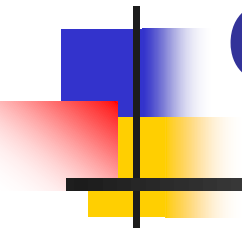
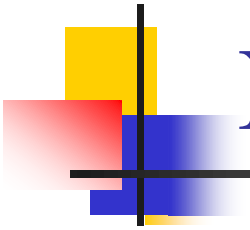


Communication Networks

Chapter 3

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)

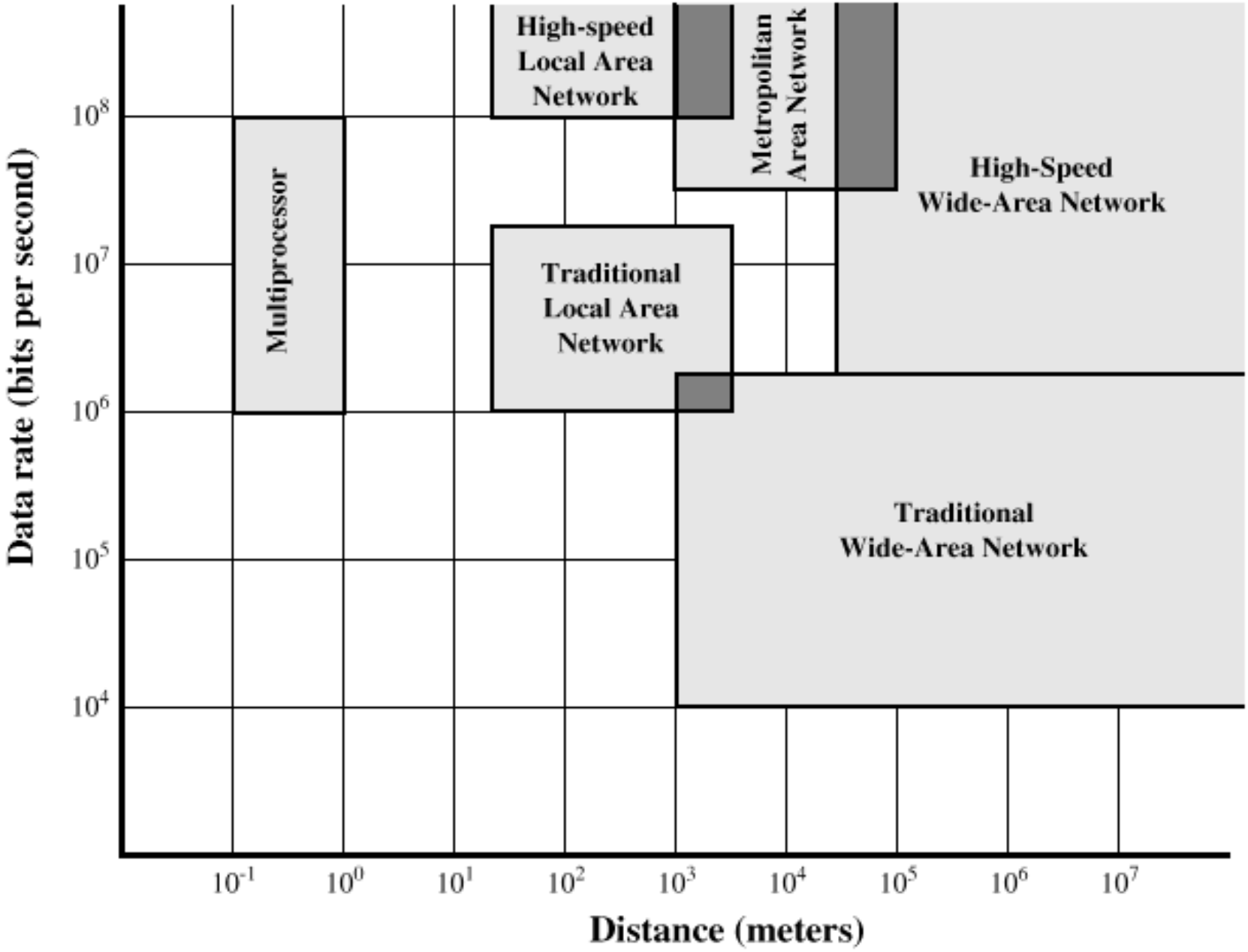
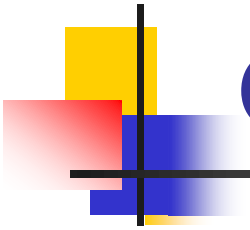
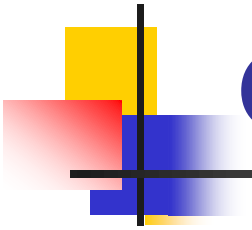


