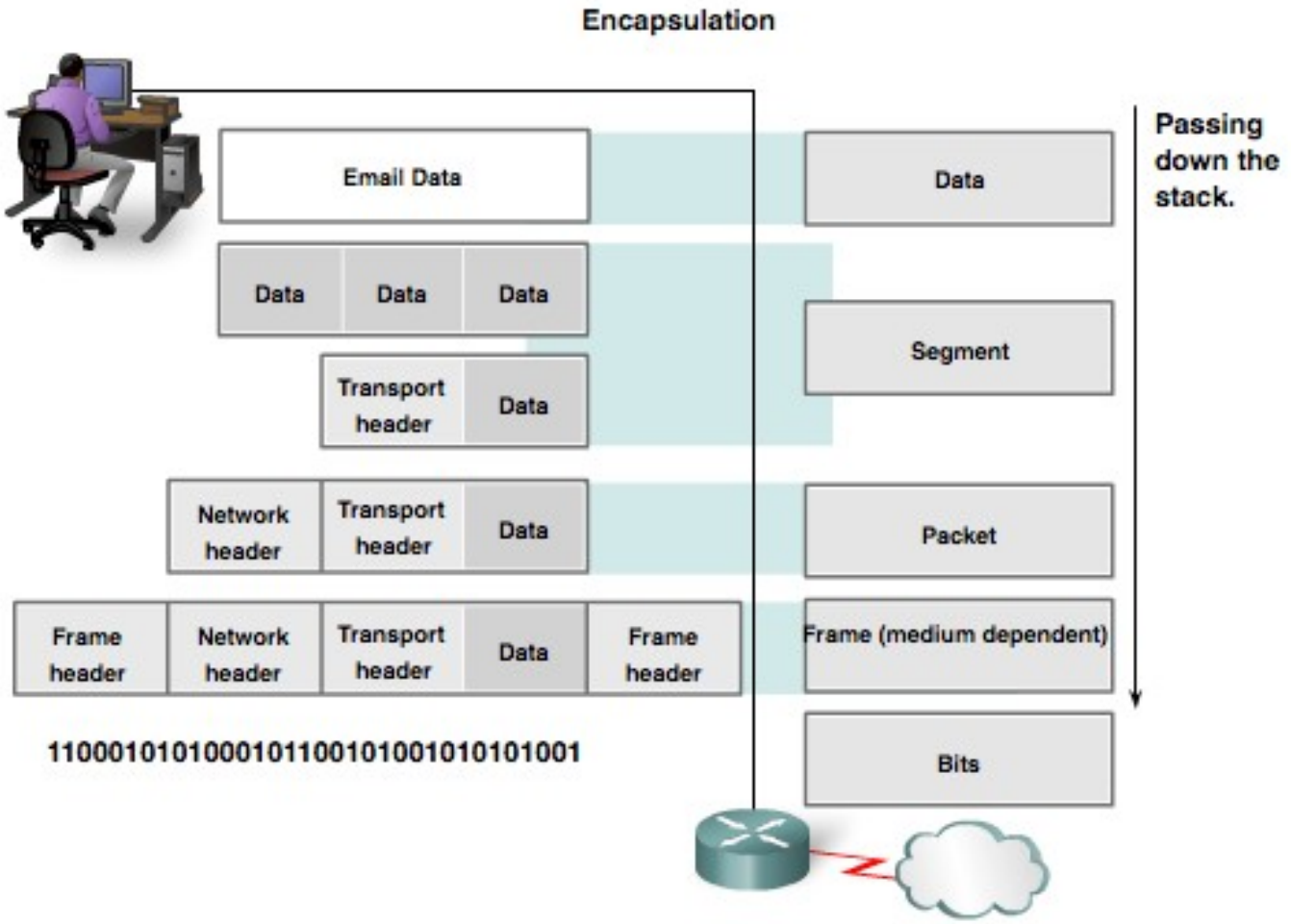
Chapter 5

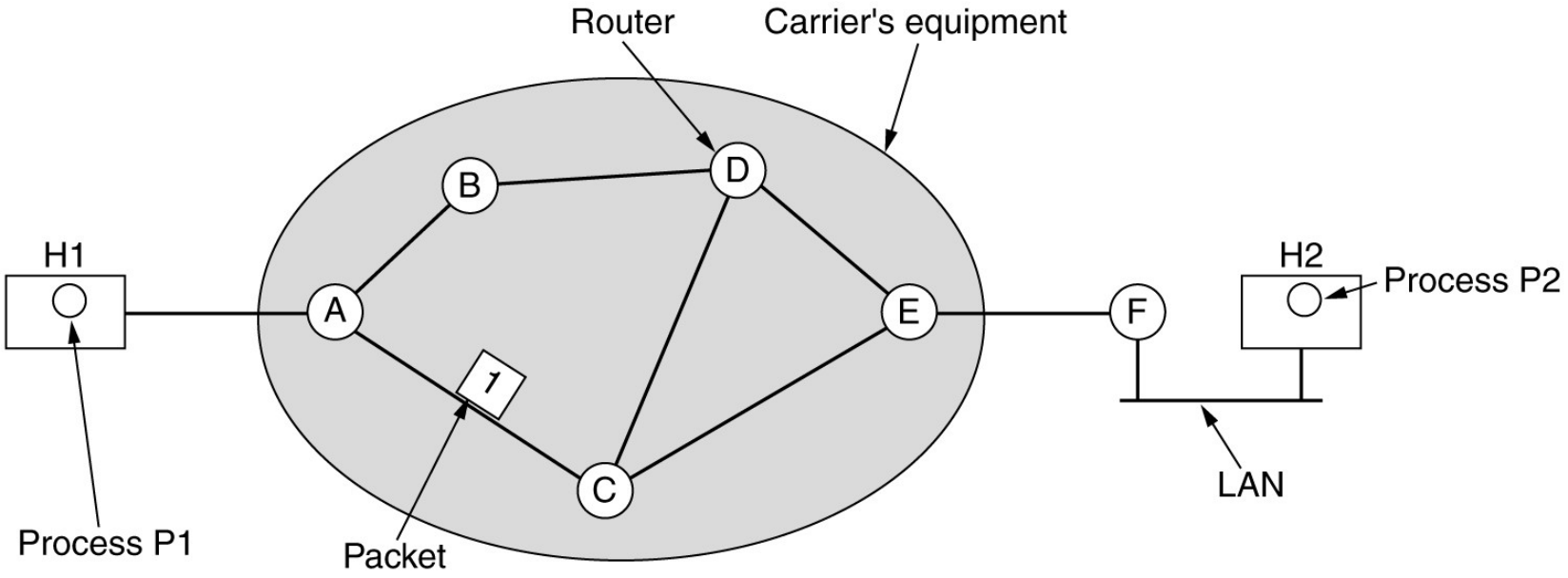
The Network Layer

Protocol Data Units (PDUs)

a) Data
b) Segment
c) Packet
d) Frame
e) Bits



Store-and-Forward Packet Switching



The environment of the network layer protocols.

