Data and Computer Communications

Chapter 10 – Circuit Switching and Packet Switching

Eighth Edition

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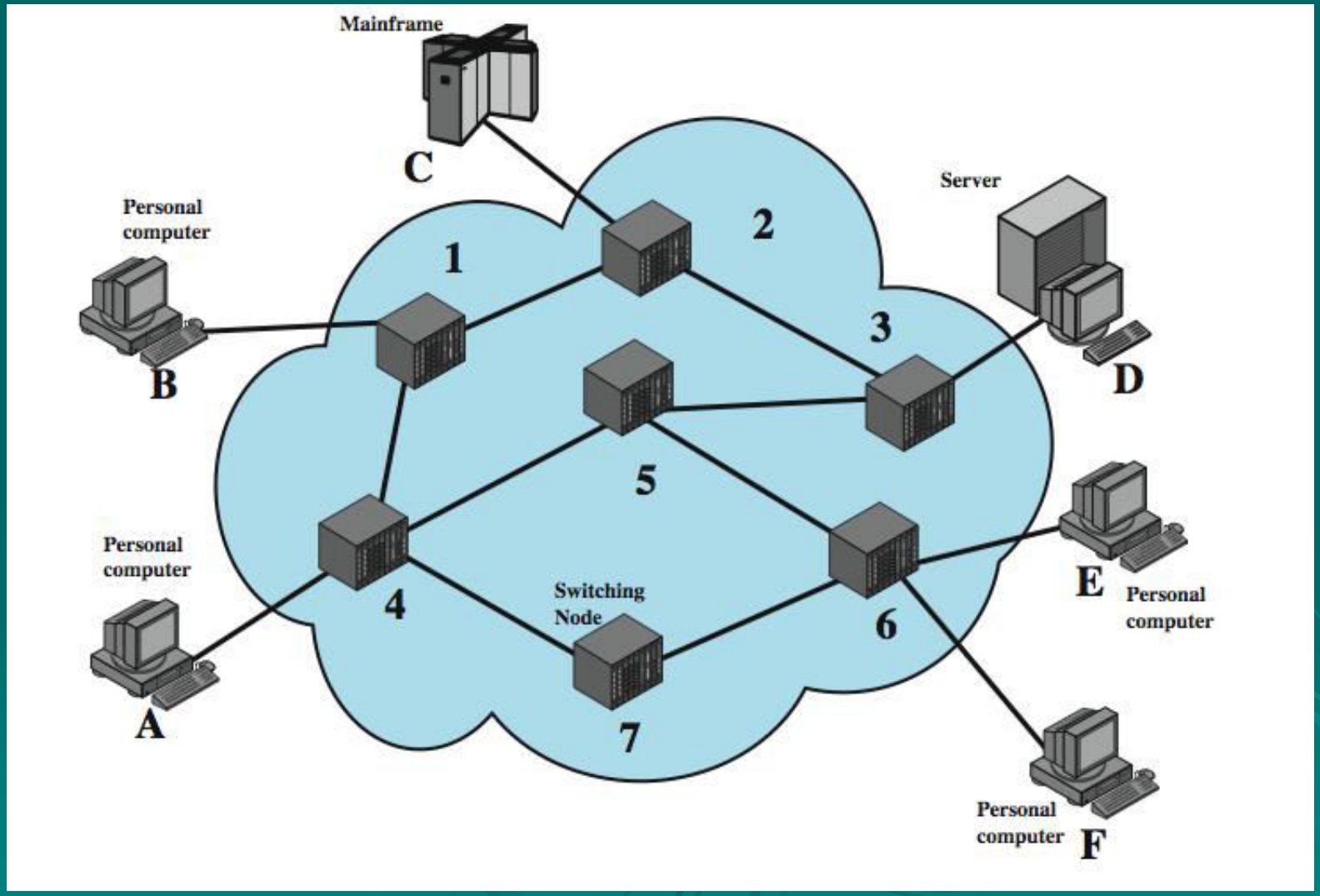
Lecture slides by Lawrie Brown

Circuit Switching and Packet Switching

He got into a District Line train at Wimbledon Park, changed on to the Victoria Line at Victoria and on to the Jubilee Line at Green Park for West Hampstead. It was a long and awkward journey but he enjoyed it.

—*King Solomon's Carpet*, Barbara Vine (Ruth Rendell)

Switched Network



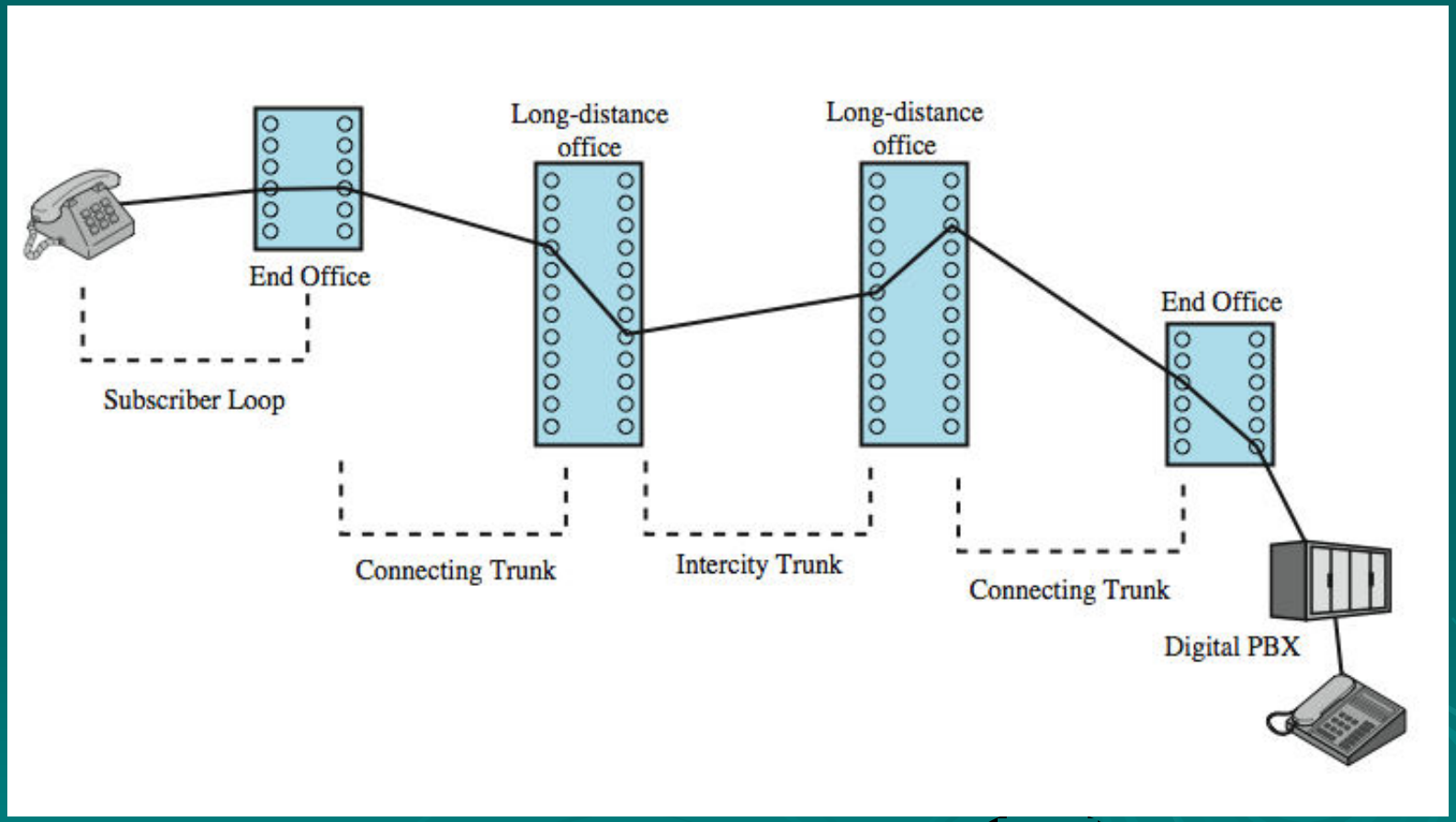
Nodes

- a collection of nodes and connections is a communications network
- nodes may connect to other nodes only, or to stations and other nodes
- network is usually partially connected
  - some redundant connections are desirable
- have two different switching technologies
  - circuit switching
  - packet switching