Figure 3.1 Comparison of Multiprocessor Systems, LANs, MANs, and WANs



Characteristics of WANs

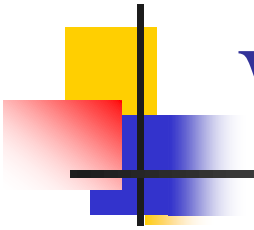
- Covers large geographical areas
- Circuits provided by multiple carriers
- Consists of interconnected switching nodes
- Traditional WANs provide modest capacity
  - 64,000 bps common
  - Business subscribers using T-1 service – 1.544 Mbps common
- Higher-speed WANs use optical fiber and transmission technique known as asynchronous transfer mode (ATM)
  - 10s and 100s of Mbps common



Characteristics of LANs

- Like WAN, LAN interconnects a variety of devices and provides a means for information exchange among them
- Traditional LANs
  - Provide data rates of 1 to 20 Mbps
- High-speed LANS
  - Provide data rates of 100 Mbps to 1 Gbps

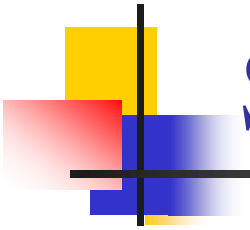
Differences between LANs and WANs



- Scope of a LAN is smaller
  - LAN interconnects devices within a single building or cluster of buildings
- LAN usually owned by one 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



Switching Terms

- Switching Nodes:
  - Intermediate switching device that moves data
  - Not concerned with content of data
- Stations:
  - End devices that wish to communicate
  - Each station is connected to a switching node
- Communications Network:
  - A collection of switching nodes

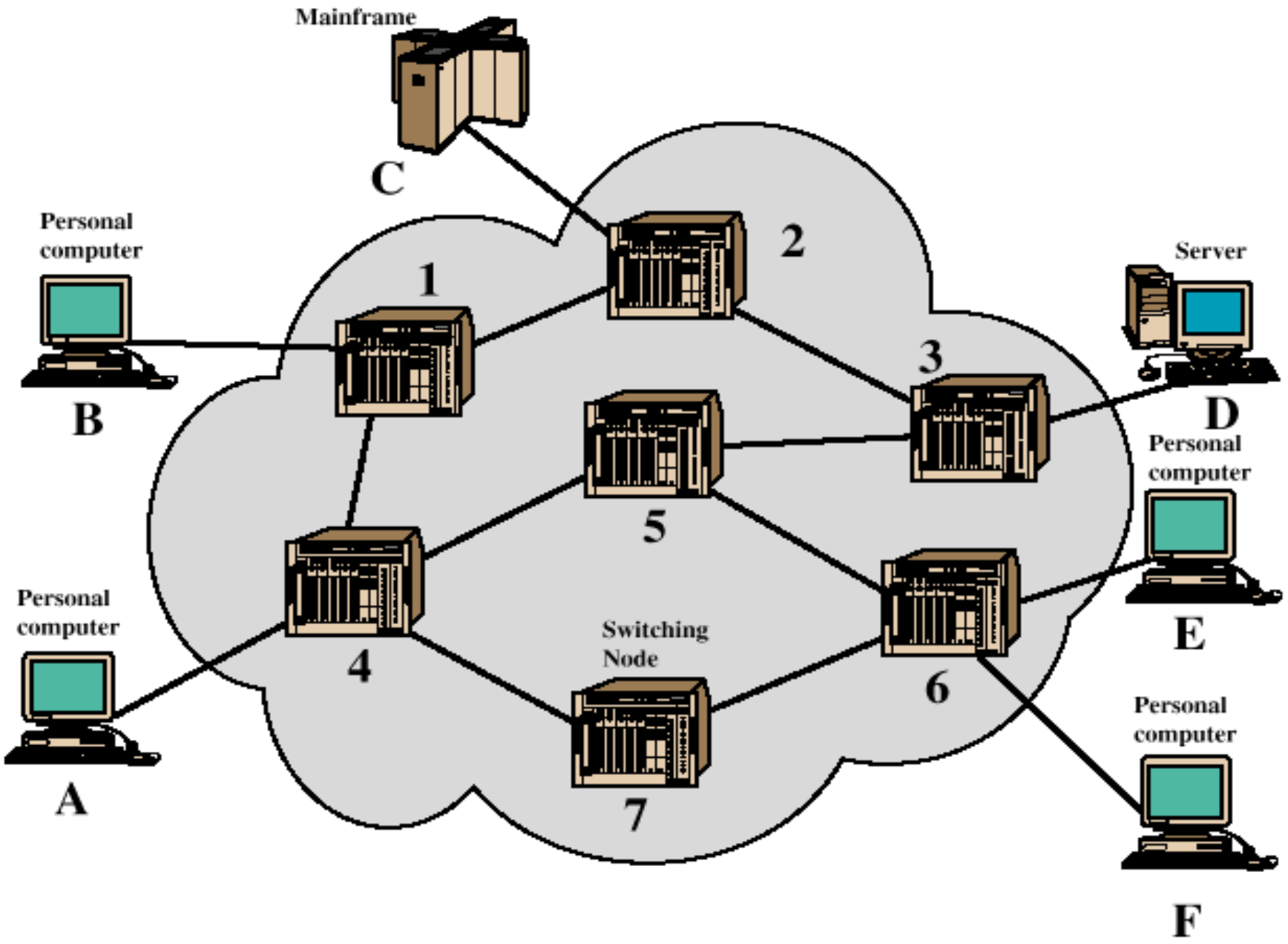
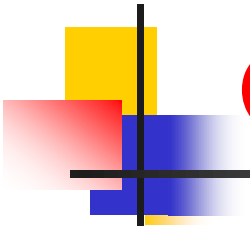