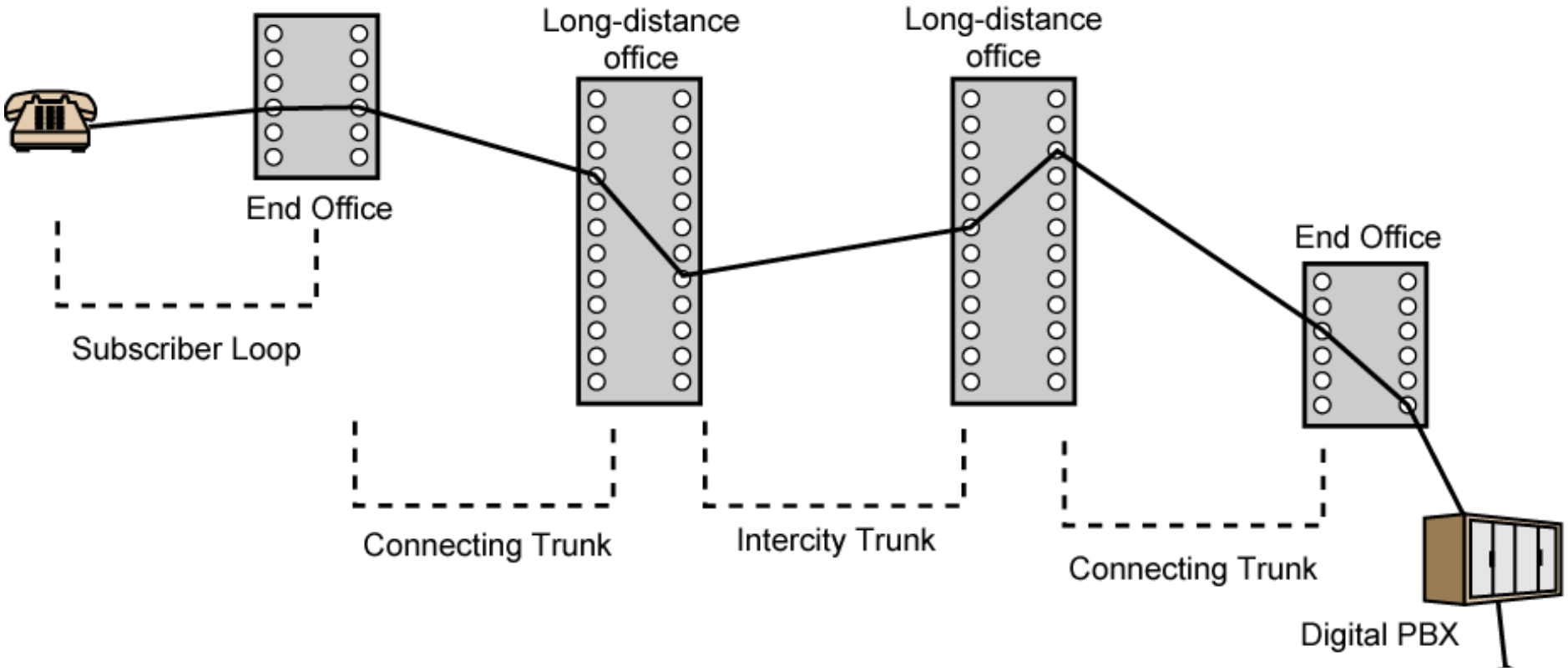
Circuit Switching

- 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)

