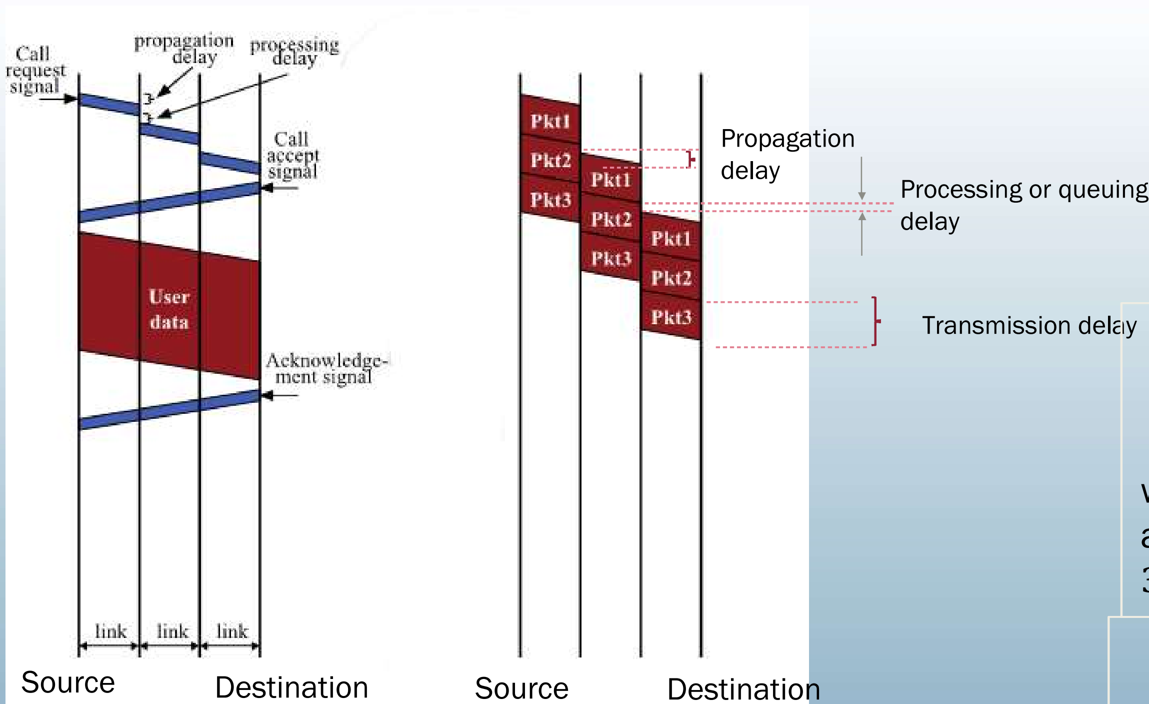
- Advantages
  - Once established, network is transparent to users
  - Information transmitted at fixed data rate with only propagation delay
- Disadvantages
  - Circuit Switching can be inefficient : Channel capacity dedicated for duration of connection
  - Utilization not 100%
  - Delay prior to signal transfer for establishment
  - If circuit is not established, then the call would be blocked

Packet Switching

- Advantages
  - Line efficiency is greater
    - Many packets over time can dynamically share the same node to node link
  - Packet-switching networks can carry out data-rate conversion
    - Two stations with different data rates can exchange information
  - Unlike circuit-switching networks that block calls when traffic is heavy, packet-switching still accepts packets, but with increased delivery delay
  - Priorities can be used
  - For Datagram Packet switching :
    - Call setup phase is avoided
    - Because it’s more primitive, it’s more flexible
    - Datagram delivery is more reliable