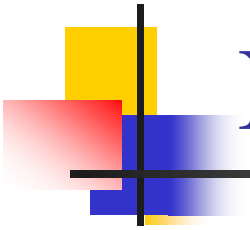
Figure 3.3 Simple Switching Network



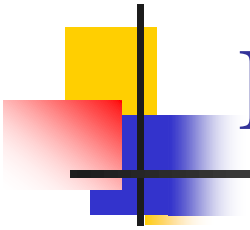
Observations of Figure 3.3

- 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
  - Network is not fully connected
  - More than one path is desirable for each pair of stations

Techniques Used in Switched Networks



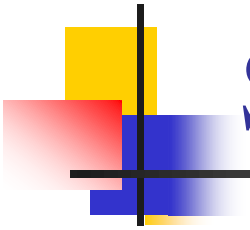
- Circuit switching
  - Dedicated communications path between two stations
  - E.g., public telephone network
- Packet switching
  - Message is broken into a series of packets
  - Each node determines next leg of transmission for each packet



Phases of Circuit Switching

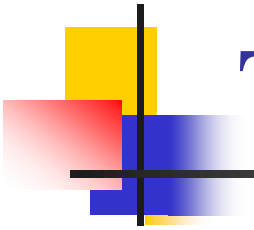
- Circuit establishment
  - An end to end circuit is established through switching nodes (dedicate path)
  - Routing information, Availability, Cost
- Information Transfer
  - Information transmitted through the network
  - Data may be analog voice, digitized voice, or binary data
- Circuit disconnect
  - Circuit is terminated (requested by one of the stations)
  - Each node deallocates dedicated resources

Characteristics of Circuit Switching

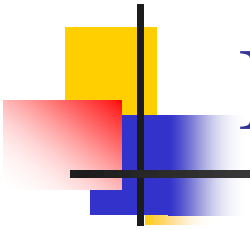


- Can be inefficient:
  - Channel capacity dedicated for duration of connection (some connections can be blocked)
  - Utilization not 100% (idle connection)
  - Delay prior to signal transfer for establishment
- Once established, network is transparent to users
- Information transmitted at fixed data rate with only propagation delay

Components of Public Telecommunications Network



- Subscribers - devices that attach to the network; mostly telephones
- Subscriber line - link between subscriber and network
  - Also called subscriber loop or local loop
- Exchanges - switching centers in the network
  - A switching centers that support subscribers is an end office
- Trunks - branches between exchanges



How Packet Switching Works

- Data is transmitted in blocks, called packets
- Before sending, the message is broken into a series of packets:
  - Typical packet length is 1000 octets (bytes)
  - Packets consists of a portion of data plus a packet header that includes control information
- At each node in a route, packet is received, stored briefly and passed to the next node

