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Data and Computer Communications
7th Edition

Chapter 10

Circuit Switching and Packet Switching

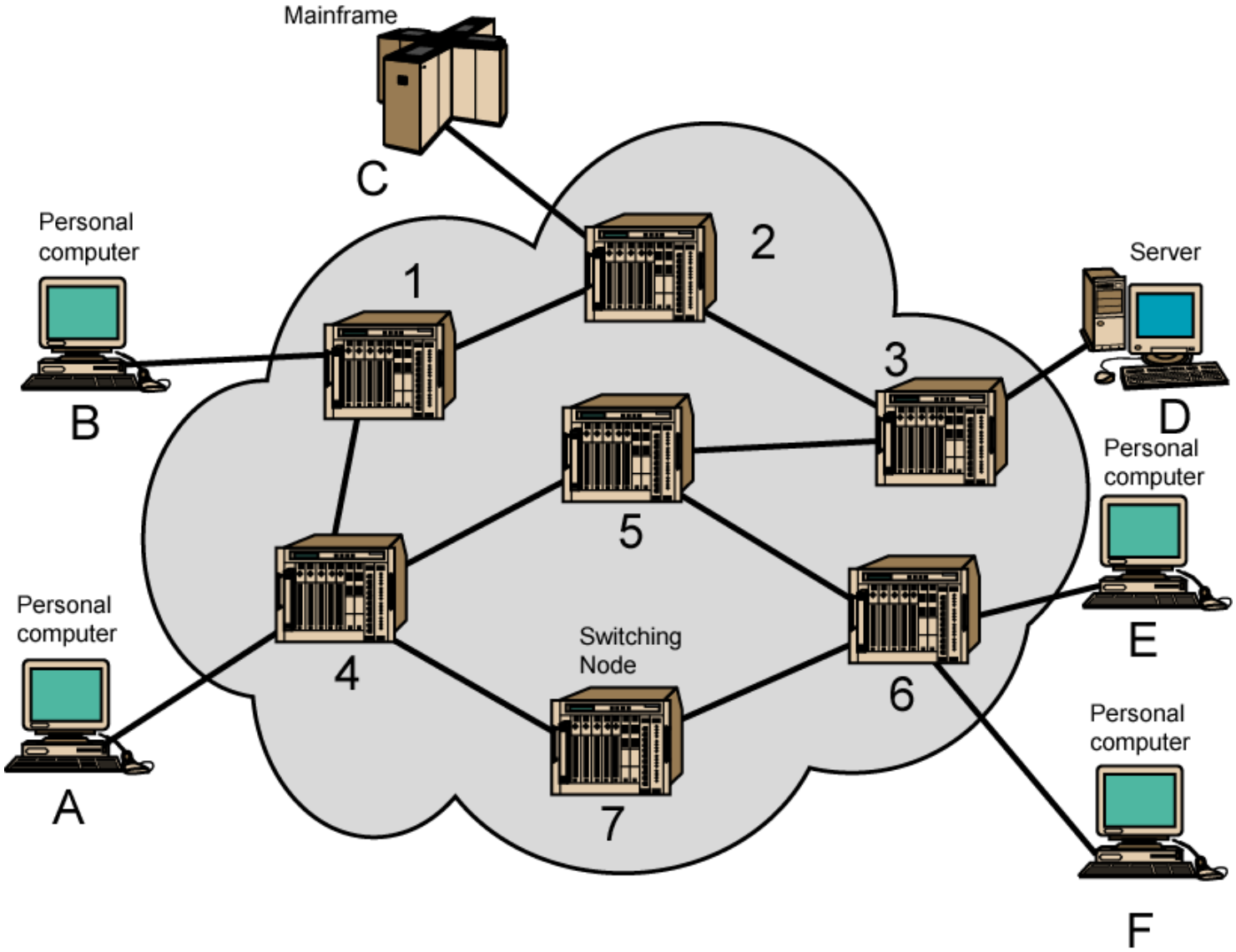
Switching Networks

- Long distance transmission is typically done over a network of switched nodes
- Nodes not concerned with content of data
- End devices are stations
  - Computer, terminal, phone, etc.
- A collection of nodes and connections is a communications network
- Data routed by being switched from node to node

Nodes

- Nodes may connect to other nodes only, or to stations and other nodes
- Node to node links usually multiplexed
- Network is usually partially connected
  - —Some redundant connections are desirable for reliability
- Two different switching technologies
  - —Circuit switching
  - —Packet switching

Simple Switched Network



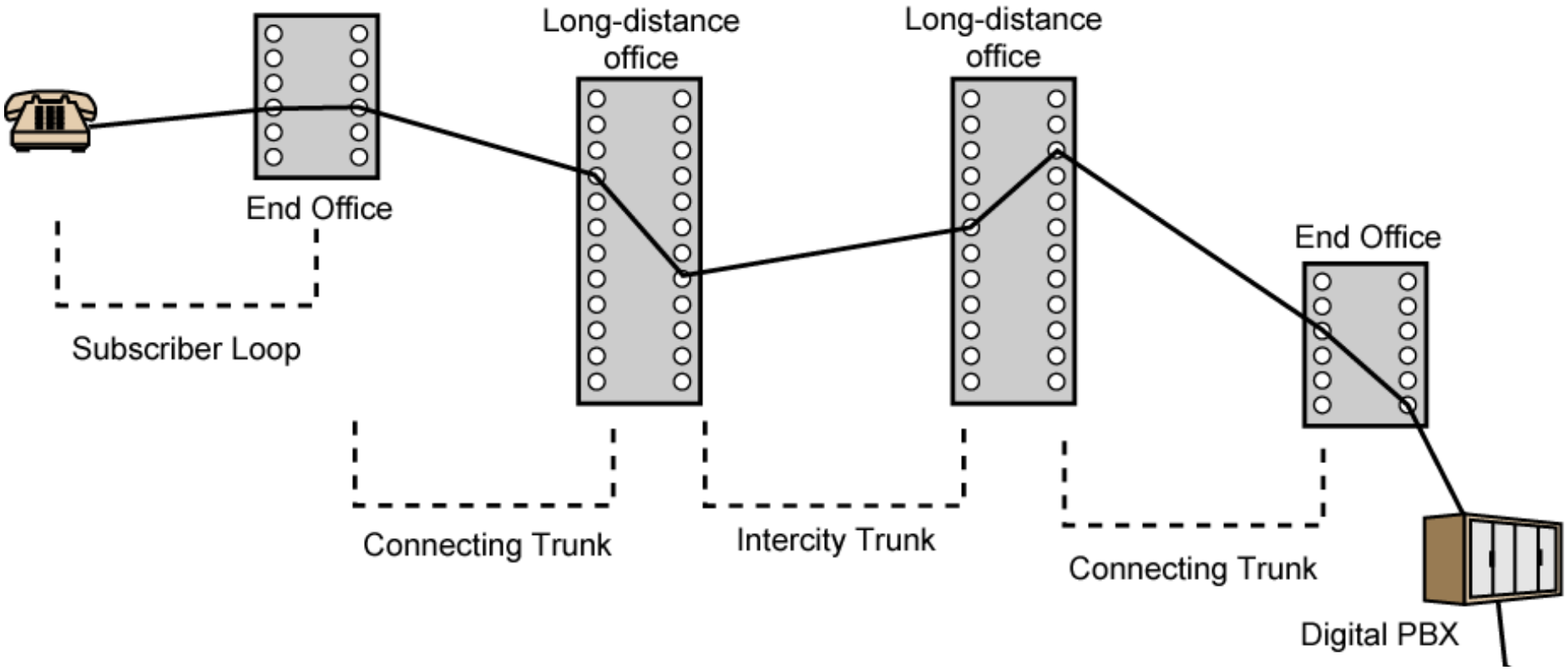
Circuit Switching

- Dedicated communication path between two stations
- Three phases
  - —Establish
  - —Transfer
  - —Disconnect
- Must have switching capacity and channel capacity to establish connection
- Must have intelligence to work out routing

Circuit Switching - Applications

- Inefficient
  - —Channel capacity dedicated for duration of connection
  - —If no data, capacity wasted
- Set up (connection) takes time
- Once connected, transfer is transparent
- Developed for voice traffic (phone)