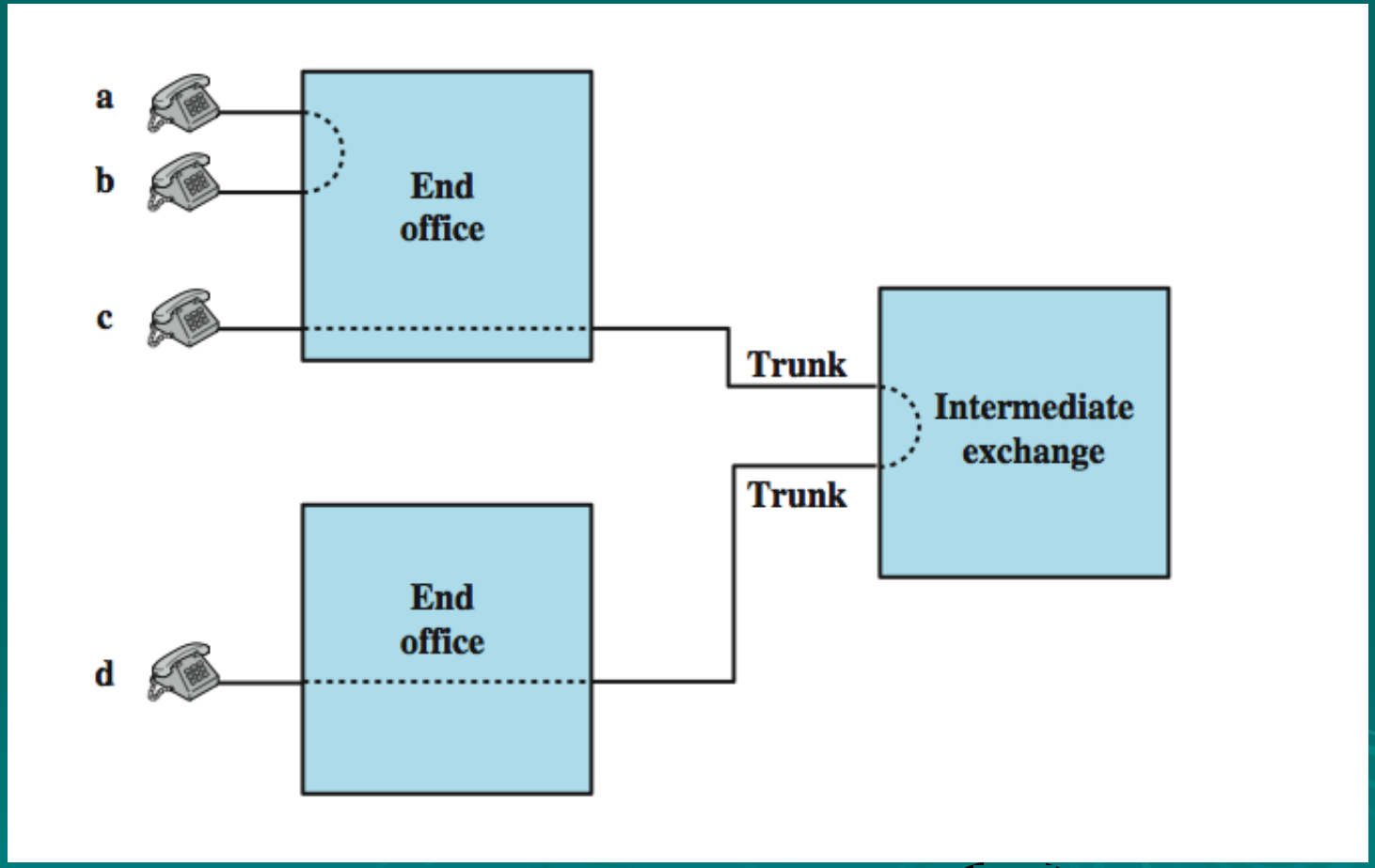
Circuit Switching

- uses a dedicated path between two stations
- has three phases
  - establish
  - transfer
  - disconnect
- inefficient
  - channel capacity dedicated for duration of connection
  - if no data, capacity wasted
- set up (connection) takes time
- once connected, transfer is transparent