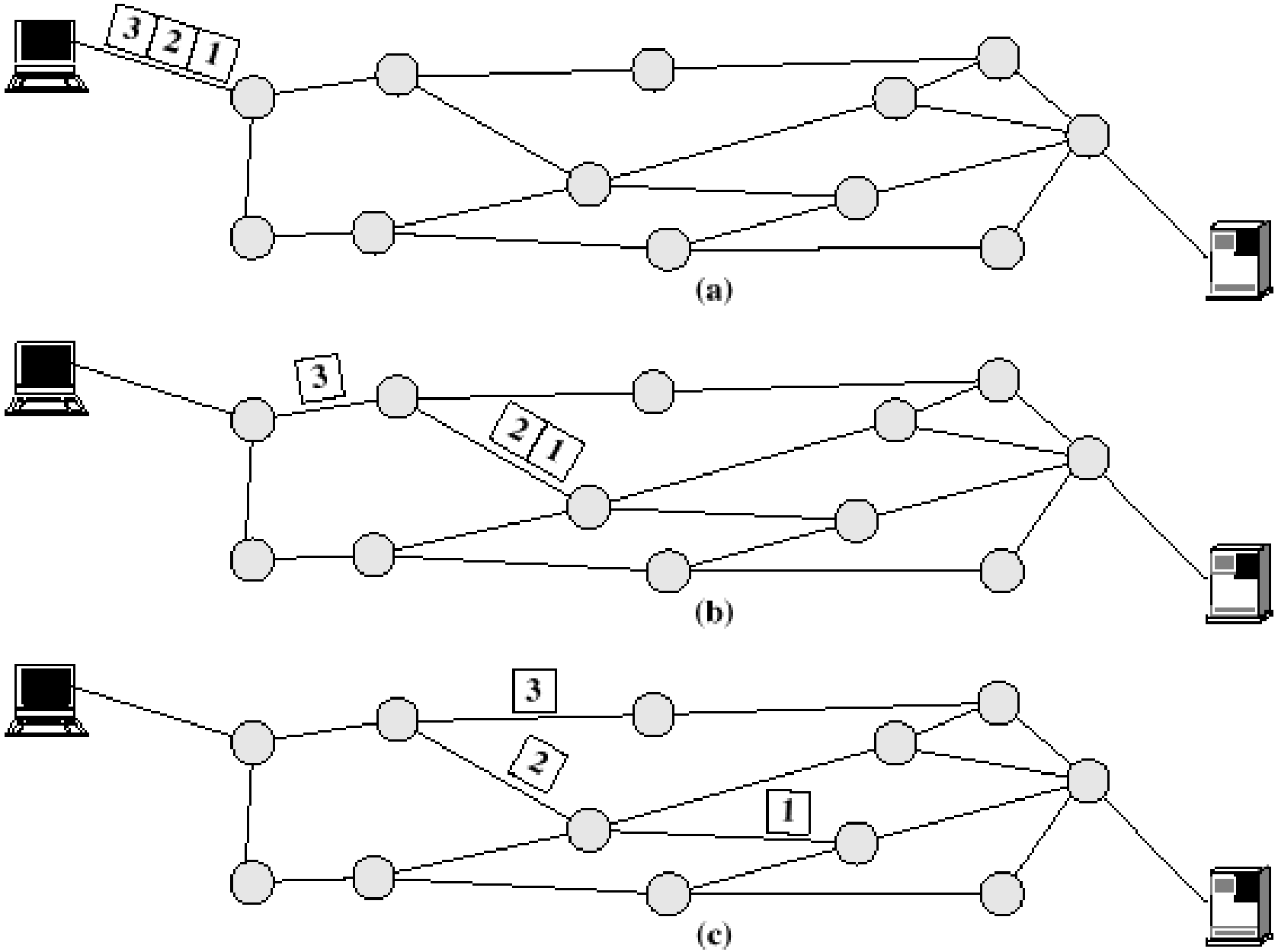


Figure 3.7 Packet Switching: Datagram Approach

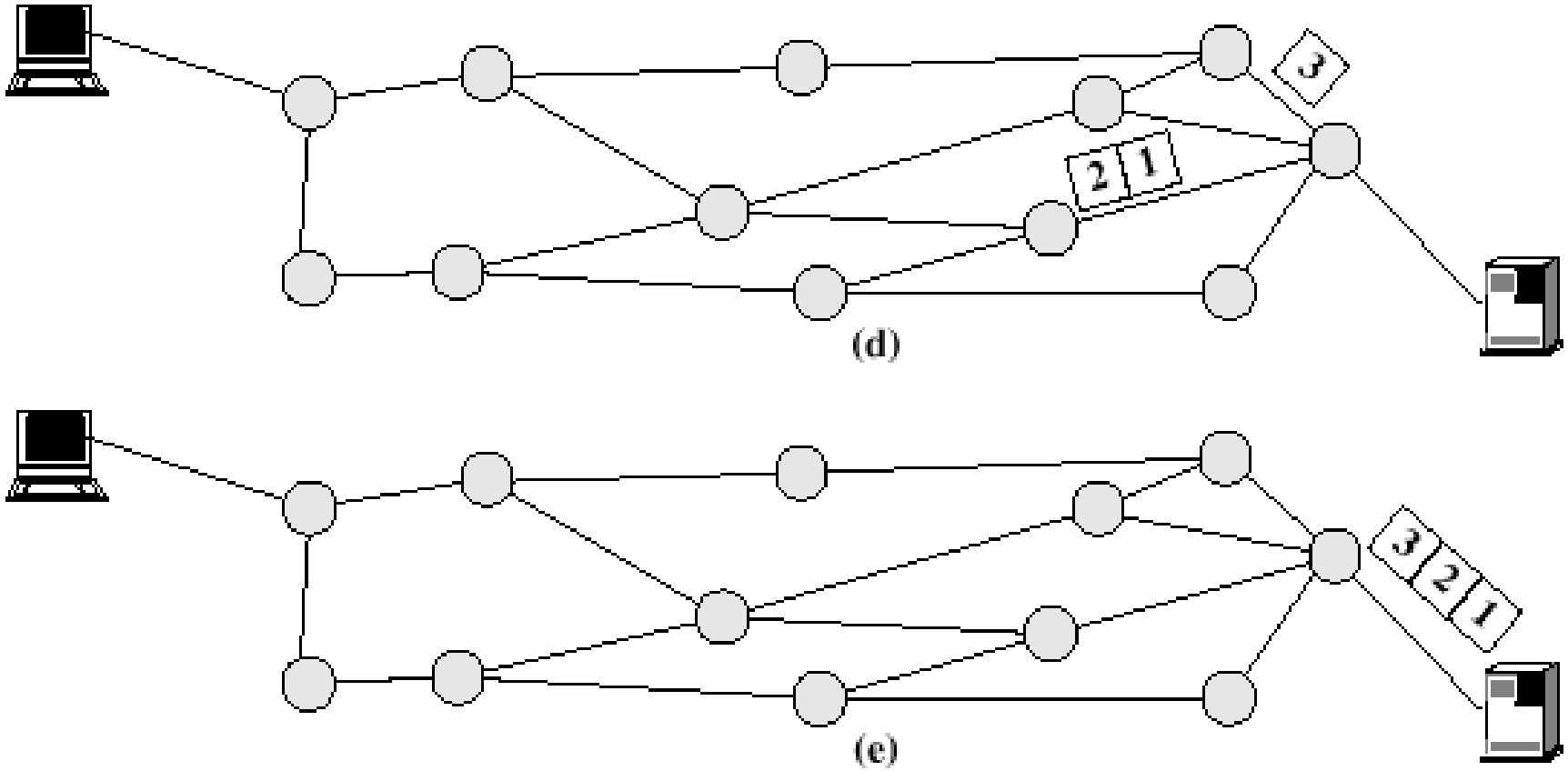
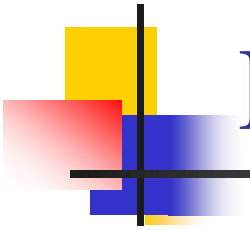


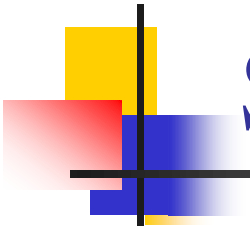
Figure 3.7 Packet Switching: Datagram Approach



Packet Switching Advantages

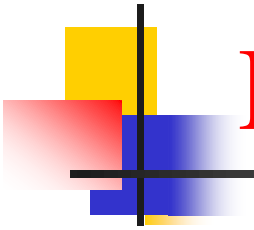
- Line efficiency is greater
  - Many packets over time can dynamically share the same node to node link
- Packet-switching networks can carry out data-rate conversion
  - Two stations with different data rates can exchange information
- Unlike circuit-switching networks that block calls when traffic is heavy, packet-switching still accepts packets, but with increased delivery delay
- Priorities can be used

Disadvantages of Packet Switching



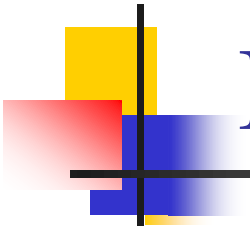
- Each packet switching node introduces a delay
- Overall packet delay can vary substantially:
  - This is referred to as jitter
  - Caused by differing packet sizes, routes taken and varying delay in the switches
- Each packet requires overhead information
  - Includes destination and sequencing information
  - Reduces communication capacity
- More processing required at each node

Packet Switching Networks - Datagram



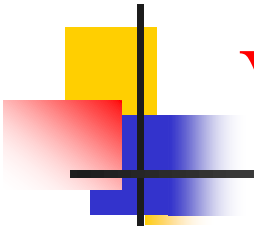
- Each packet treated independently, without reference to previous packets
- Each node chooses next node on packet's path
- Packets don't necessarily follow same route and may arrive out of sequence
- Exit node restores packets to original order
- Responsibility of exit node or destination to detect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

Packet Switching Networks – Datagram



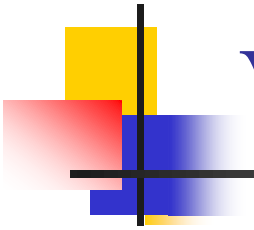
- Advantages:
  - Call setup phase is avoided
  - Because it's more primitive, it's more flexible
  - Datagram delivery is more reliable
    - Node failure
    - Link congestion