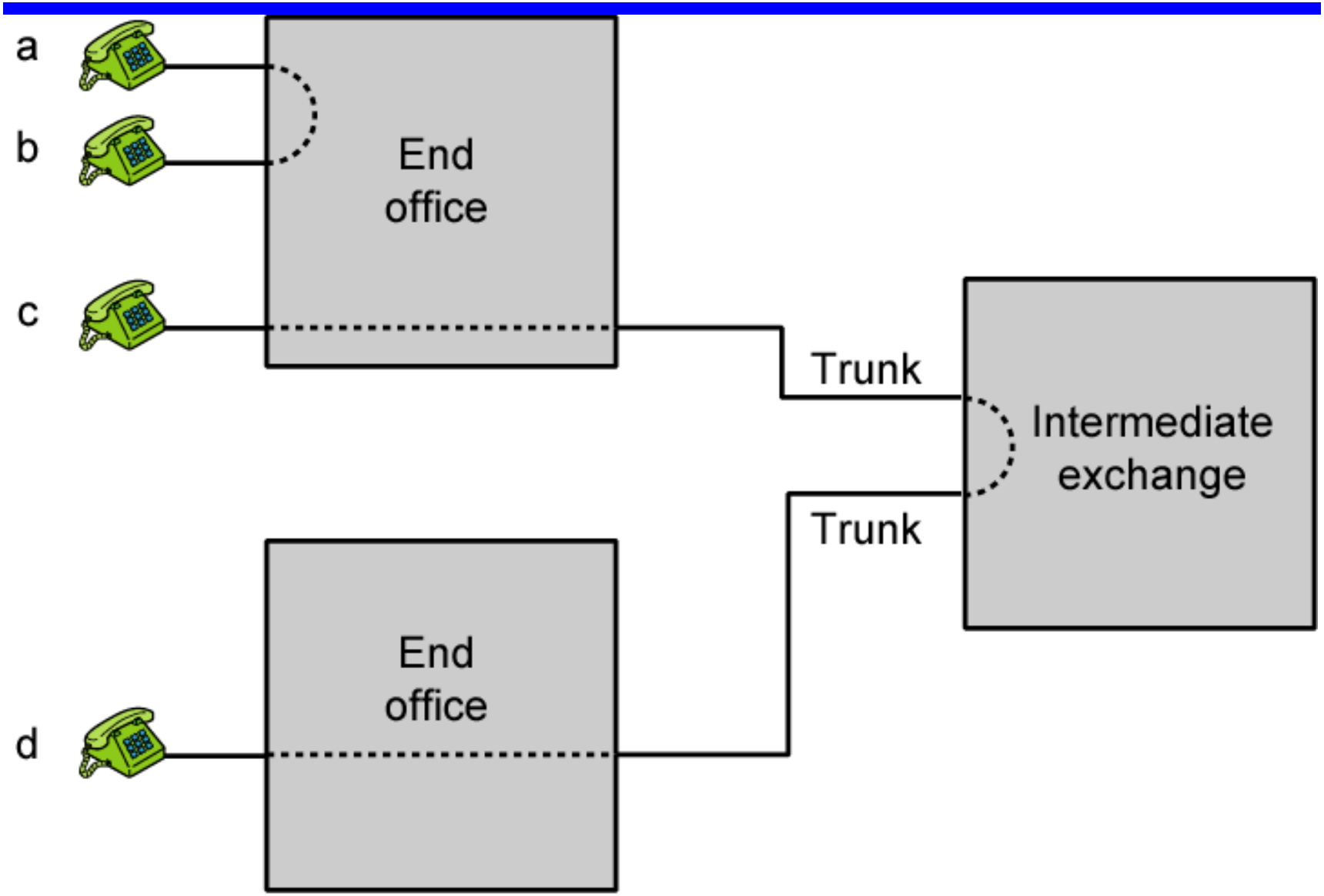
Public Circuit Switched Network



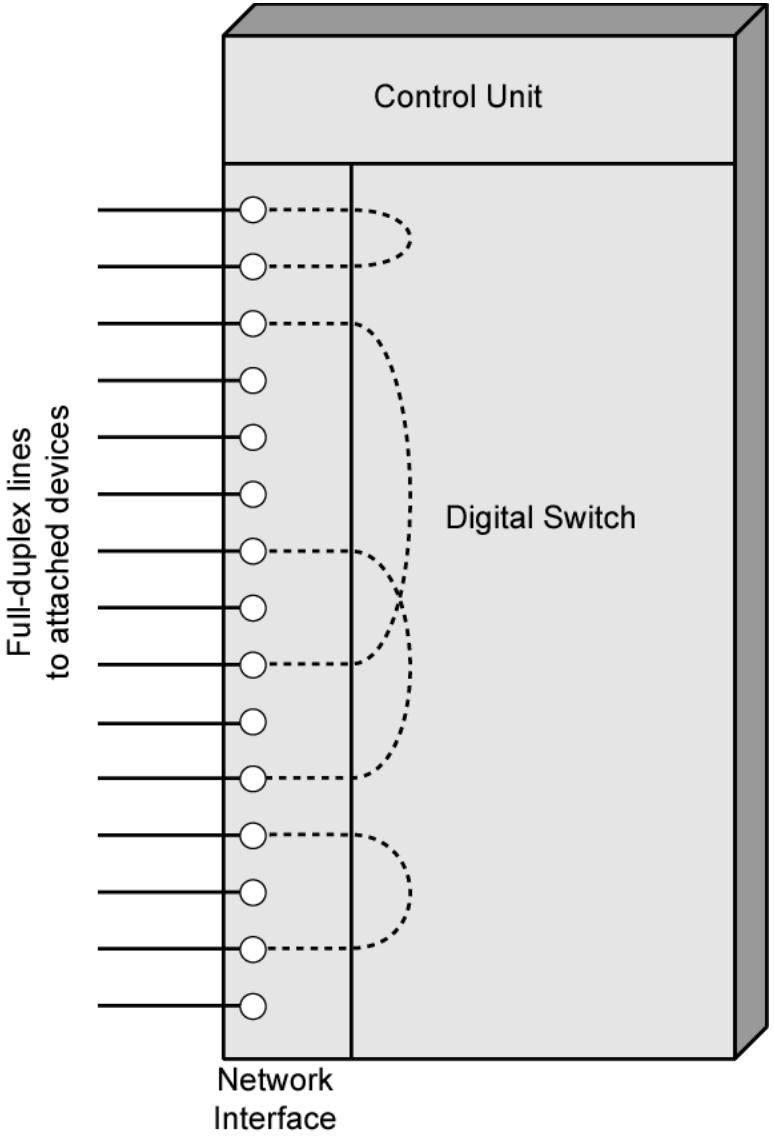
Telecomms Components

- Subscriber
  - Devices attached to network
- Subscriber line
  - Local Loop
  - Subscriber loop
  - Connection to network
  - Few km up to few tens of km
- Exchange
  - Switching centers
  - End office - supports subscribers
- Trunks
  - Branches between exchanges
  - Multiplexed

Circuit Establishment



Circuit Switch Elements



Circuit Switching Concepts

- Digital Switch
  - —Provide transparent signal path between devices
- Network Interface
- Control Unit
  - —Establish connections
    - Generally on demand
    - Handle and acknowledge requests
    - Determine if destination is free
    - construct path
  - —Maintain connection
  - —Disconnect