Event Timing Diagram

- Circuit and datagram packet switching



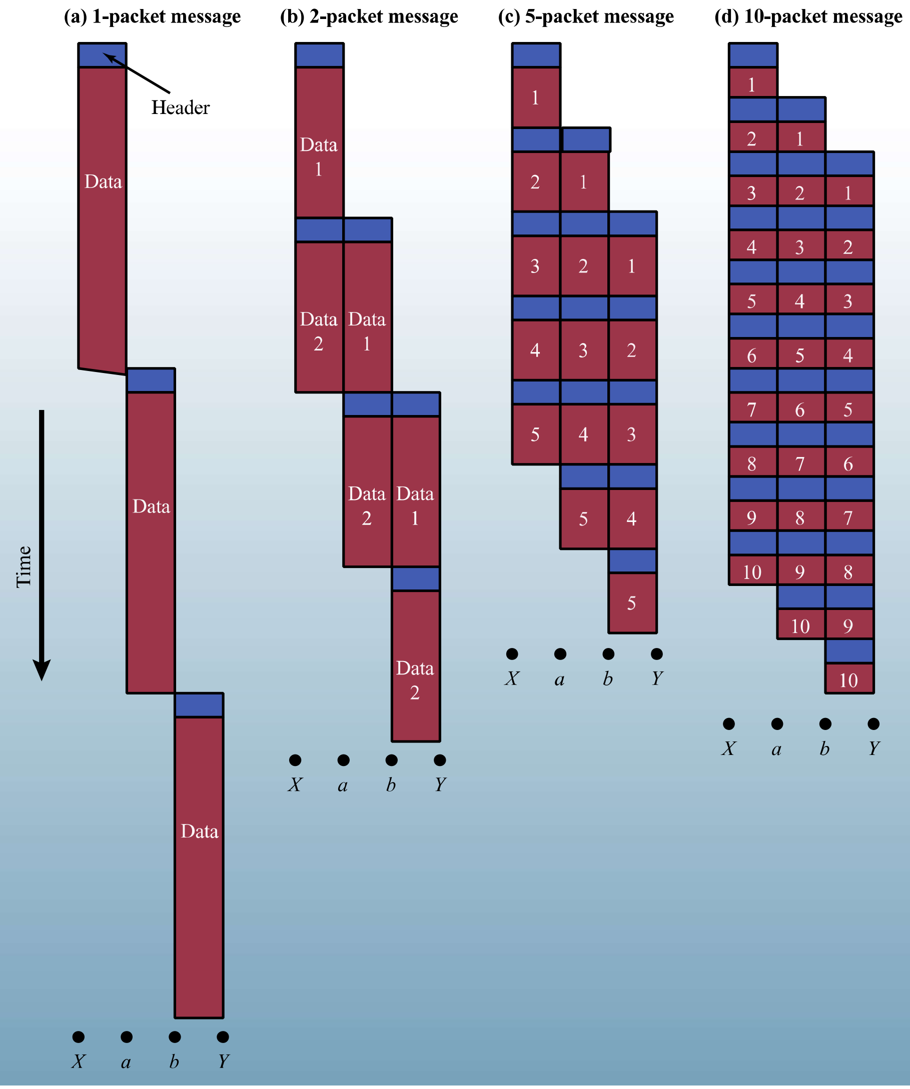
$$Propagation\ delay\ (time) =$$
$$t_{prop} = \frac{S}{c}$$

where S denotes the length of the link and c denotes the speed of the light = $3 \times 10^8\ {}^{m}/_{sec}$

$$Transmission\ delay (time) =$$
$$t_{tr} = \frac{L}{R}$$

where L denotes the length of the frame (in bits) and R denotes the transmission rate (in ${}^{bit}/_{sec}$)

Effect on Packet Size



- Typically, a switching node treats each packet as “store and forward”
  - Each packet is independent, so that allowing the node to do store and forward simultaneously for different packet
  - Breaking up packets decreases transmission time because transmission is allowed to overlap

Effect on Packet Size : Example

- Suppose a node wants to transmit 40 bytes message through a packet switching network (datagram), with transmission rate of R bytes/second. Three bytes of header information are added into every packet transmitted over the network. Four nodes are assumed involved in this network. Propagation time is ignored in this case.
  - Case 1 : Entire message is set into one packet. Total packet size is L=40+3 =43 bytes. Transmission time would be 43/R second for each hop. Total time is 129/R seconds (See the left figure in slide 17)

Effect on Packet Size : Example

- Case 2 : Entire message is split into two packets. Each packet has size of L=20+3 =23 bytes. Packet transmission time of each node would be 46/R seconds. Since each nodes can store and forward in the same time, then total transmission time would be 46/R+23/R+23/R=92/R seconds (see the second left figure in slide 17)

- Case 3 : Entire message is split into 5 packets. Each packet has size of L=8+3=11 bytes. Total transmission time to send entire message through network is 55/R+11/R+11/R=77/R seconds (see the third left figure in slide 17)

- Case 4 : Entire message is split into 10 packets. Each packet has size of L=7 bytes. Total transmission time is 84/R seconds (longer than Case 3!),(see the right figure in slide 17)