Packet Switching Networks – Virtual Circuit



- Preplanned route established before packets sent
- All packets between source and destination follow this route
- Routing decision not required by nodes for each packet
- Emulates a circuit in a circuit switching network but is not a dedicated path
  - Packets still buffered at each node and queued for output over a line
  - Packets from other connections can share the same path

Packet Switching Networks – Virtual Circuit



- Advantages:
  - Packets arrive in original order
  - Packets arrive correctly (e.g. retransmission)
  - Packets transmitted more rapidly without routing decisions made at each node

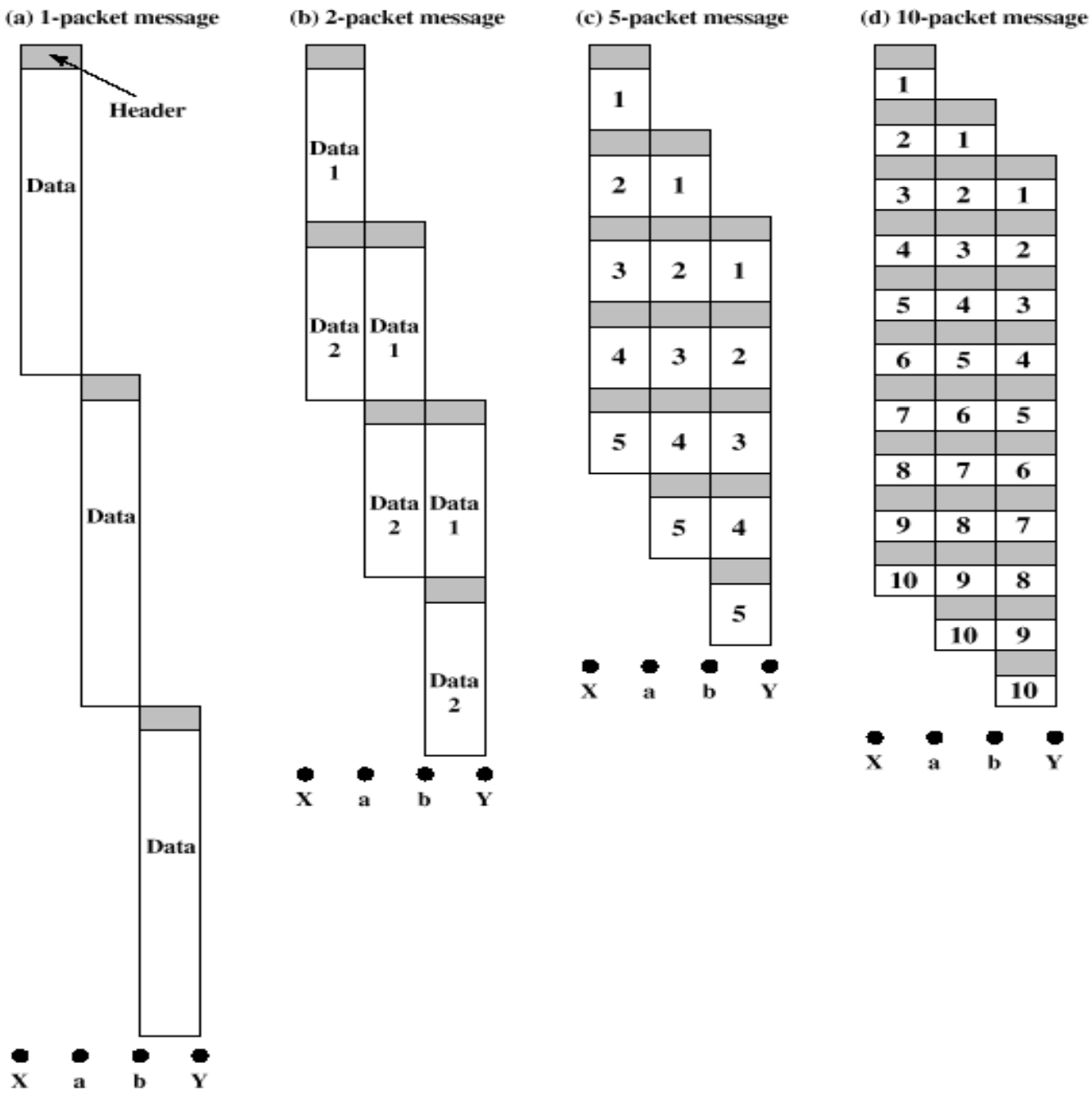
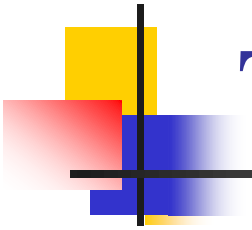


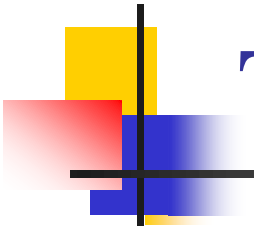
Figure 3.9 Effect of Packet Size on Transmission Time