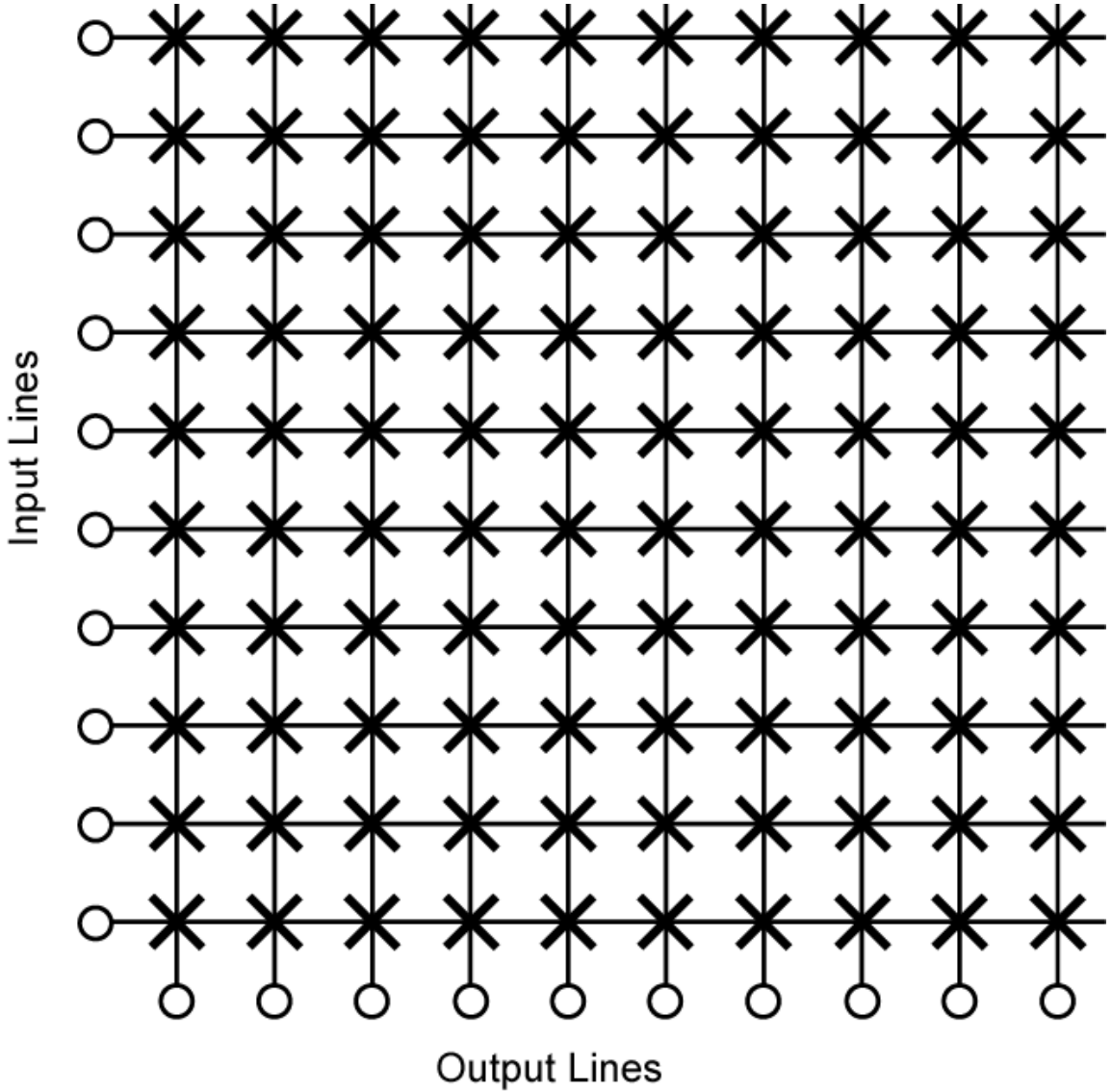
Blocking or Non-blocking

- Blocking
  - —A network is unable to connect stations because all paths are in use
  - —A blocking network allows this
  - —Used on voice systems
    - Short duration calls
- Non-blocking
  - —Permits all stations to connect (in pairs) at once
  - —Used for some data connections

Space Division Switching

- Developed for analog environment
- Separate physical paths
- Crossbar switch
  - —Number of crosspoints grows as square of number of stations
  - —Loss of crosspoint prevents connection
  - —Inefficient use of crosspoints
    - All stations connected, only a few crosspoints in use
  - —Non-blocking

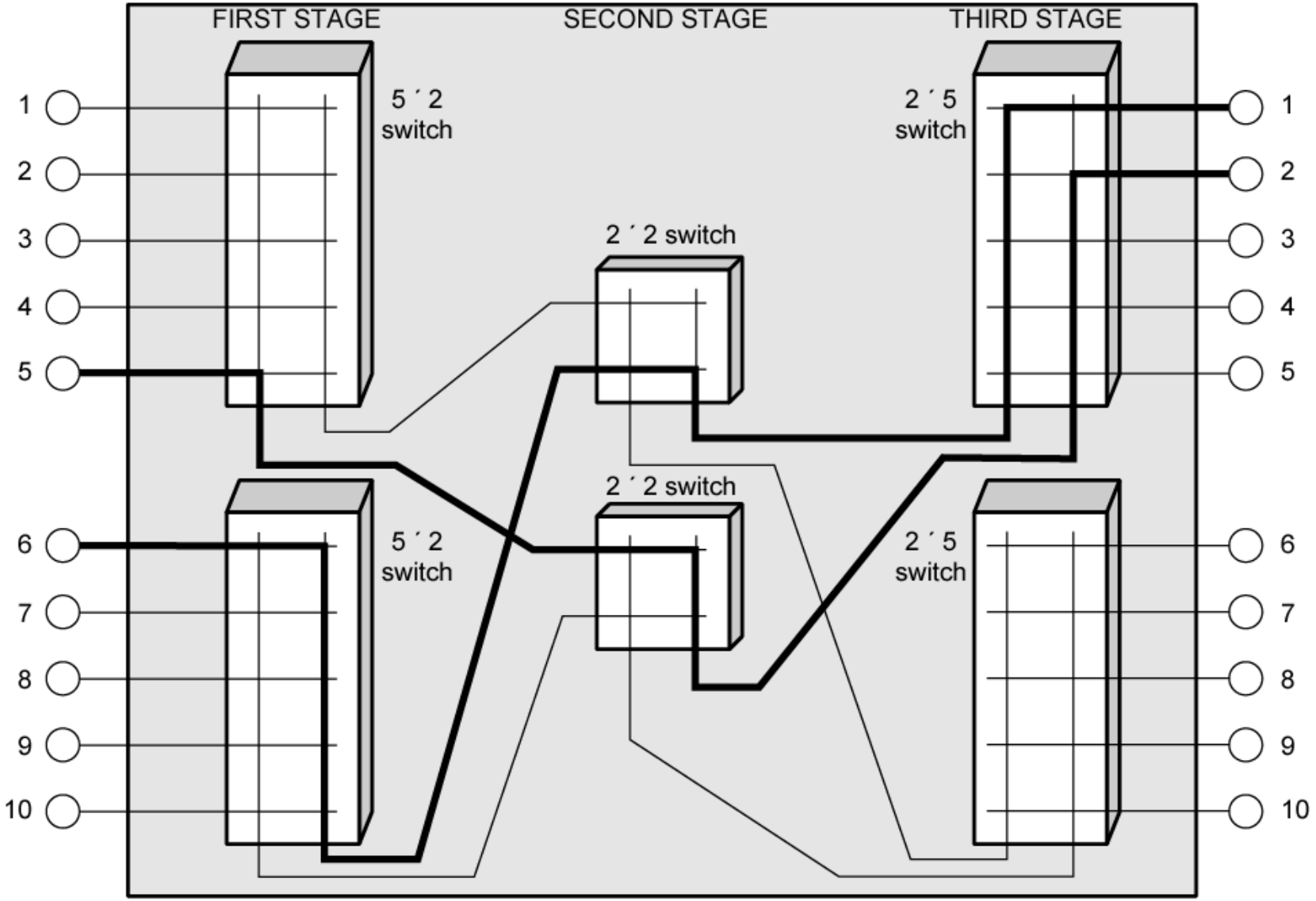
Space Division Switch



Multistage Switch

- Reduced number of crosspoints
- More than one path through network
  - Increased reliability
- More complex control
- May be blocking