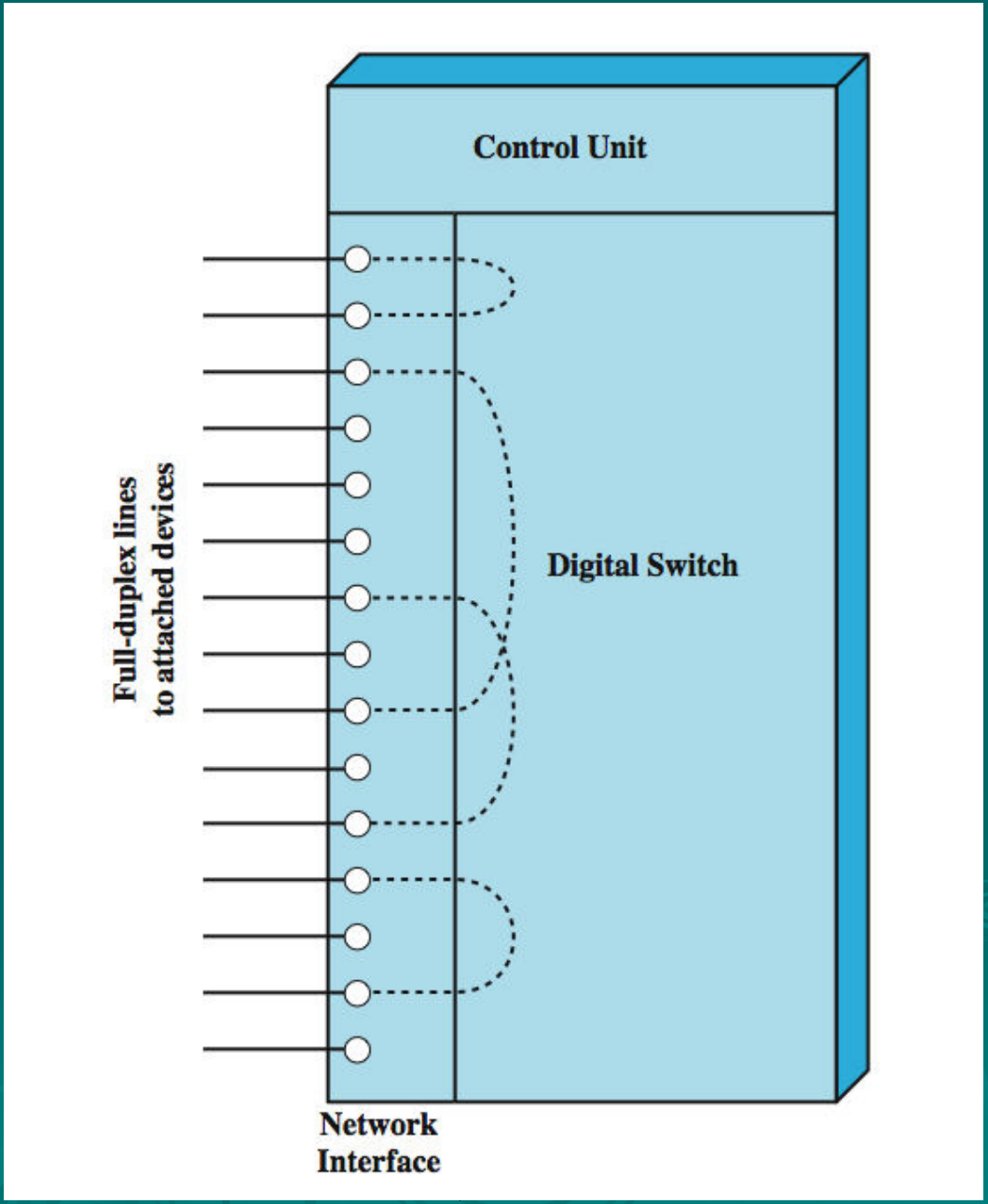
Public Circuit Switched Network



Circuit Establishment



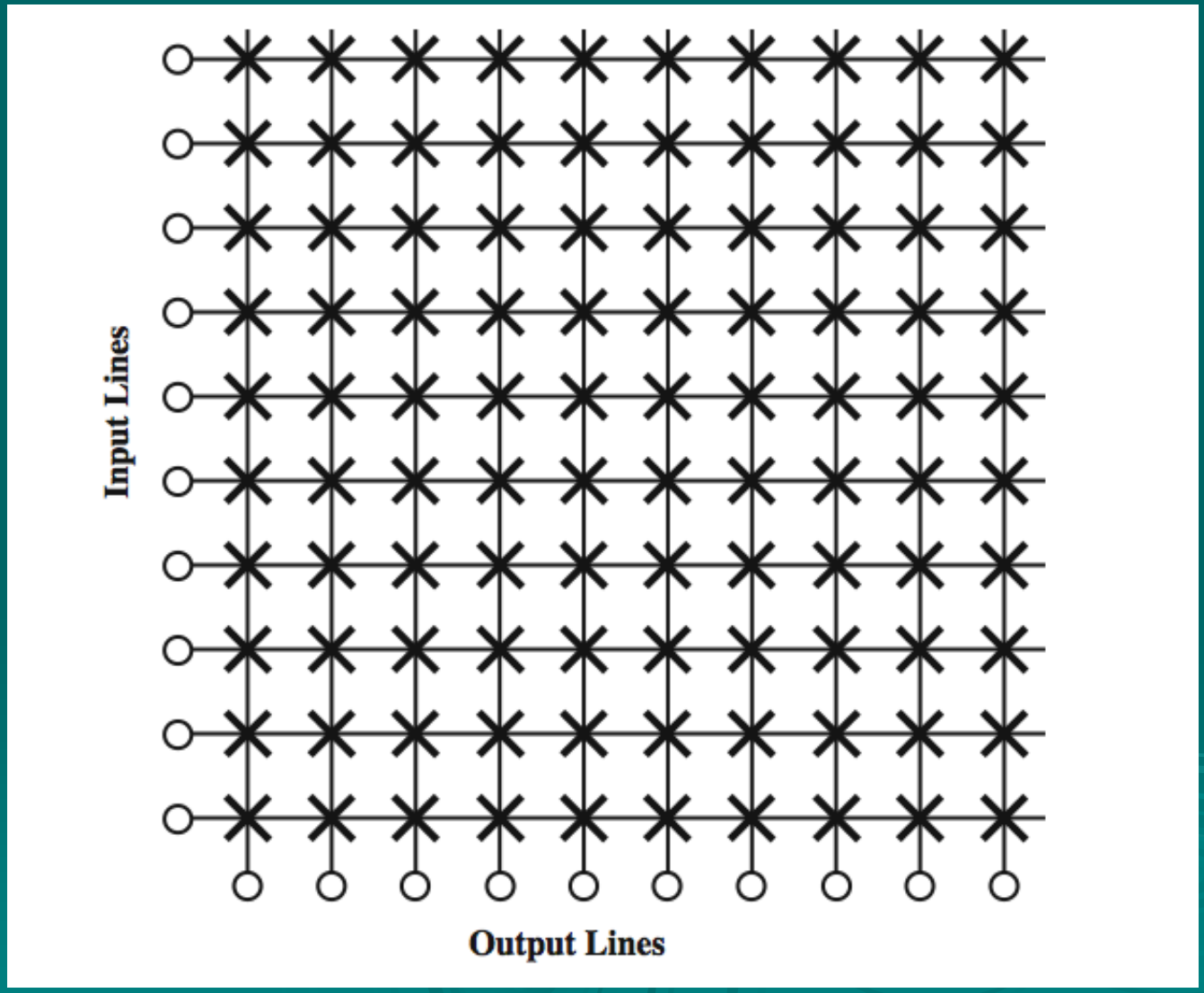
Circuit Switch Elements



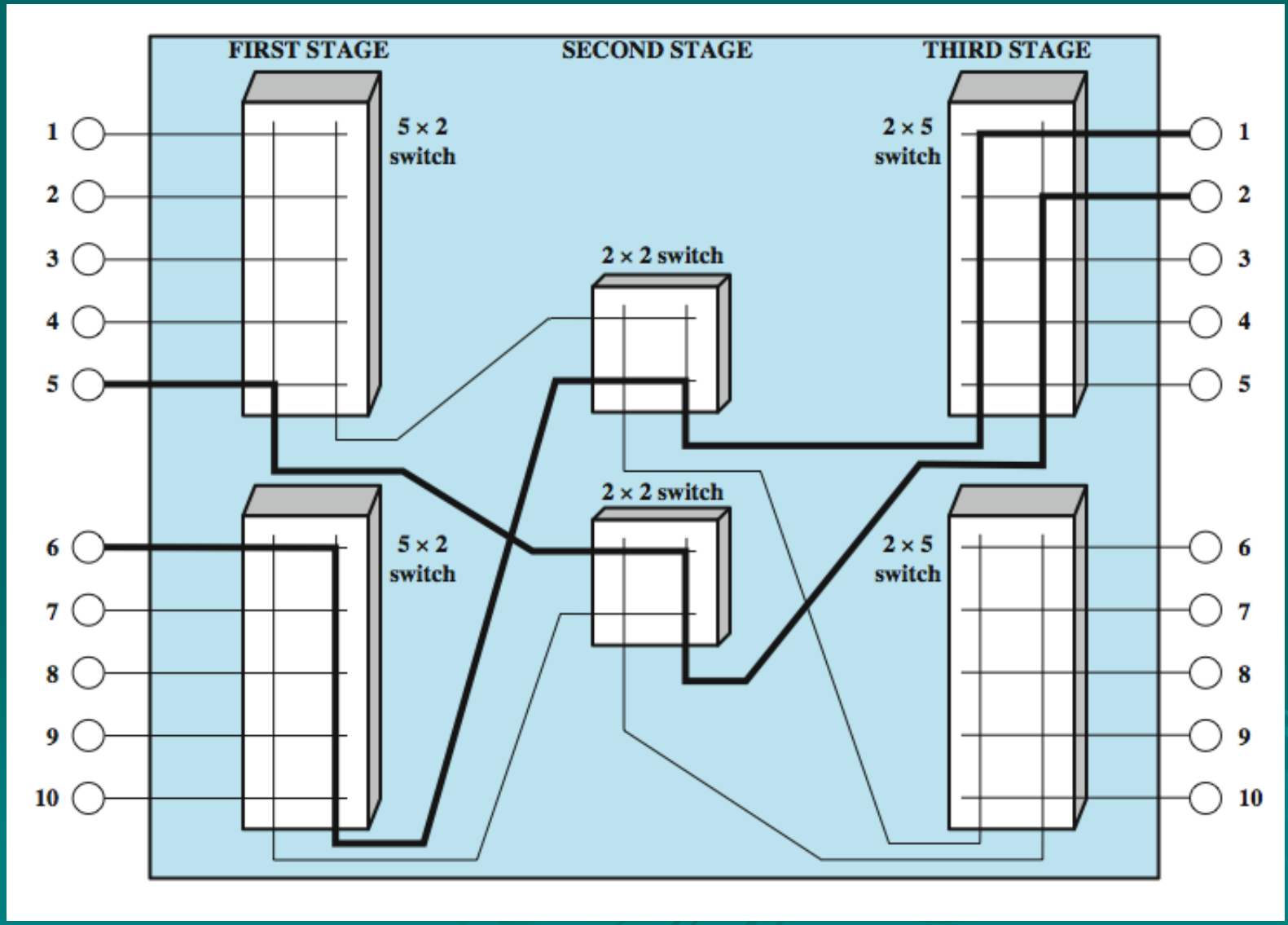
Blocking or Non-blocking

- blocking network
  - may be unable to connect stations because all paths are in use
  - used on voice systems
- non-blocking network
  - permits all stations to connect at once
  - used for some data connections