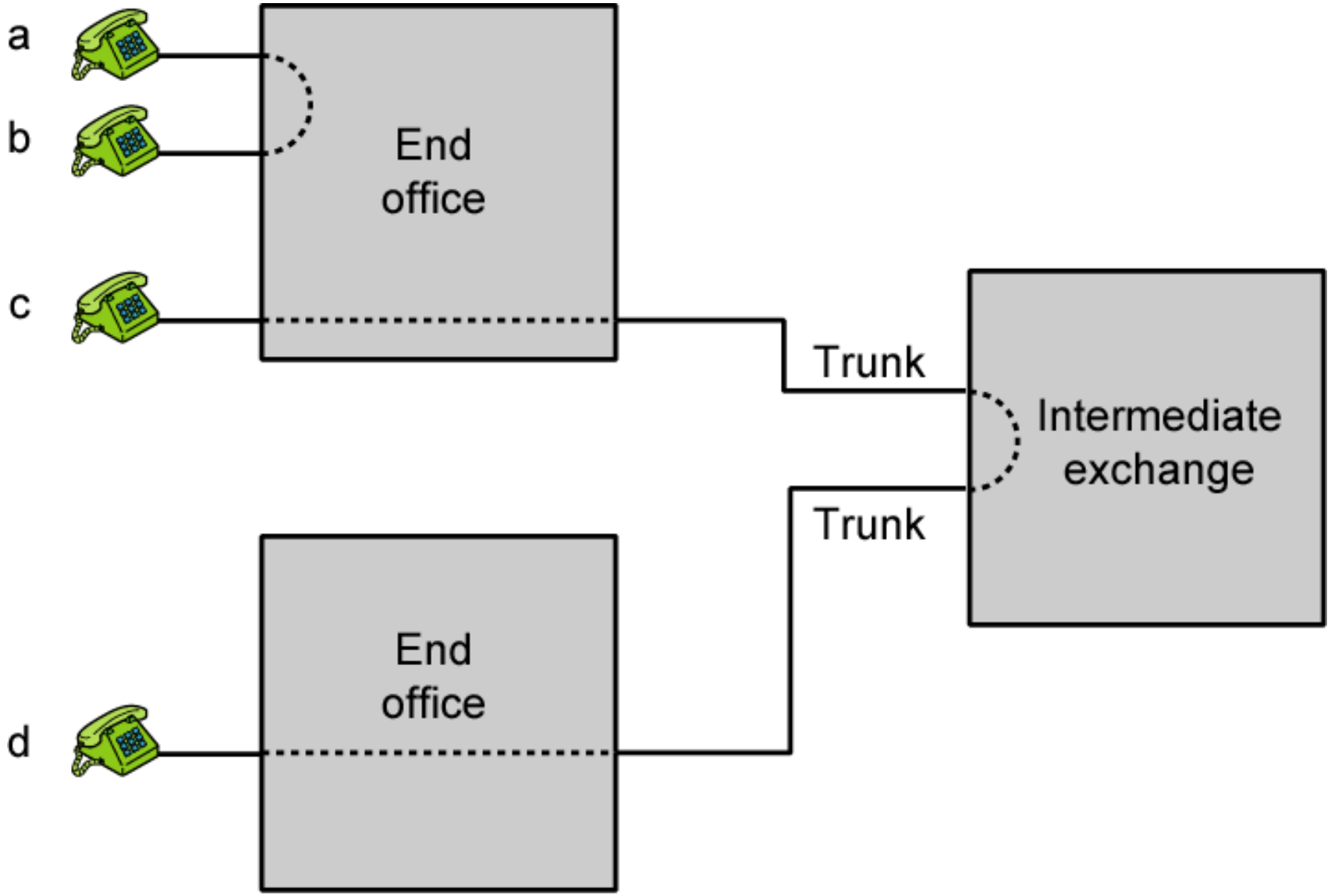
Public Circuit Switched Network



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

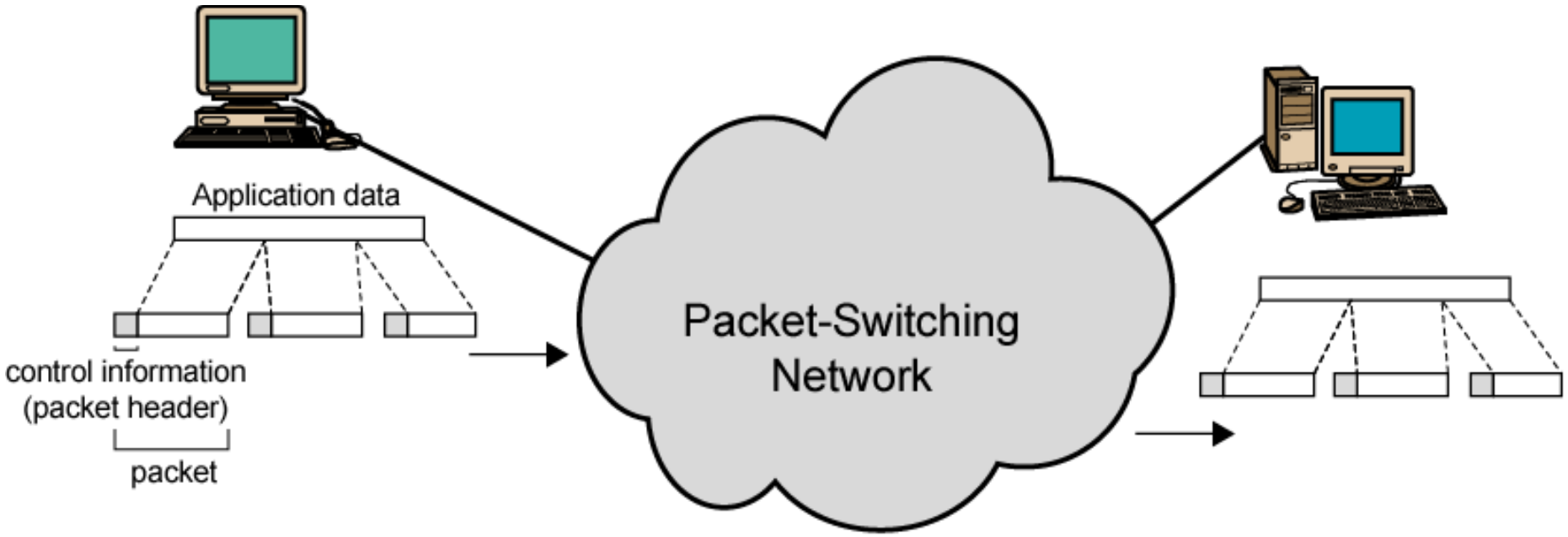
Circuit Establishment