Three Stage Space Division Switch



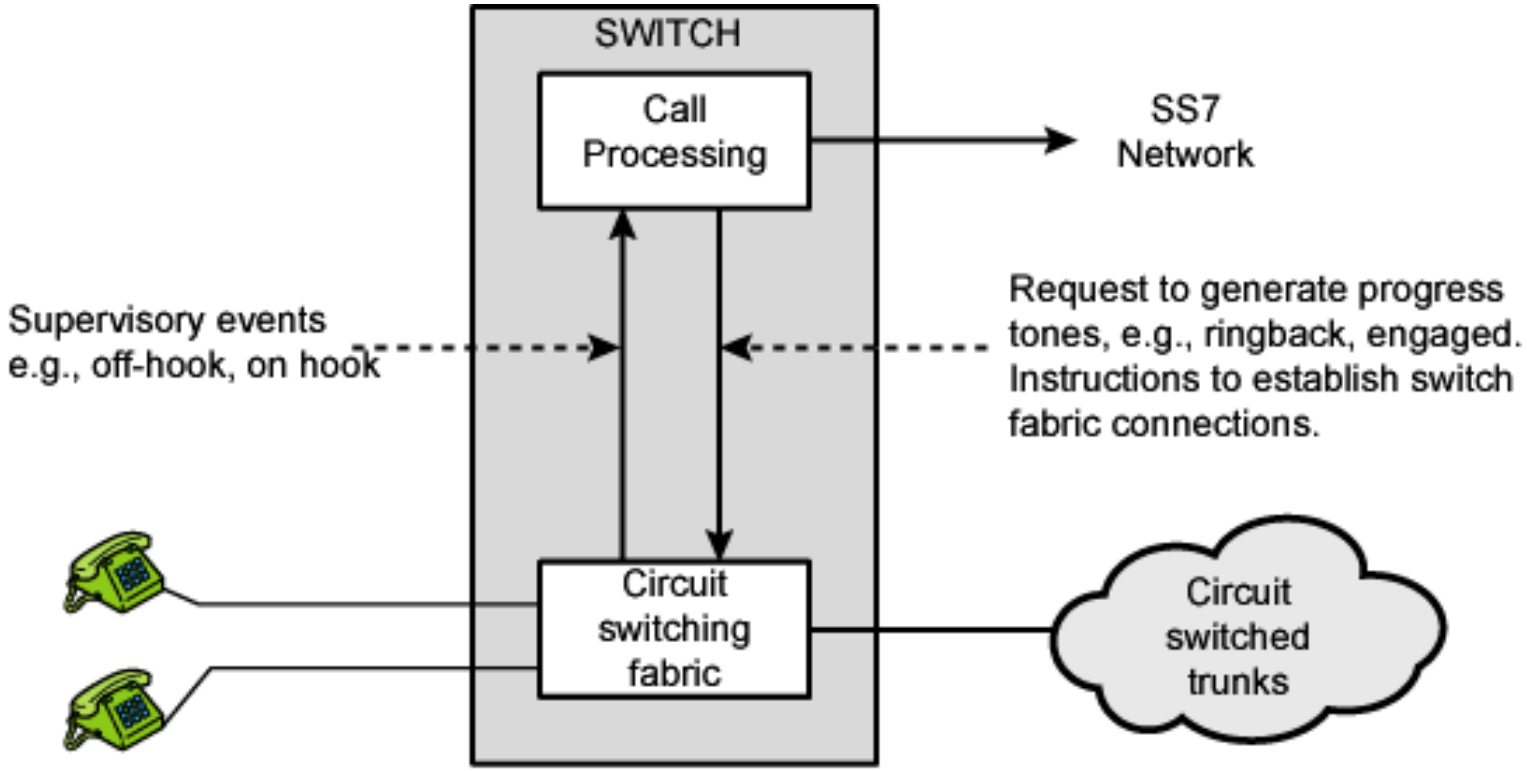
Time Division Switching

- Modern digital systems rely on intelligent control of space and 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

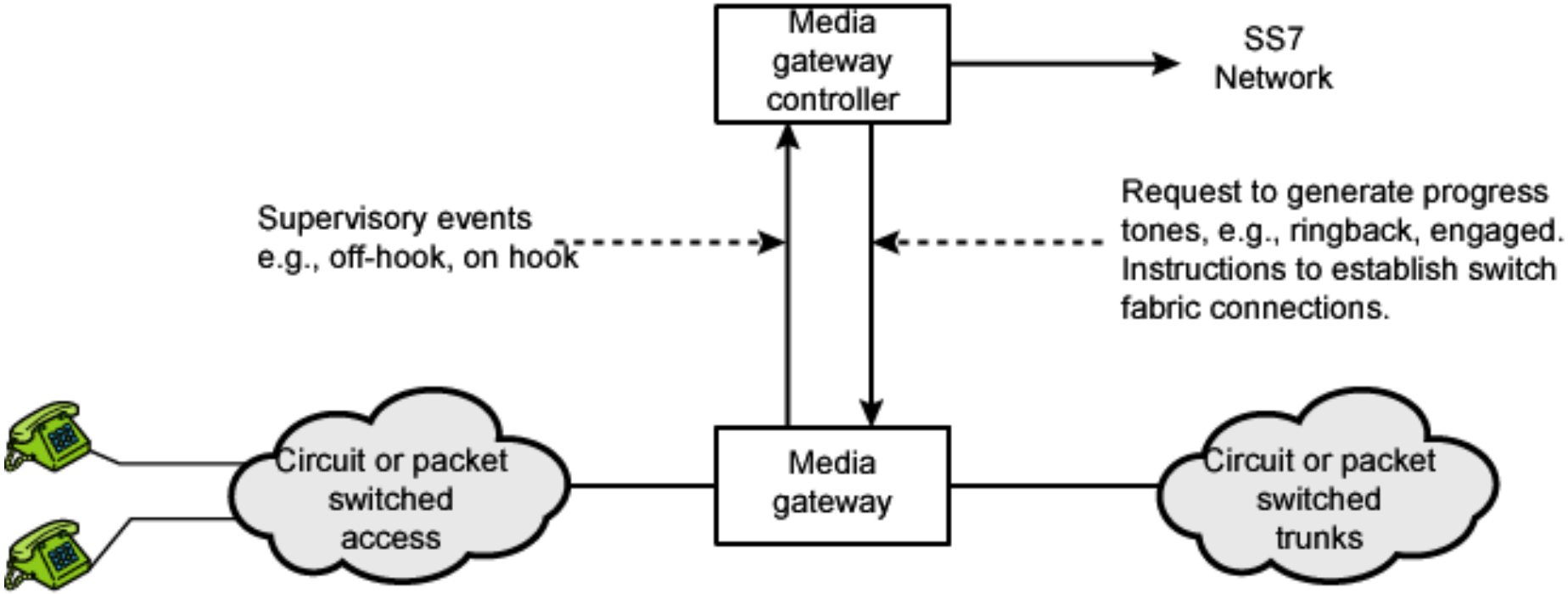
Softswitch Architecture

- General purpose computer running software to make it a smart phone switch
- Lower costs
- Greater functionality
  - Packetizing of digitized voice data
  - Allowing voice over IP
- Most complex part of telephone network switch is software controlling call process
  - Call routing
  - Call processing logic
  - Typically running on proprietary processor
- Separate call processing from hardware function of switch
- Physical switching done by media gateway
- Call processing done by media gateway controller

Traditional Circuit Switching



Softswitch


Media gateway controller
SS7 Network
Supervisory events e.g., off-hook, on hook
Request to generate progress tones, e.g., ringback, engaged. Instructions to establish switch fabric connections.
Circuit or packet switched access
Media gateway
Circuit or packet switched trunks