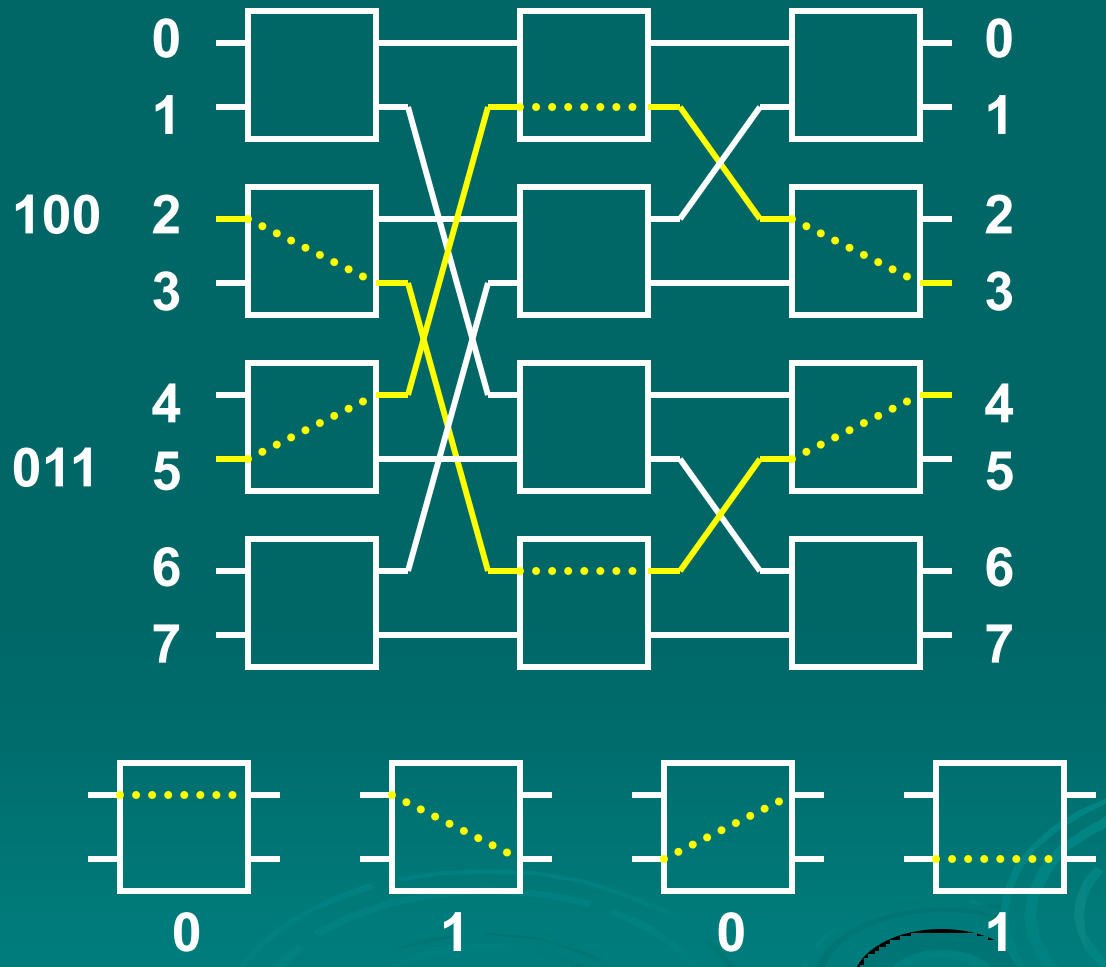
Space Division Switch



3 Stage Space Division Switch



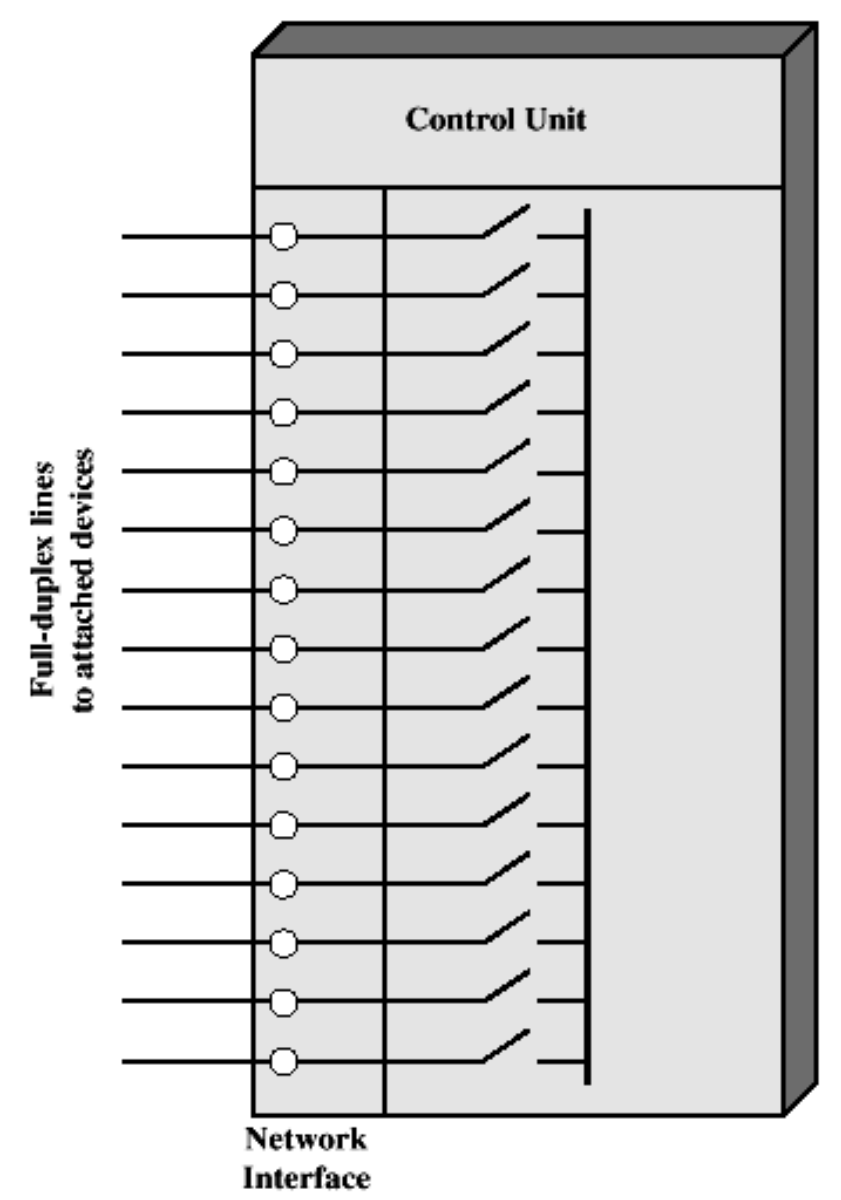
E.g. Banyan Switch (ATM)



Time Division Switching

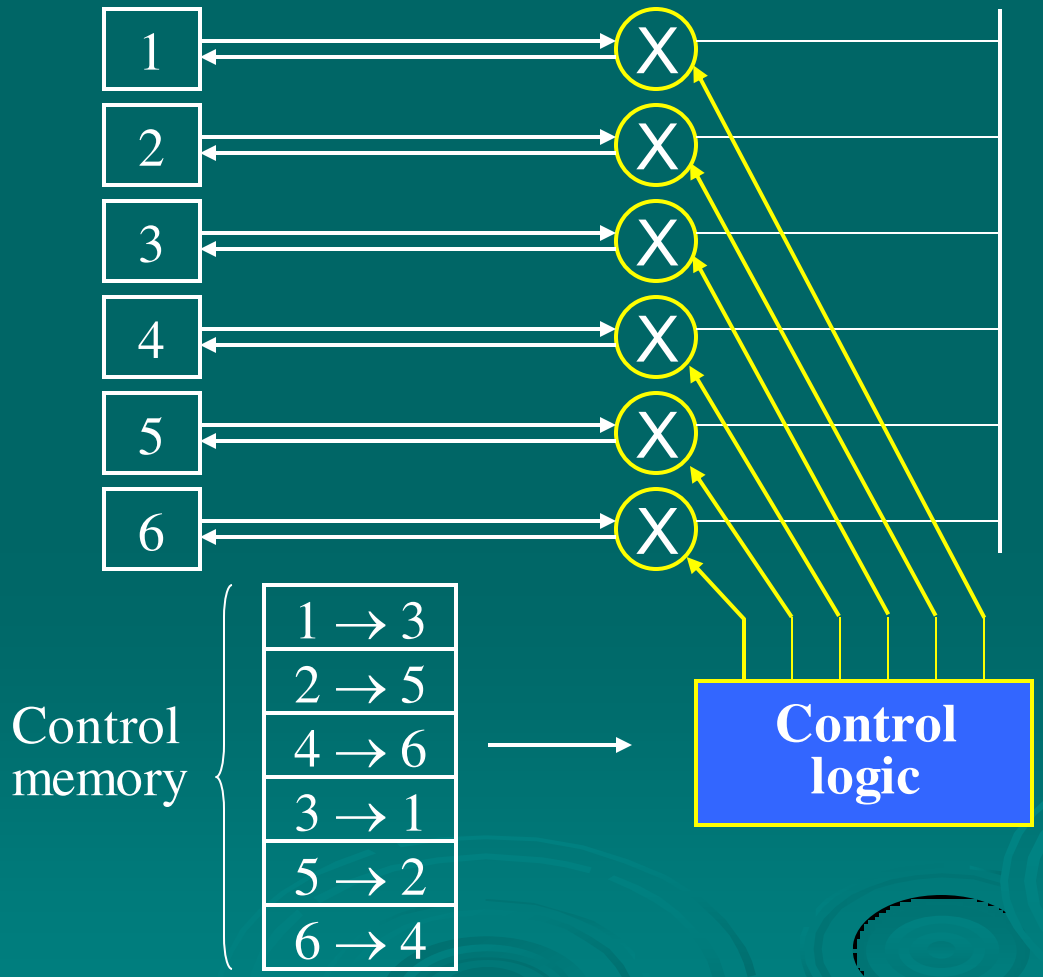
- modern digital systems use intelligent control of space & time division elements
- use digital time division techniques to set up and maintain virtual circuits
- partition low speed bit stream into pieces that share higher speed stream
- individual pieces manipulated by control logic to flow from input to output

Time-division Switching

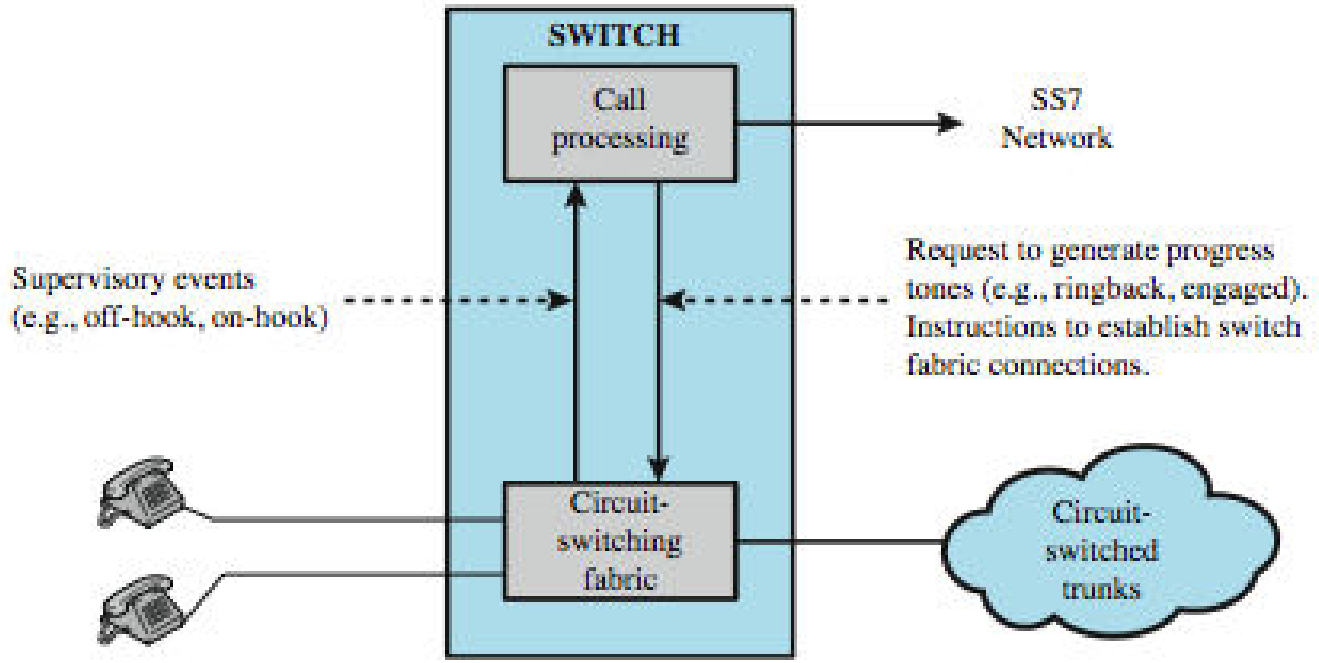


Time-division Switching (cont)