Packet Switching: 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

a) Station breaks long message into packets

b) Packets sent one at a time to the network

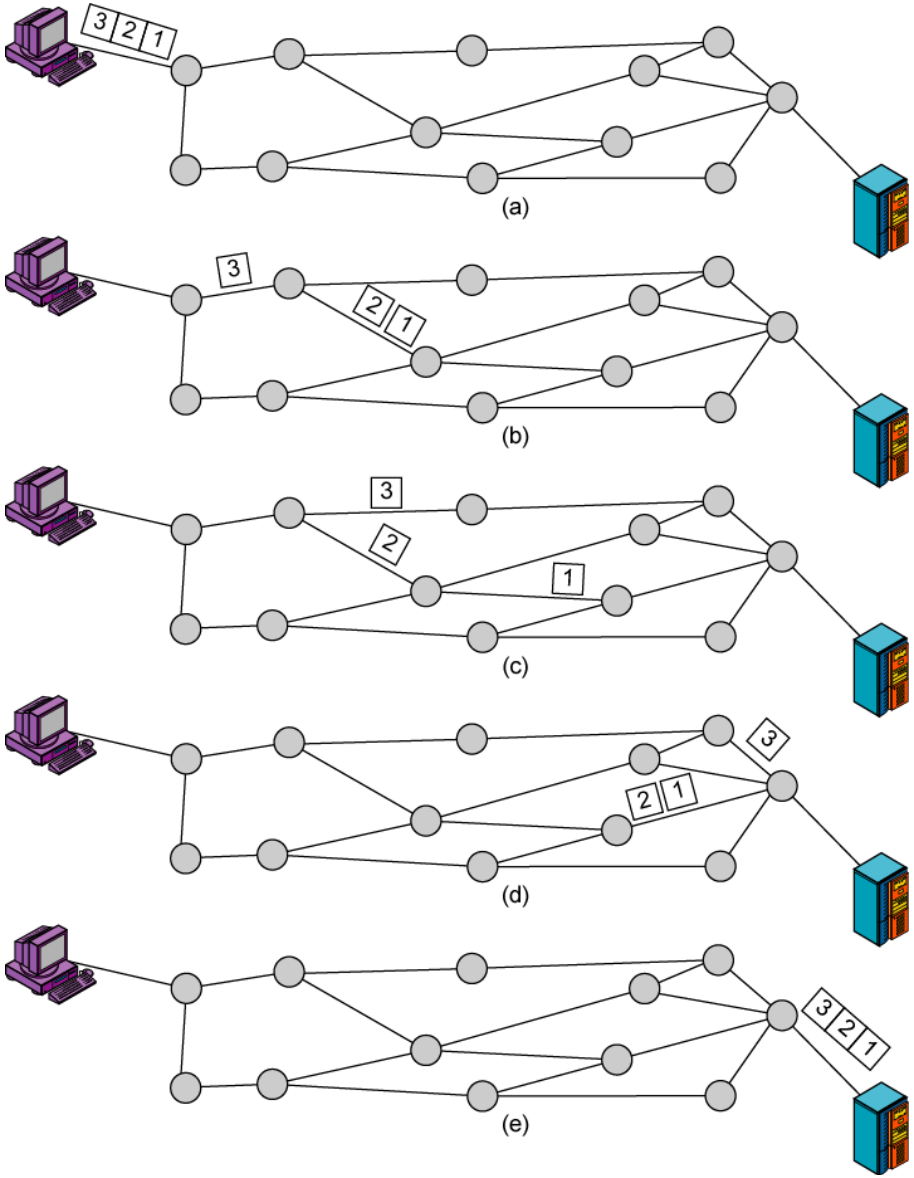
c) Packets handled in two ways