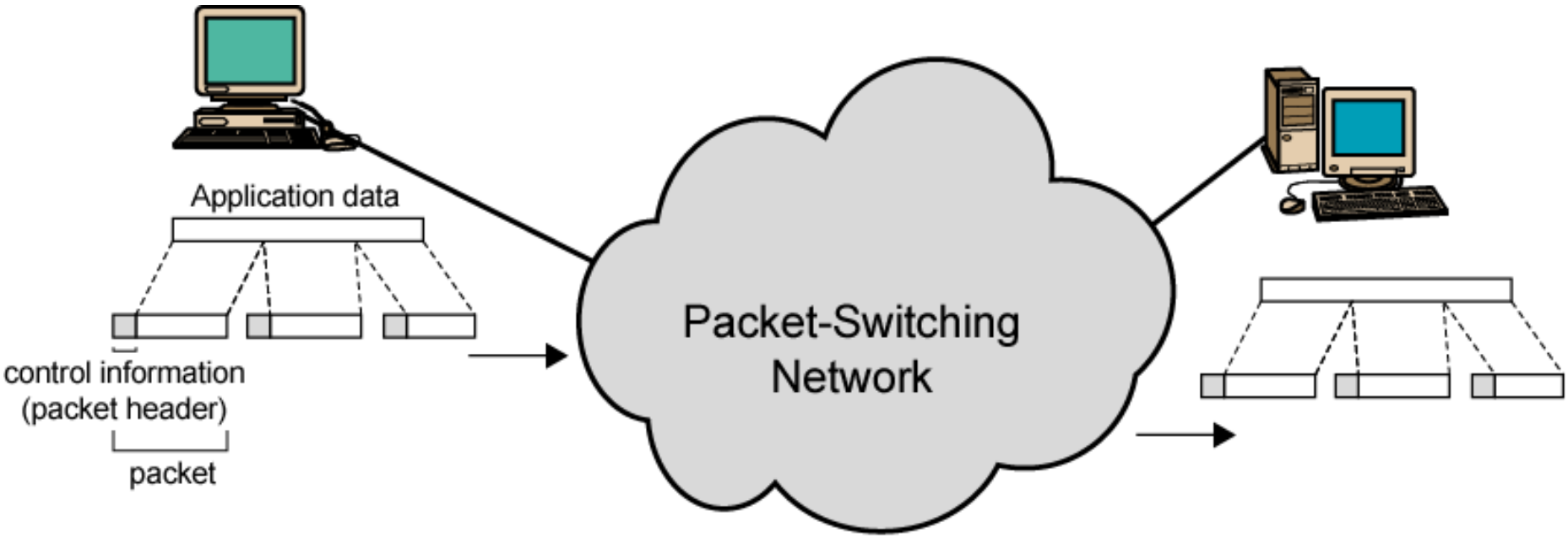
Packet Switching Principles

- Circuit switching designed for voice
  - —Resources dedicated to a particular call
  - —Much of the time a data connection is idle
  - —Data rate is fixed
    - Both ends must operate at the same rate

Basic Operation

- Data transmitted in small packets
  - —Typically 1000 octets
  - —Longer messages split into series of packets
  - —Each packet contains a portion of user data plus some control info
- Control info
  - —Routing (addressing) info
- Packets are received, stored briefly (buffered) and past on to the next node
  - —Store and forward

Use of Packets



Advantages

- Line efficiency
  - Single node to node link can be shared by many packets over time
  - Packets queued and transmitted as fast as possible
- Data rate conversion
  - Each station connects to the local node at its own speed
  - Nodes buffer data if required to equalize rates
- Packets are accepted even when network is busy
  - Delivery may slow down
- Priorities can be used

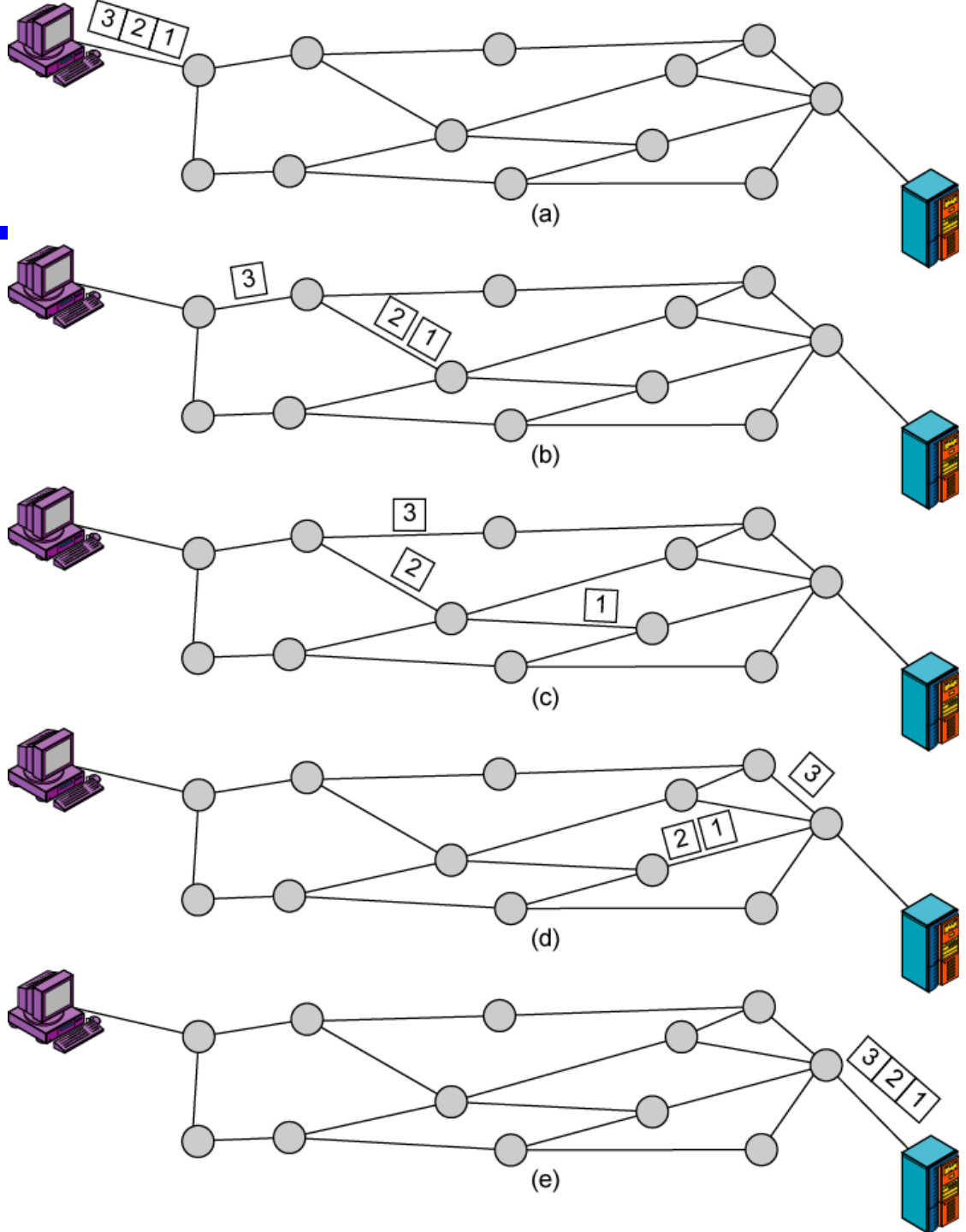
Switching Technique

- Station breaks long message into packets
- Packets sent one at a time to the network
- Packets handled in two ways
  - —Datagram
  - —Virtual circuit

Datagram

- Each packet treated independently
- Packets can take any practical route
- Packets may arrive out of order
- Packets may go missing
- Up to receiver to re-order packets and recover from missing packets