- **Control of a TDM bus switch**

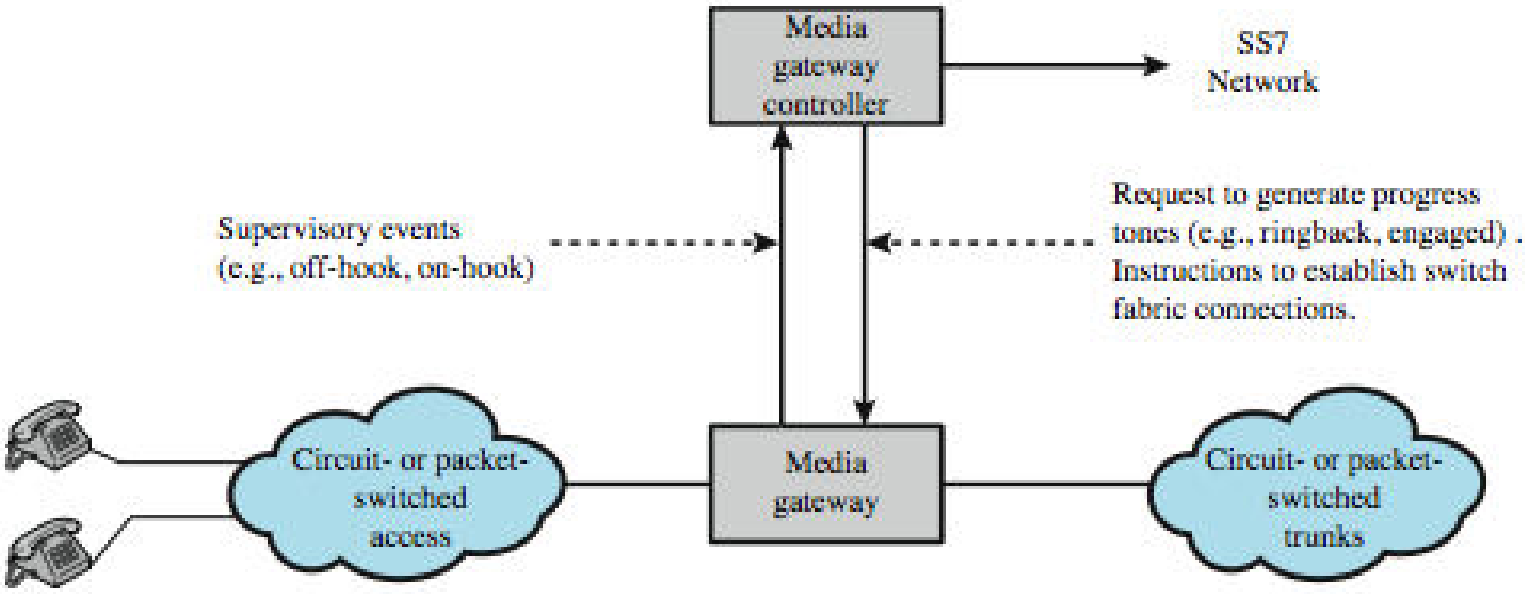


Traditional Circuit Switching



(a) Traditional circuit switching

Softswitch

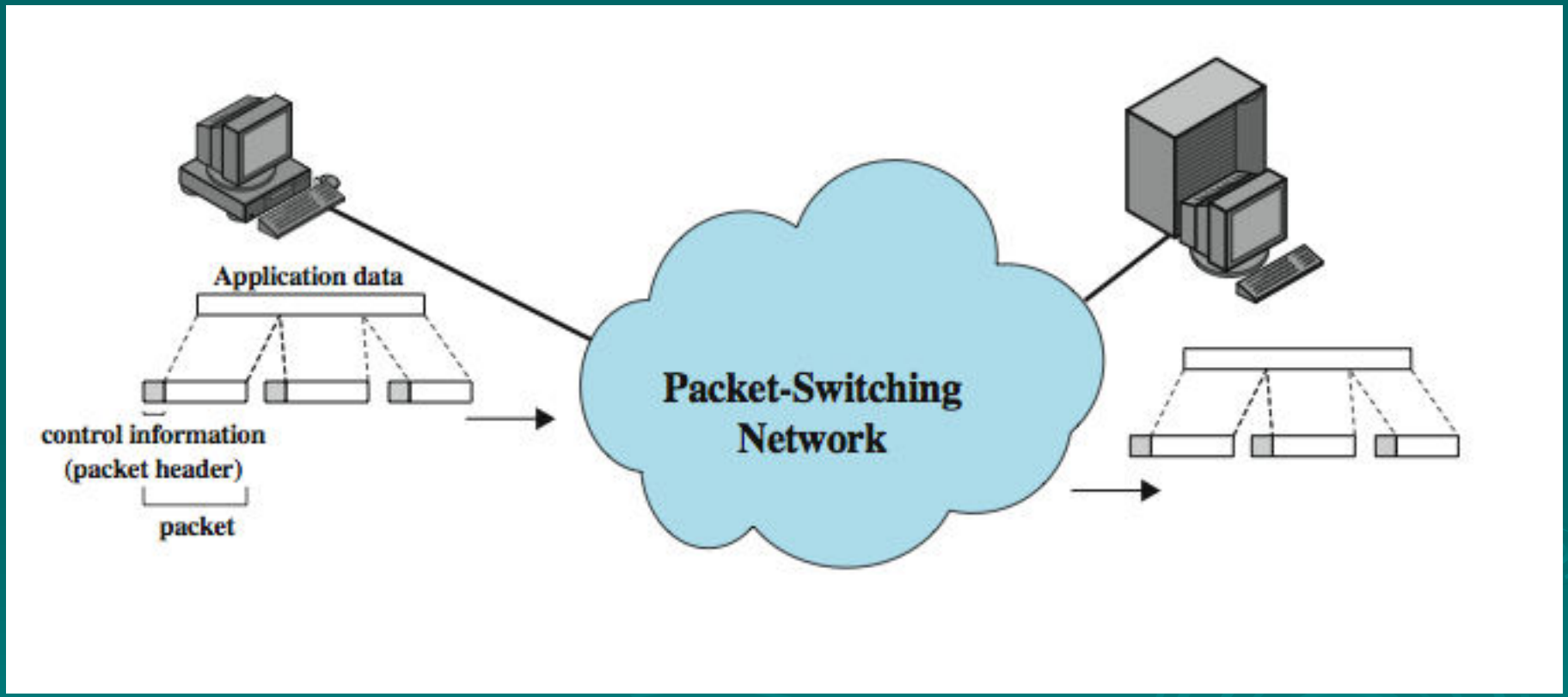


(b) Softswitch architecture

Packet Switching

- circuit switching was designed for voice
- packet switching was designed for data
- transmitted in small packets
- packets contains user data and control info
  - user data may be part of a larger message
  - control info includes routing (addressing) info
- packets are received, stored briefly (buffered) and past on to the next node

Packet Switching



Advantages

- line efficiency
  - single link shared by many packets over time
  - packets queued and transmitted as fast as possible
- data rate conversion
  - stations connects to local node at own speed
  - nodes buffer data if required to equalize rates
- packets accepted even when network is busy
- priorities can be used

Switching Techniques

- station breaks long message into packets
- packets sent one at a time to the network
- packets can be handled in two ways
  - datagram
  - virtual circuit