Effect of Packet Size on Transmission



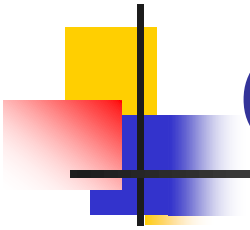
- Breaking up packets decreases transmission time because transmission is allowed to overlap
- Figure 3.9a
  - Entire message (40 octets) + header information (3 octets) sent at once
  - Transmission time: 129 octet-times
- Figure 3.9b
  - Message broken into 2 packets (20 octets) + header (3 octets)
  - Transmission time: 92 octet-times

Effect of Packet Size on Transmission

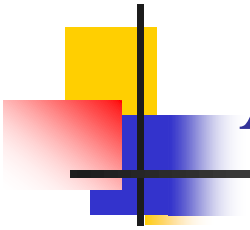


- Figure 3.9c
  - Message broken into 5 packets (8 octets) + header (3 octets)
  - Transmission time: 77 octet-times
- Figure 3.9d
  - Making the packets too small, transmission time starts increases
  - Each packet requires a fixed header; the more packets, the more headers

Asynchronous Transfer Mode (ATM)

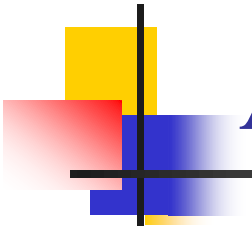


- Also known as cell relay
- Operates at high data rates
- Resembles packet switching
  - Involves transfer of data in discrete chunks, like packet switching
  - Allows multiple logical connections to be multiplexed over a single physical interface
- Minimal error and flow control capabilities reduces overhead processing and size
- Fixed-size cells simplify processing at ATM nodes



ATM Terminology

- Virtual channel connection (VCC)
  - Logical connection in ATM
  - Basic unit of switching in ATM network
  - Analogous to a virtual circuit in packet switching networks
  - Exchanges variable-rate, full-duplex flow of fixed-size cells
- Virtual path connection (VPC)
  - Bundle of VCCs that have the same end points



Advantages of Virtual Paths

- Simplified network architecture
- Increased network performance and reliability
- Reduced processing and short connection setup time
- Enhanced network services

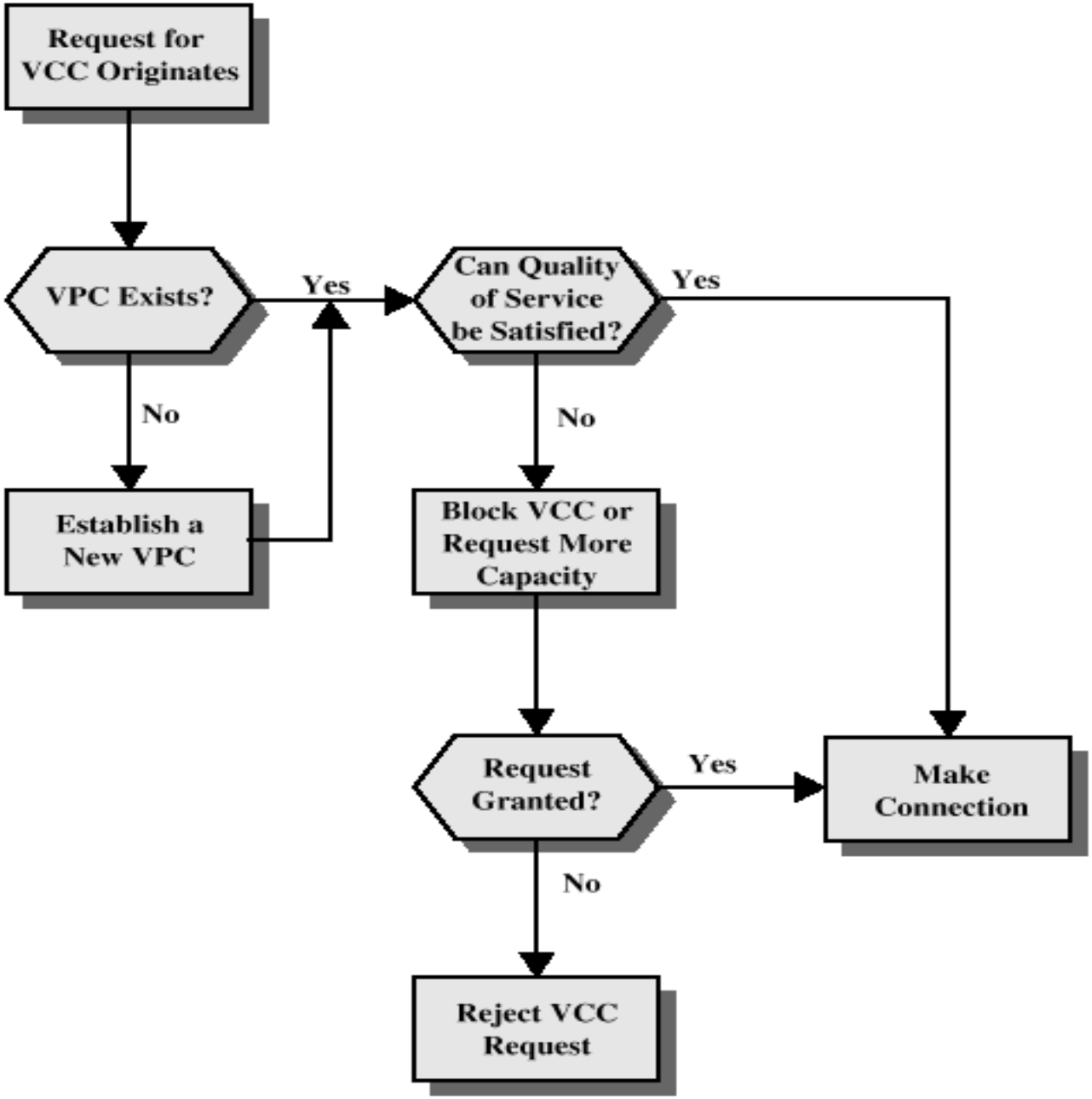
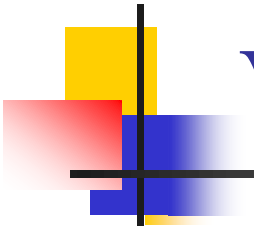