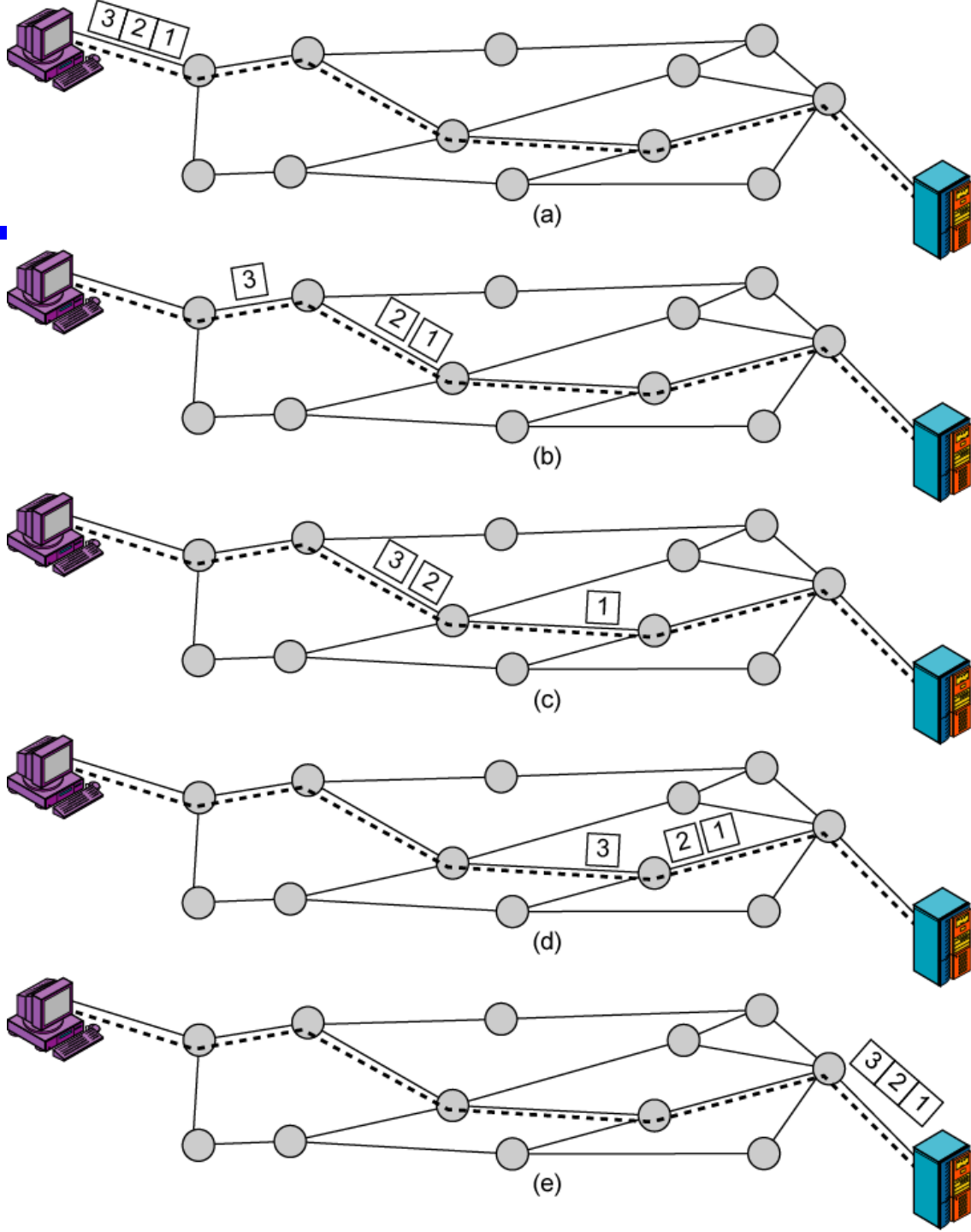
Datagram Diagram



Virtual Circuit

- Preplanned route established before any packets sent
- Call request and call accept packets establish connection (handshake)
- Each packet contains a virtual circuit identifier instead of destination address
- No routing decisions required for each packet
- Clear request to drop circuit
- Not a dedicated path

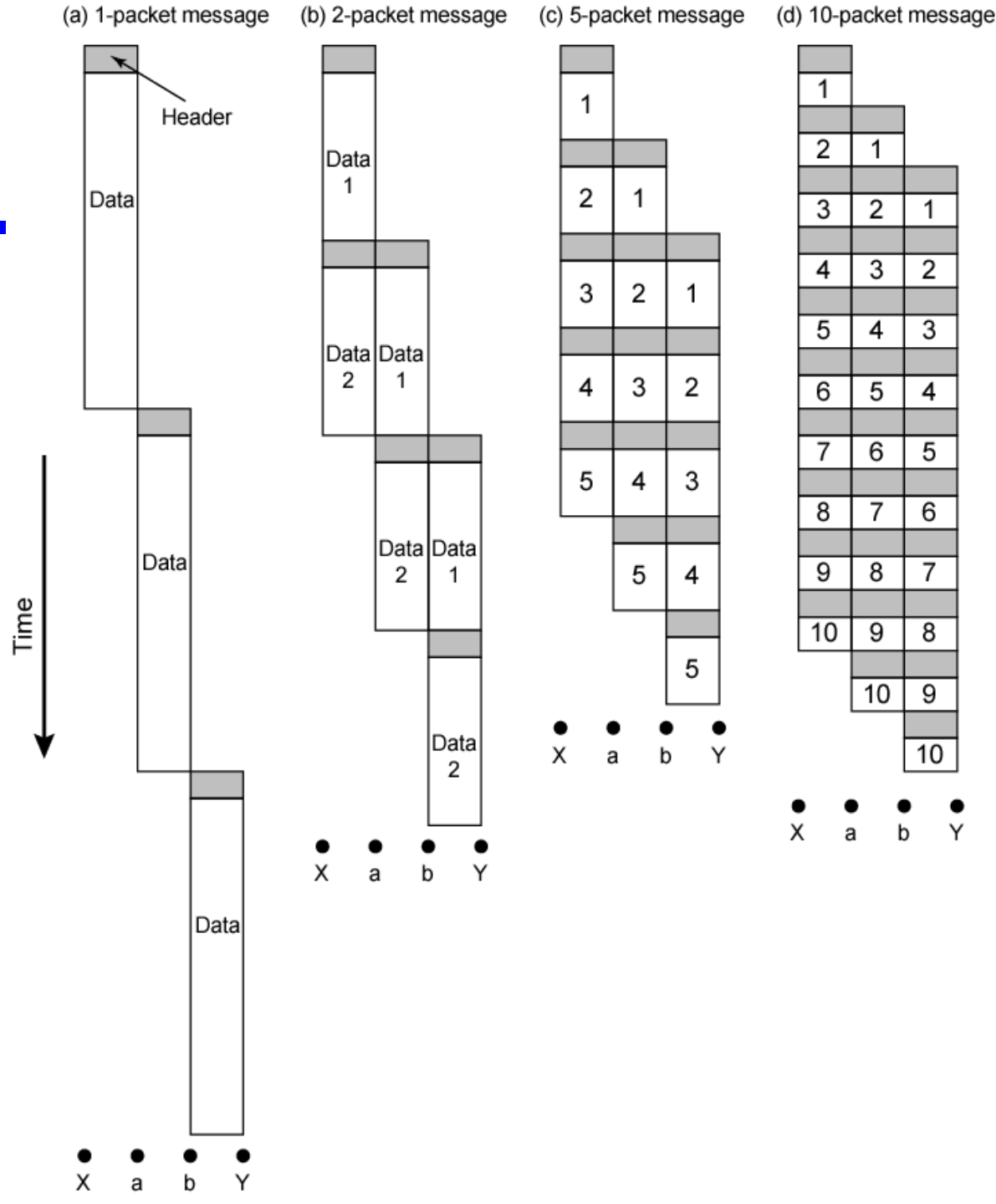
Virtual Circuit Diagram



Virtual Circuits v Datagram

- Virtual circuits
  - —Network can provide sequencing and error control
  - —Packets are forwarded more quickly
    - No routing decisions to make
  - —Less reliable
    - Loss of a node looses all circuits through that node
- Datagram
  - —No call setup phase
    - Better if few packets
  - —More flexible
    - Routing can be used to avoid congested parts of the network