Datagram Diagram

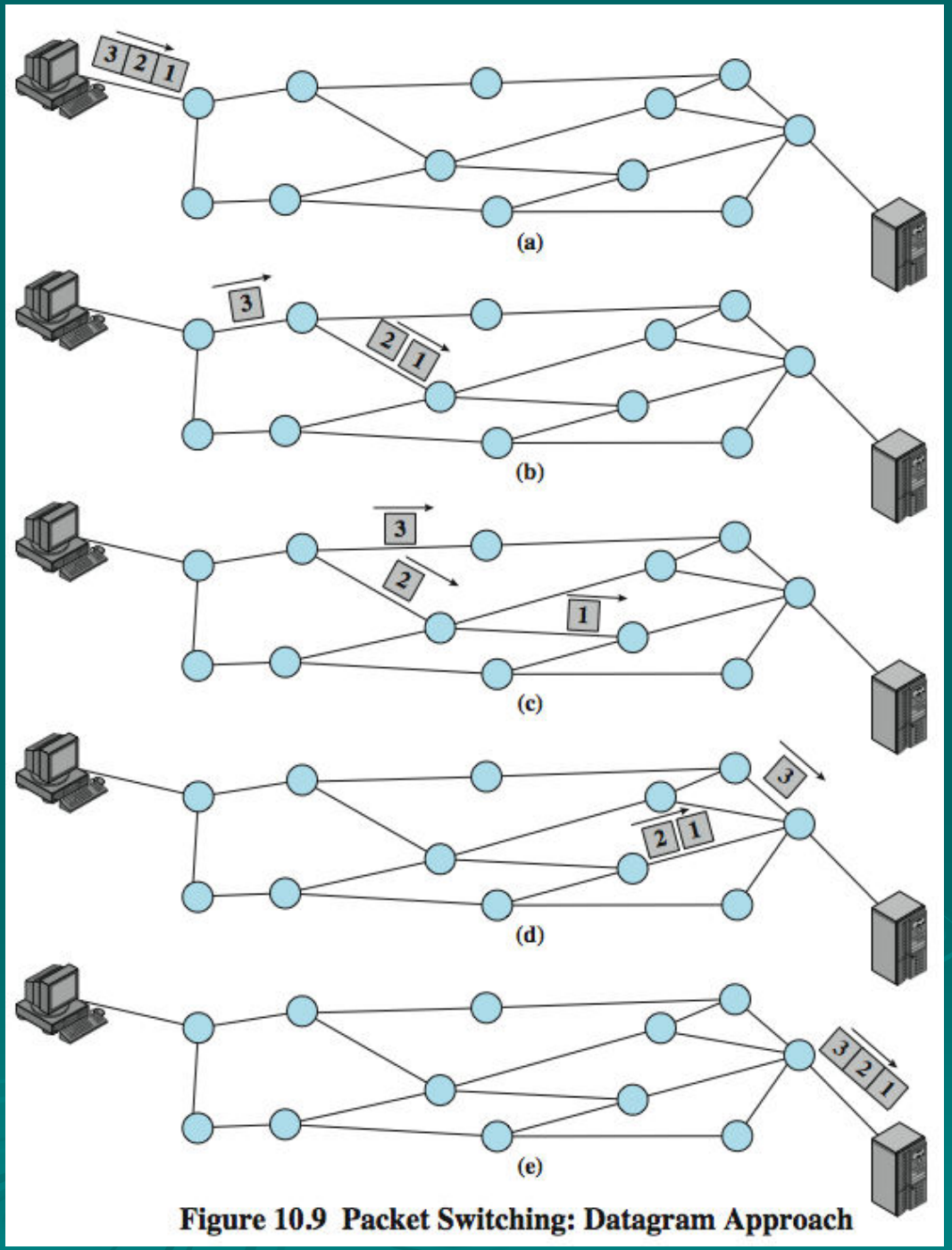


Figure 10.9 Packet Switching: Datagram Approach

Virtual Circuit Diagram

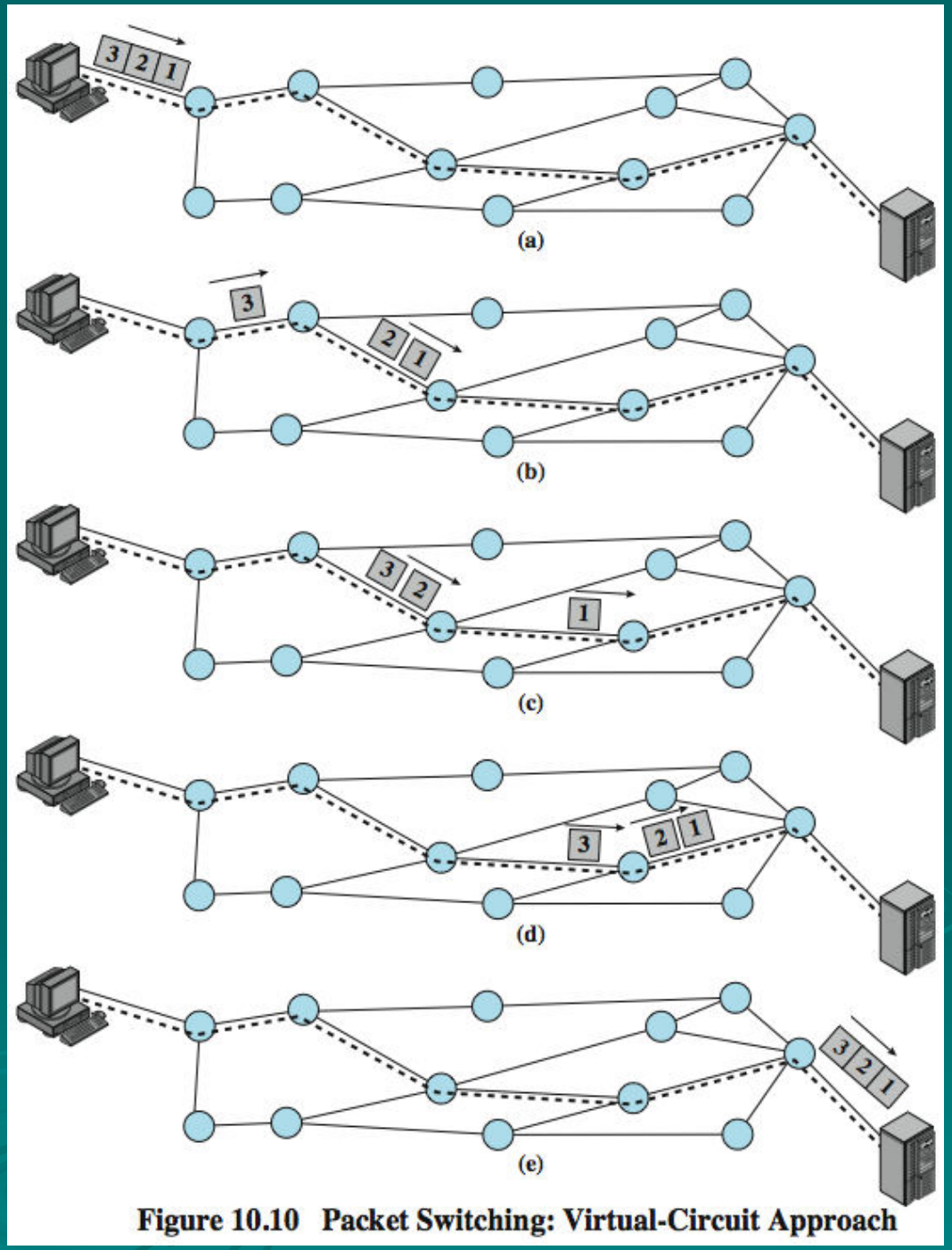
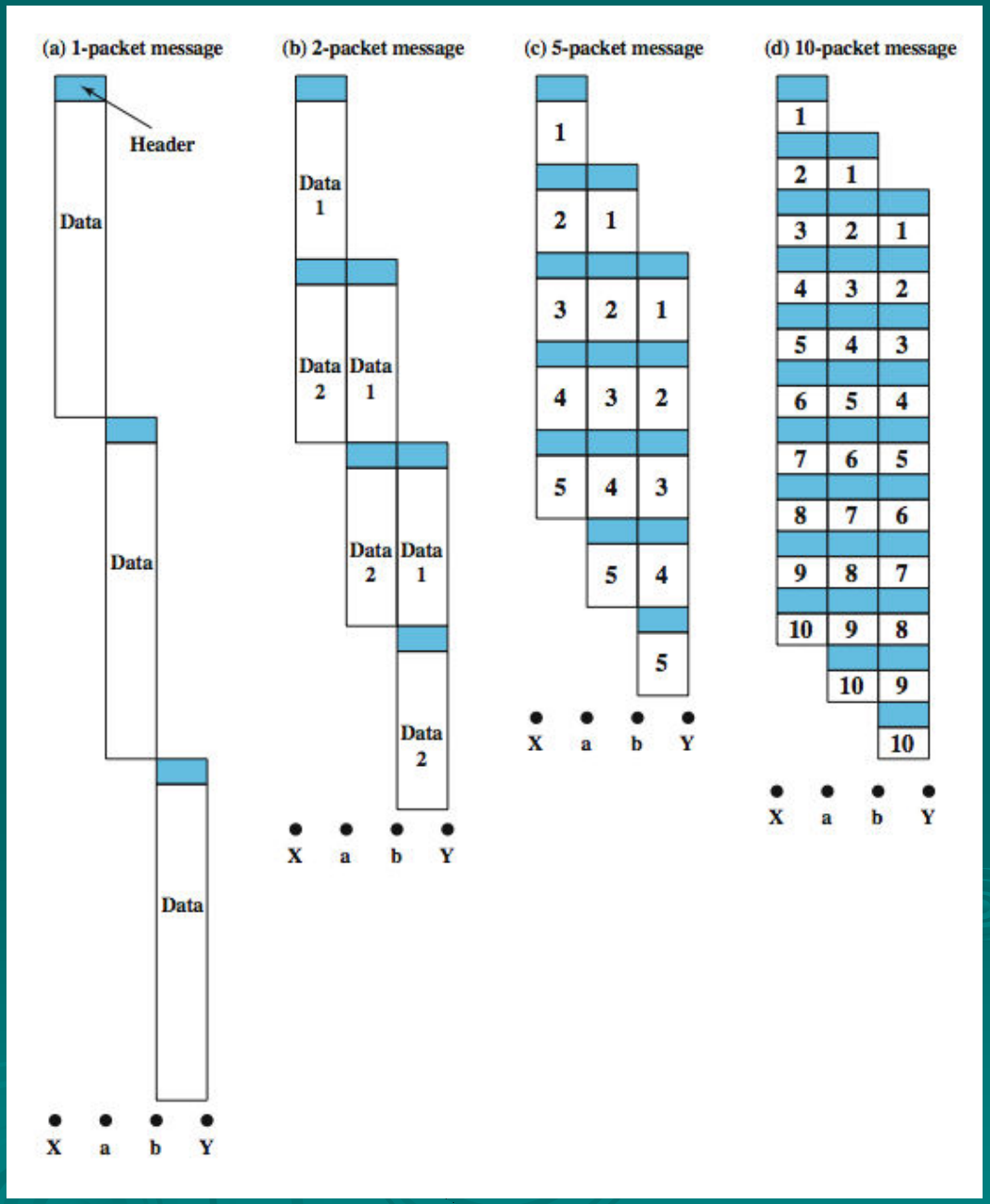