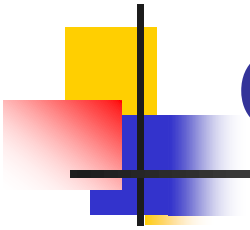
Figure 3.11 Call Establishent Using Virtual Paths



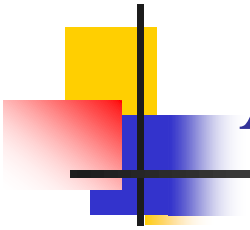
Virtual Channel Connection Uses

- Between end users
  - Can carry end-to-end user data or control signaling between two users
- Between an end user and a network entity
  - Used for user-to-network control signaling
- Between two network entities
  - Used for network traffic management and routing functions

Virtual Path/Virtual Channel Characteristics

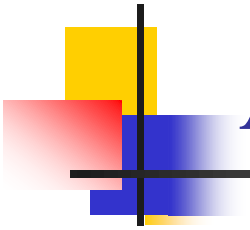


- Quality of service
  - Specified by parameters such as cell loss ratio and cell delay variation
- Switched and semipermanent virtual channel connections
- Cell sequence integrity
- Traffic parameter negotiation and usage monitoring
- Virtual channel identifier restriction within a VPC



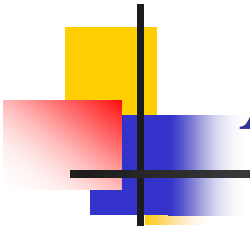
ATM Cell Header Format

- Generic flow control (GFC) – 4 bits, used only in user-network interface
  - Used to alleviate short-term overload conditions in network
- Virtual path identifier (VPI) – 8 bits at the user-network interface, 12 bits at network-network interface
  - Routing field
- Virtual channel identifier (VCI) – 8 bits
  - Used for routing to and from end user



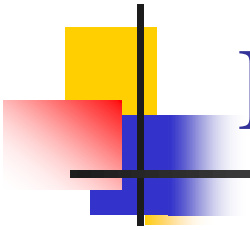
ATM Cell Header Format

- Payload type (PT) – 3 bits
  - Indicates type of information in information field
- Cell loss priority (CLP) – 1 bit
  - Provides guidance to network in the event of congestion
- Header error control (HEC) – 8 bit
  - Error code



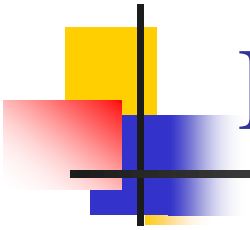
ATM Service Categories

- Real-time service
  - Constant bit rate (CBR)
  - Real-time variable bit rate (rt-VBR)
- Non-real-time service
  - Non-real-time variable bit rate (nrt-VBR)
  - Available bit rate (ABR)
  - Unspecified bit rate (UBR)



Examples of CBR Applications

- Videoconferencing
- Interactive audio (e.g., telephony)
- Audio/video distribution (e.g., television, distance learning, pay-per-view)
- Audio/video retrieval (e.g., video-on-demand, audio library)



Examples of UBR applications

- Text/data/image transfer, messaging, distribution, retrieval
- Remote terminal (e.g., telecommuting)