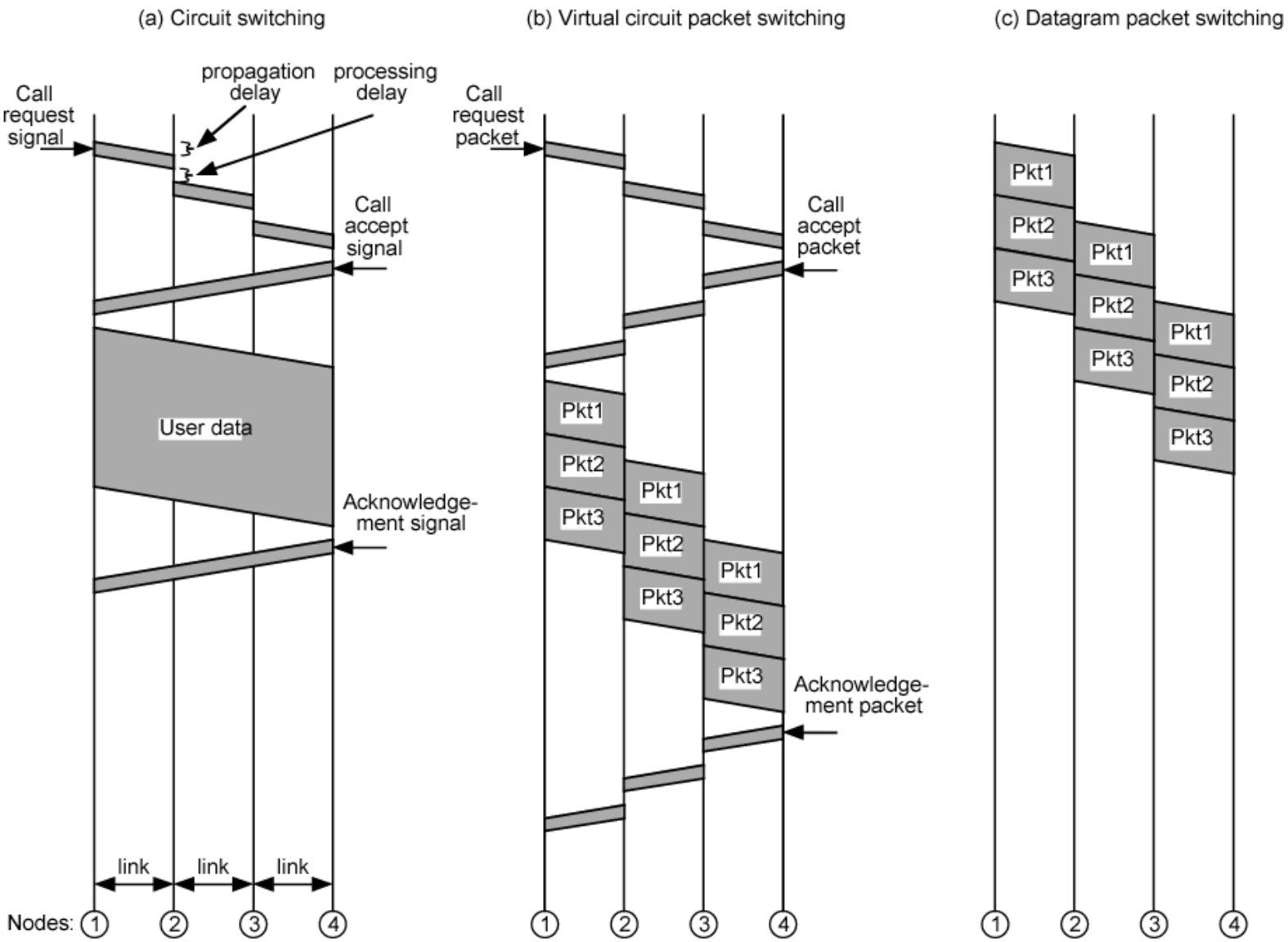
Packet Size


(a) 1-packet message
(b) 2-packet message
(c) 5-packet message
(d) 10-packet message
Header
Data
Time
X
a
b
Y

Circuit v Packet Switching

- Performance
  - —Propagation delay
  - —Transmission time
  - —Node delay

Event Timing



X.25

- 1976
- 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 attached station and link to node
- Data terminal equipment DTE (user equipment)
- Data circuit terminating equipment DCE (node)
- Uses physical layer specification X.21
- Reliable transfer across physical link
- Sequence of frames

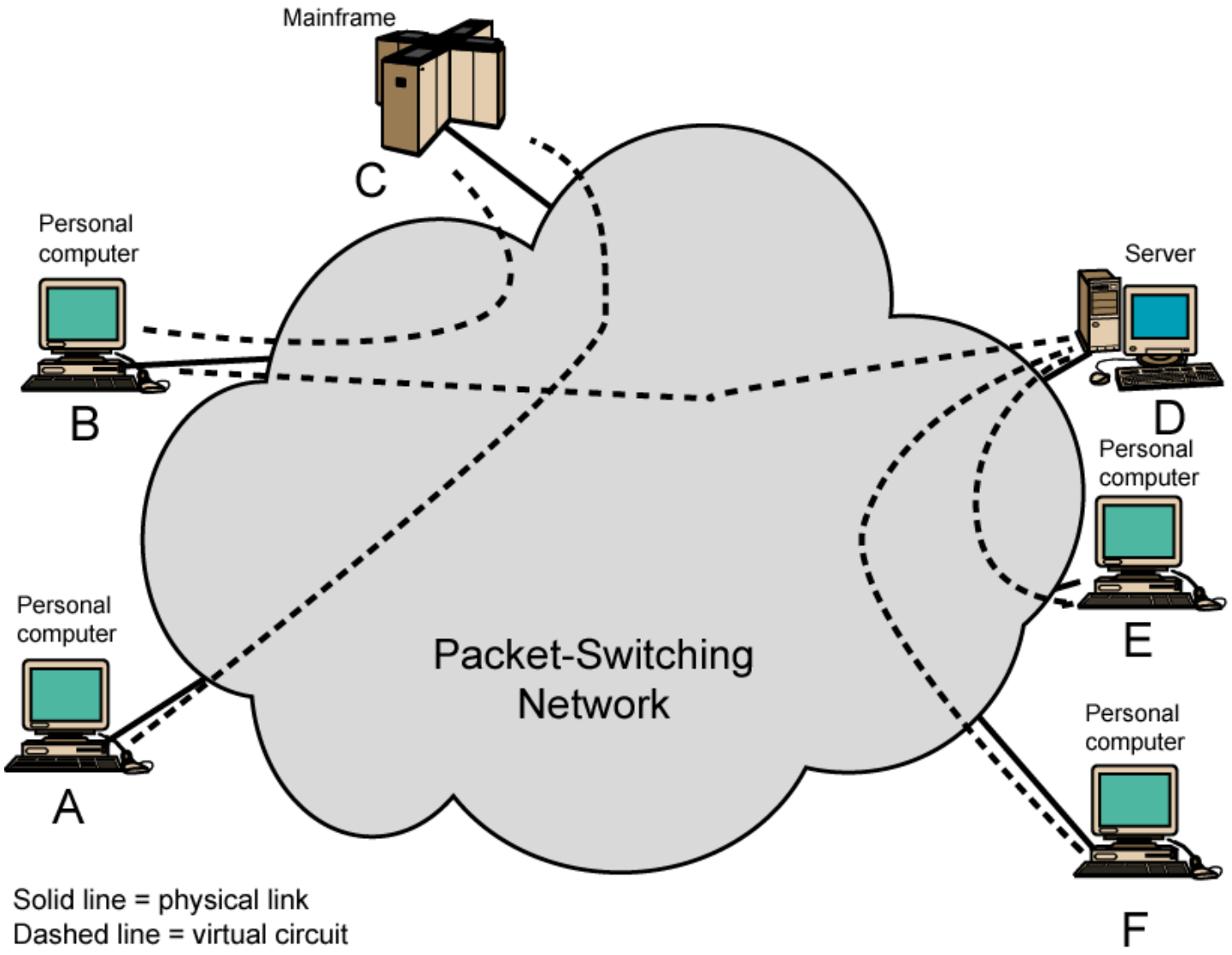
X.25 - Link

- Link Access Protocol Balanced (LAPB)
  - —Subset of HDLC
  - —see chapter 7

X.25 - Packet

- External virtual circuits
- Logical connections (virtual circuits) between subscribers