Figure 10.10 Packet Switching: Virtual-Circuit Approach

Virtual Circuits vs. Datagram

- virtual circuits
  - network can provide sequencing and error control
  - packets are forwarded more quickly
  - less reliable
- datagram
  - no call setup phase
  - more flexible
  - more reliable

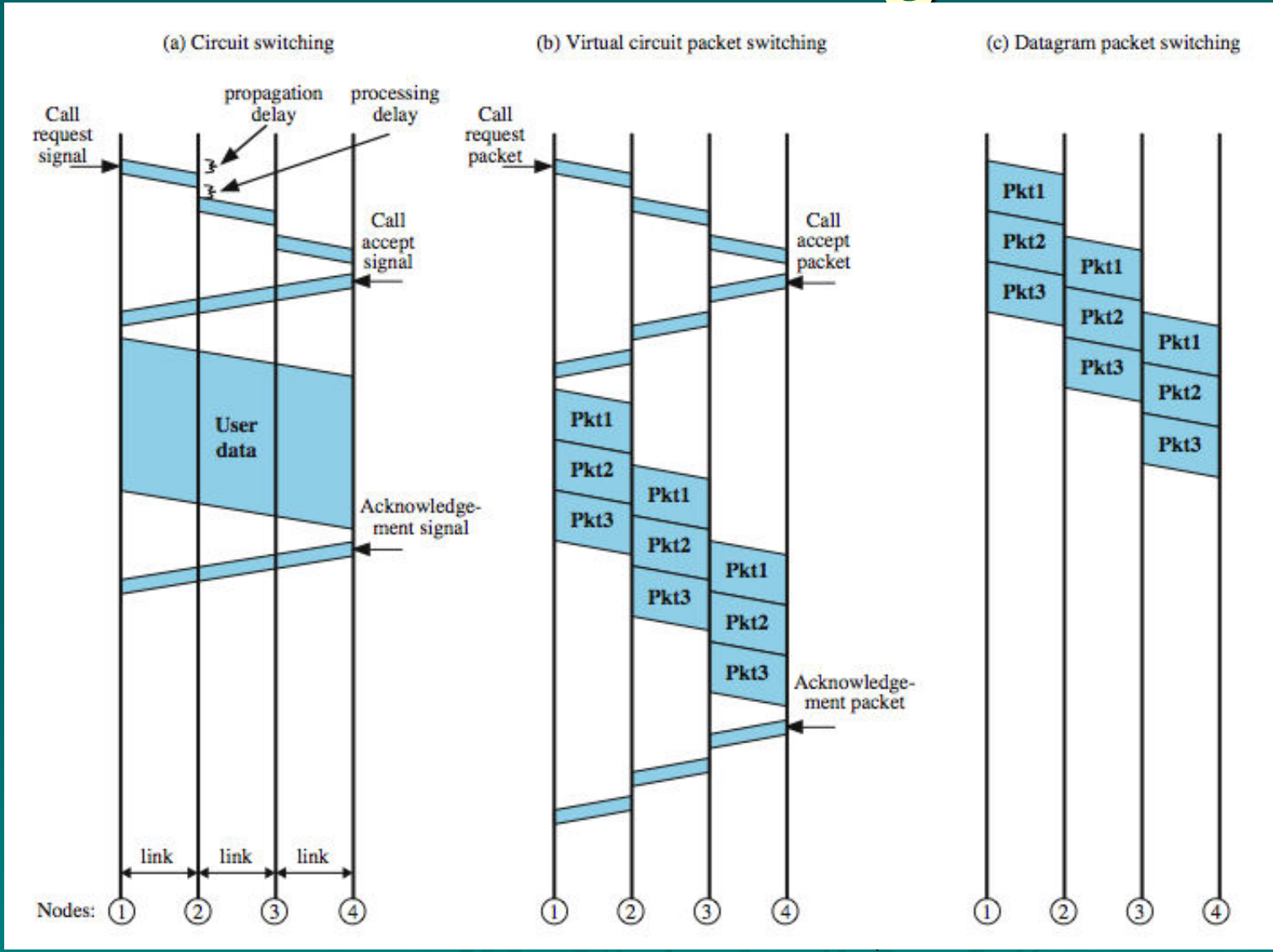
Packet Size


(a) 1-packet message
Header
Data
Data
Data
X
a
b
Y
(b) 2-packet message
Data 1
Data 2
Data 1
Data 2
Data 1
Data 2
X
a
b
Y
(c) 5-packet message
1
2 1
3 2 1
4 3 2
5 4 3
5 4
5
X
a
b
Y
(d) 10-packet message
1
2 1
3 2 1
4 3 2
5 4 3
6 5 4
7 6 5
8 7 6
9 8 7
10 9 8
10 9
10
X
a
b
Y

Circuit vs. Packet Switching

- Table 10.1
- performance depends on various delays
  - propagation delay
  - transmission time
  - node delay
- range of other characteristics, including:
  - transparency
  - amount of overhead

Event Timing



X.25

- ITU-T standard for interface between host and packet switched network
- almost universal on packet switched networks and packet switching in ISDN
- defines three layers
  - Physical
  - Link
  - Packet

X.25 - Physical

- interface between station node link
- two ends are distinct
  - Data Terminal Equipment DTE (user equipment)
  - Data Circuit-terminating Equipment DCE (node)
- physical layer specification is X.21
- can substitute alternative such as EIA-232

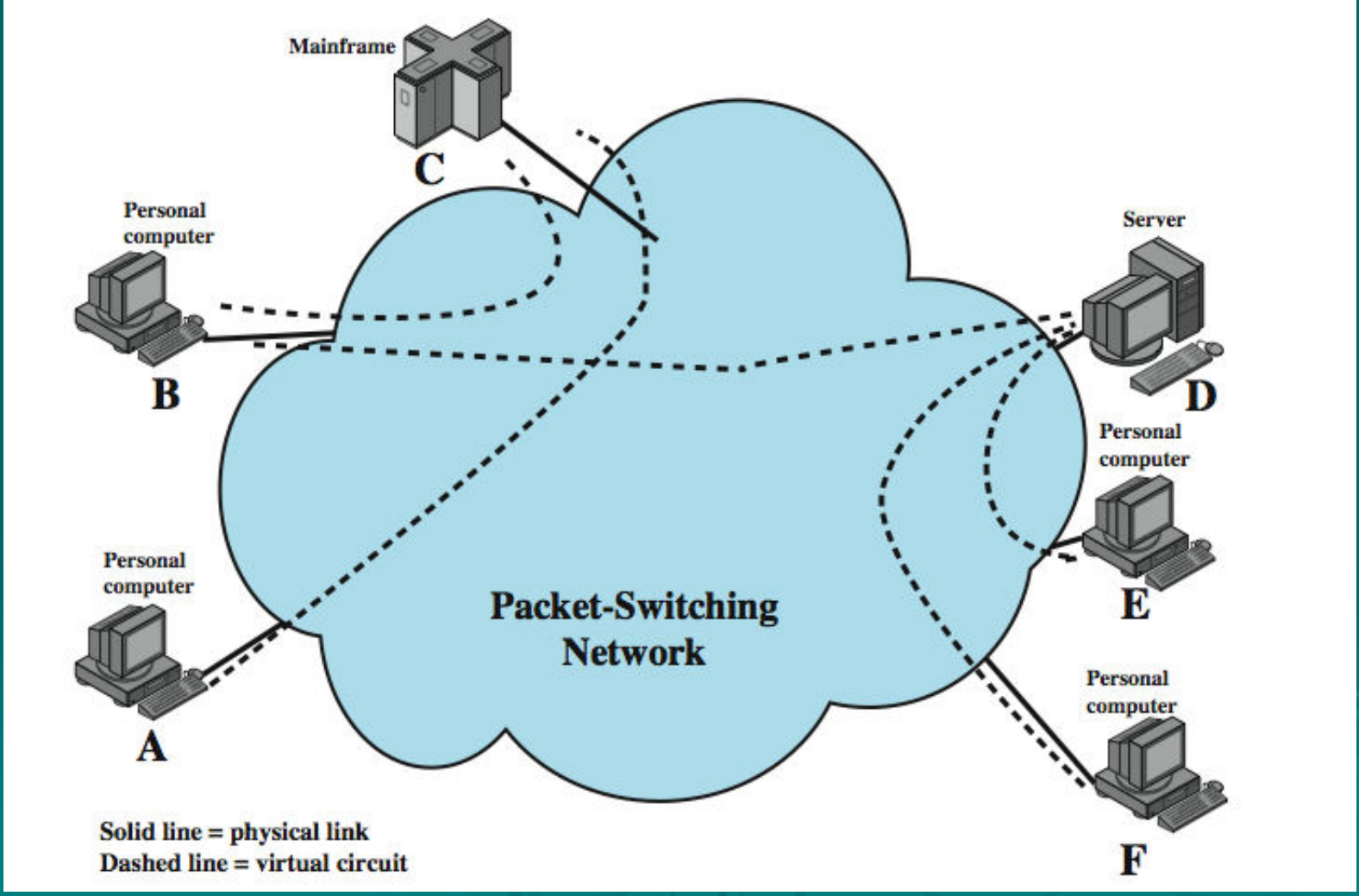
X.25 - Link

- Link Access Protocol Balanced (LAPB)
  - Subset of HDLC
  - see chapter 7
- provides reliable transfer of data over link
- sending as a sequence of frames

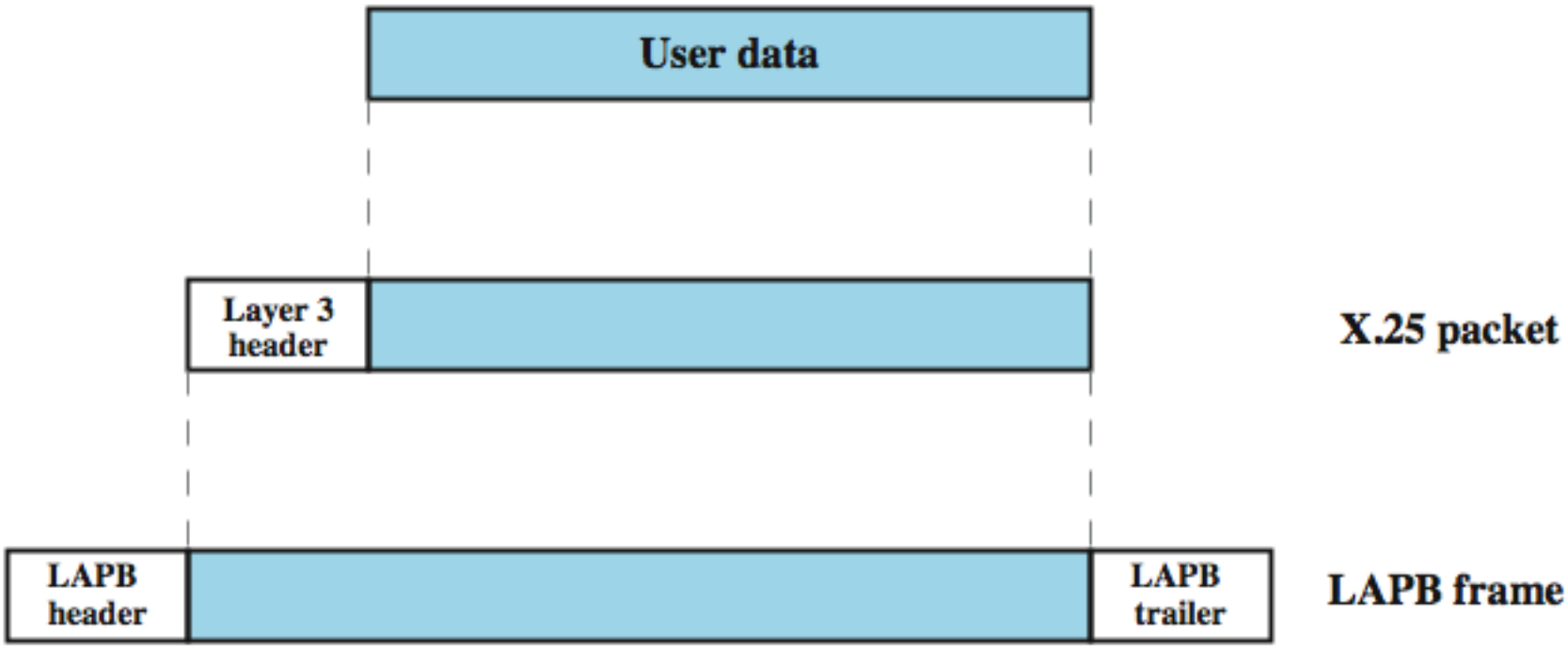
X.25 - Packet

- provides a logical connections (virtual circuit) between subscribers
- all data in this connection form a single stream between the end stations
- established on demand
- termed external virtual circuits

X.25 Use of Virtual Circuits



User Data and X.25 Protocol Control Information



Issues with X.25

- key features include:
  - call control packets, in band signaling
  - multiplexing of virtual circuits at layer 3
  - layers 2 and 3 include flow and error control
- hence have considerable overhead
- not appropriate for modern digital systems with high reliability

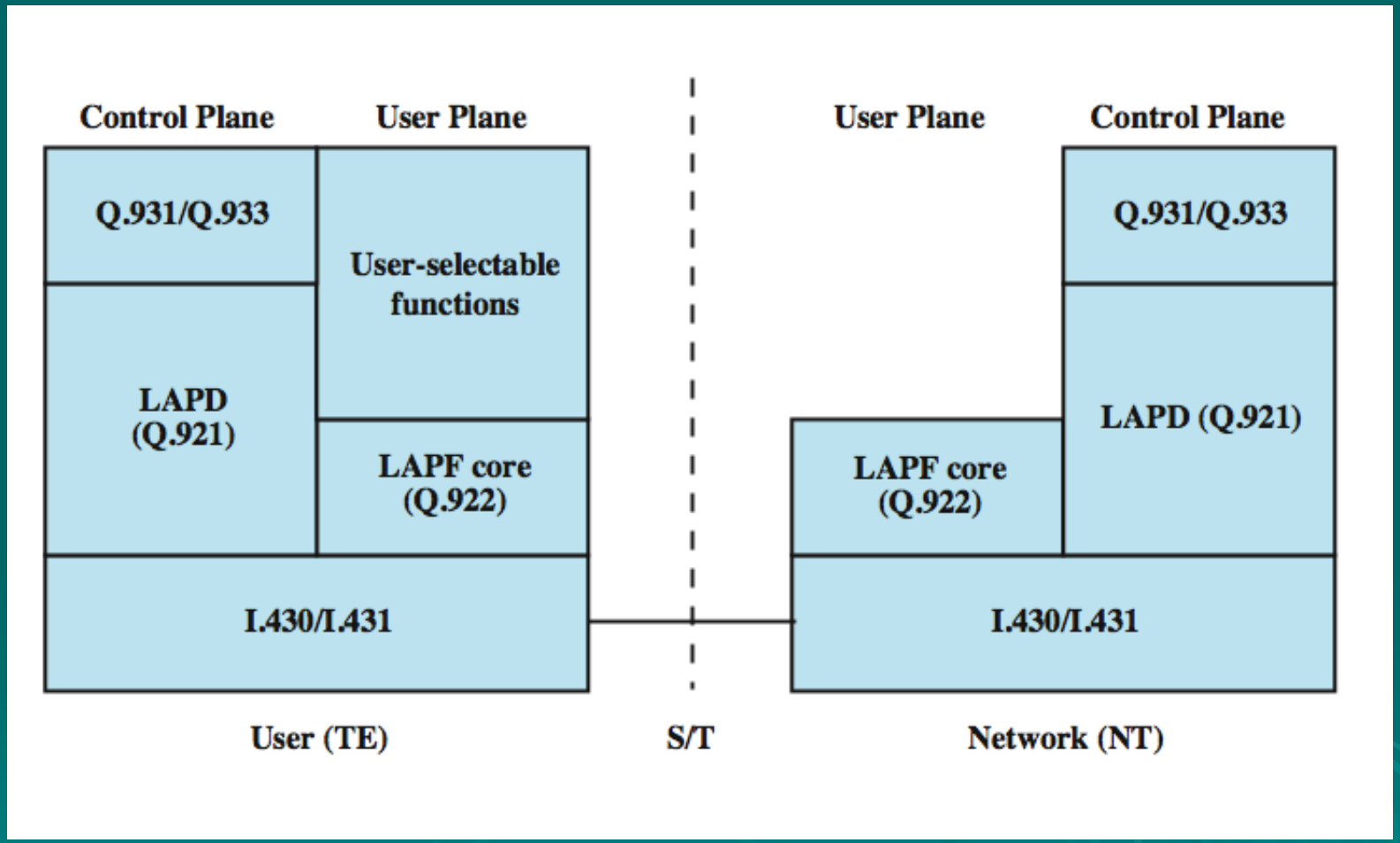
Frame Relay

- designed to eliminate most X.25 overhead
- has large installed base
- key differences:
  - call control carried in separate logical connection
  - multiplexing and switching at layer 2
  - no hop by hop error or flow control
  - hence end to end flow and error control (if used) are done by higher layer
- a single user data frame is sent from source to destination and higher layer ACK sent back

Advantages and Disadvantages

- lost link by link error and flow control
- increased reliability means less an issue
- streamlined communications process
  - lower delay
  - higher throughput
- frame relay can be used for access speeds up to and over 2Mbps

Protocol Architecture



LAPF Functionality

- LAPF (Link Access Procedure for Frame Mode Bearer Services) defined in Q.922
- only core functionality used:
  - frame delimiting, alignment and transparency
  - frame mux and demux using addressing field
  - ensure frame is integral number of octets
  - ensure frame is neither too long nor short
  - detection of transmission errors
  - congestion control functions
- form sub-layer of data link layer
  - data transfer between subscribers only

Frame Relay Data Link Connections

- logical connection between subscribers
- data transferred over them
- not protected by flow or error control
- uses separate connection for call control
- overall results in significantly less work in network

User Data Transfer

- only have one frame type which
  - carries user data
- no control frames means
  - no inband signaling
  - no sequence numbers
- flag and FCS function as in HDLC
- address field carries DLCI
- DLCI (Data Link Connection Identifier) has local significance only

Summary

- circuit verses packet switching network approaches
- X.25
- frame relay