X.25 Use of Virtual Circuits



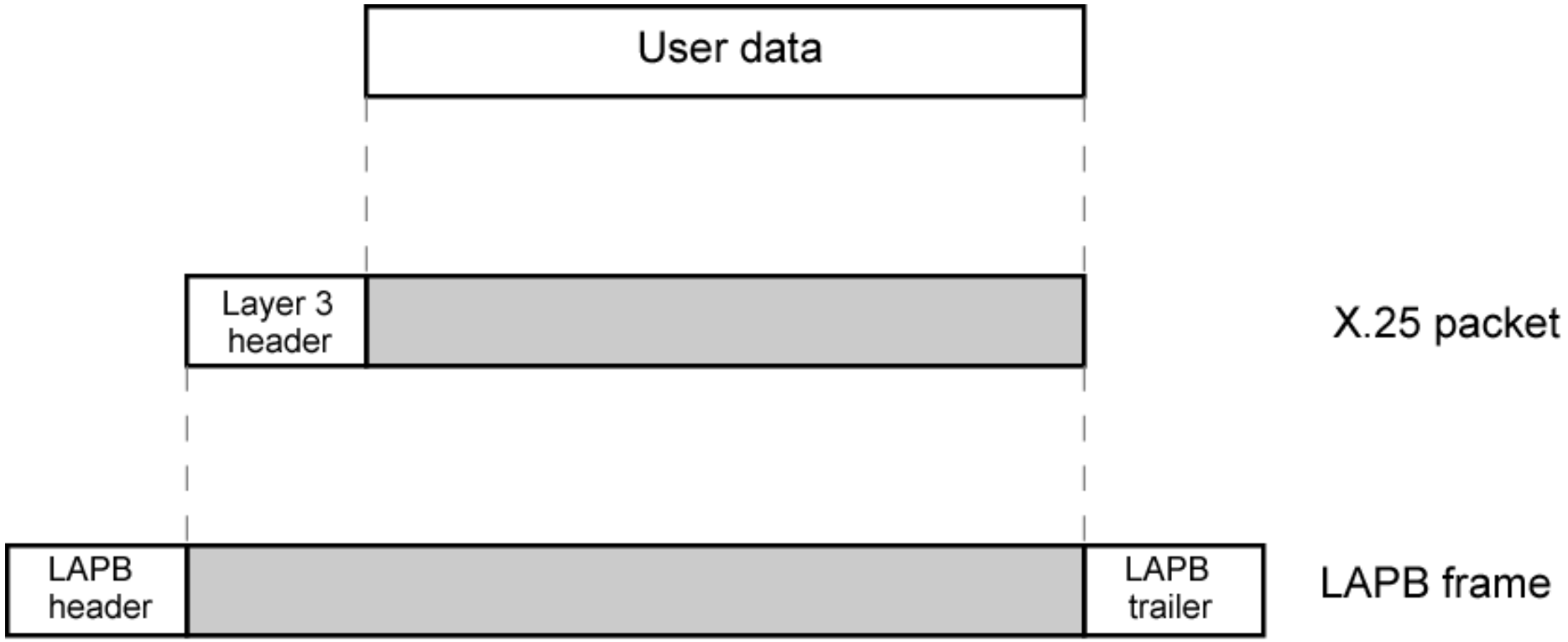
Virtual Circuit Service

- Logical connection between two stations
  - —External virtual circuit
- Specific preplanned route through network
  - —Internal virtual circuit
- Typically one to one relationship between external and internal virtual circuits
- Can employ X.25 with datagram style network
- External virtual circuits require logical channel
  - —All data considered part of stream

X.25 Levels

- User data passes to X.25 level 3
- X.25 appends control information
  - —Header
  - —Identifies virtual circuit
  - —Provides sequence numbers for flow and error control
- X.25 packet passed down to LAPB entity
- LAPB appends further control information

User Data and X.25 Protocol Control Information



Frame Relay

- Designed to be more efficient than X.25
- Developed before ATM
- Larger installed base than ATM
- ATM now of more interest on high speed networks

Frame Relay Background - X.25

- Call control packets, in band signaling
- Multiplexing of virtual circuits at layer 3
- Layer 2 and 3 include flow and error control
- Considerable overhead
- Not appropriate for modern digital systems with high reliability

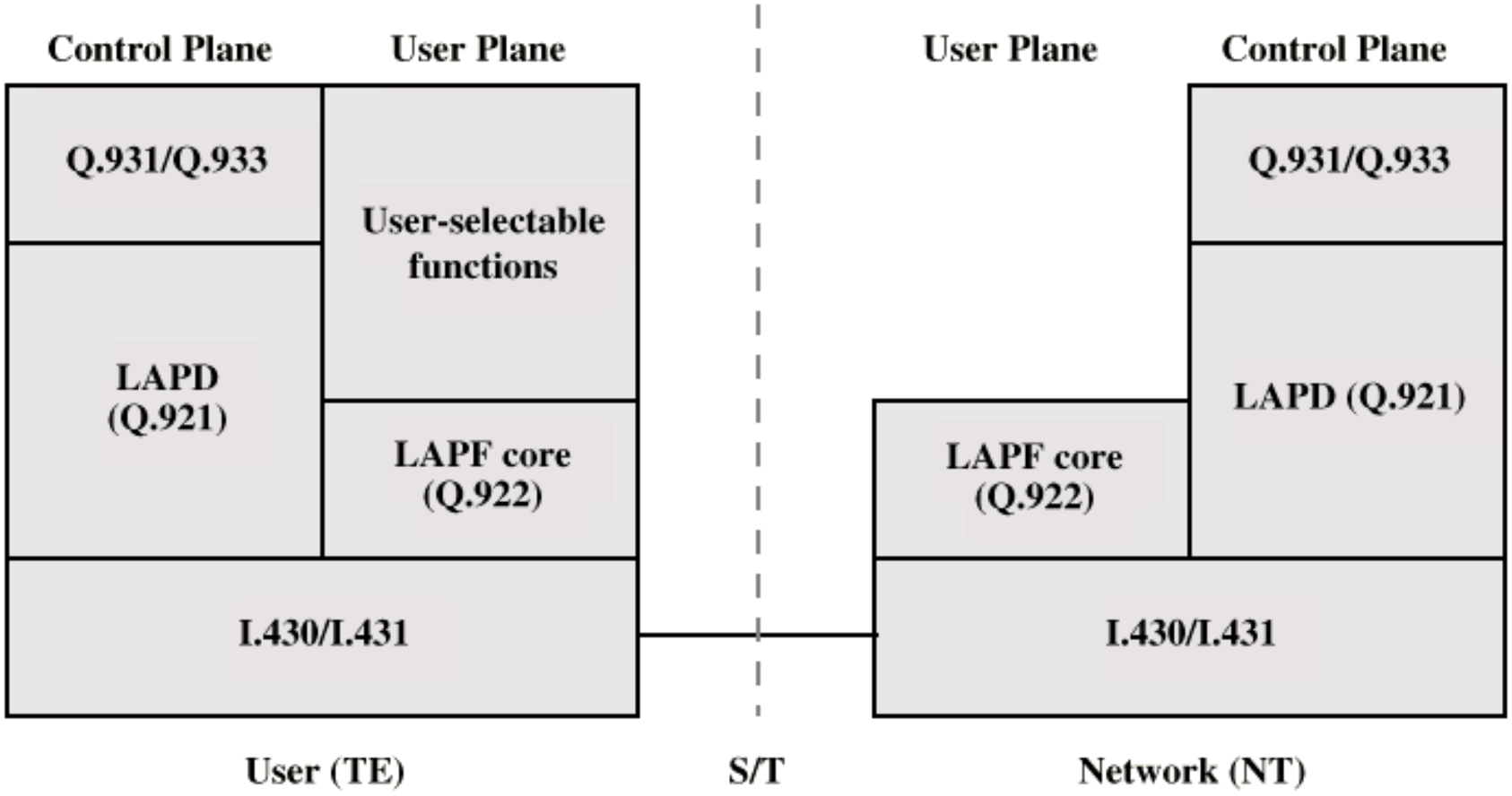
Frame Relay - Differences

- Call control carried in separate logical connection
- Multiplexing and switching at layer 2
  - —Eliminates one layer of processing
- No hop by hop error or flow control
- End to end flow and error control (if used) are done by higher layer
- Single user data frame sent from source to destination and ACK (from higher layer) sent back

Advantages and Disadvantages

- Lost link by link error and flow control
  - —Increased reliability makes this less of a problem
- Streamlined communications process
  - —Lower delay
  - —Higher throughput
- ITU-T recommend frame relay above 2Mbps

Protocol Architecture



Control Plane

- Between subscriber and network
- Separate logical channel used
  - —Similar to common channel signaling for circuit switching services
- Data link layer
  - —LAPD (Q.921)
  - —Reliable data link control
  - —Error and flow control
  - —Between user (TE) and network (NT)
  - —Used for exchange of Q.933 control signal messages

User Plane

- End to end functionality
- Transfer of info between ends
- LAPF (Link Access Procedure for Frame Mode Bearer Services) Q.922
  - —Frame delimiting, alignment and transparency
  - —Frame mux and demux using addressing field
  - —Ensure frame is integral number of octets (zero bit insertion/extraction)
  - —Ensure frame is neither too long nor short
  - —Detection of transmission errors
  - —Congestion control functions

User Data Transfer

- One frame type
  - —User data
  - —No control frame
- No inband signaling
- No sequence numbers
  - —No flow nor error control

Required Reading

- Stallings Chapter 10
- ITU-T web site
- Telephone company web sites (not much technical info - mostly marketing)
- X.25 info from ITU-T web site
- Frame Relay forum