- **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

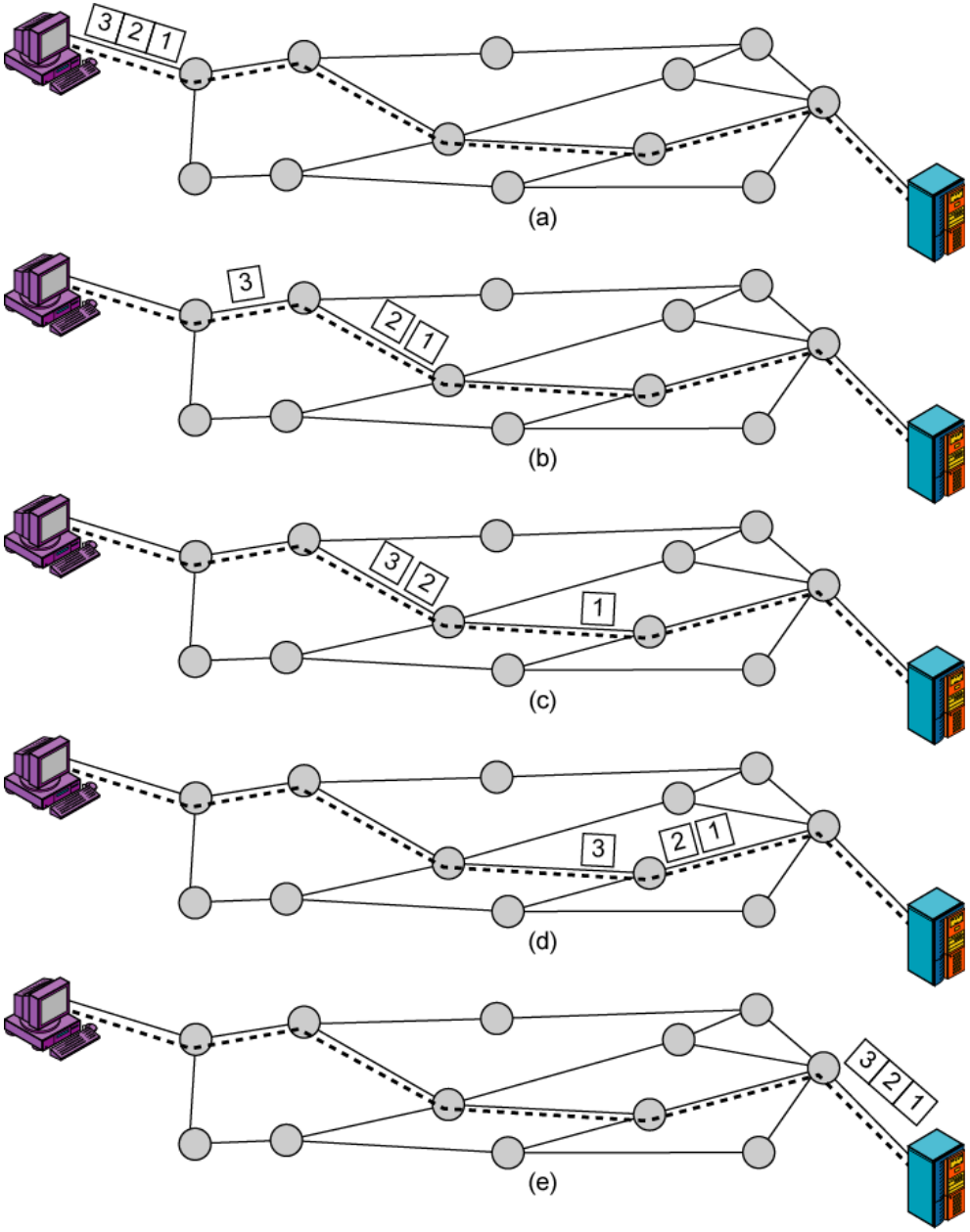
Datagram Example



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: **sharing possible**

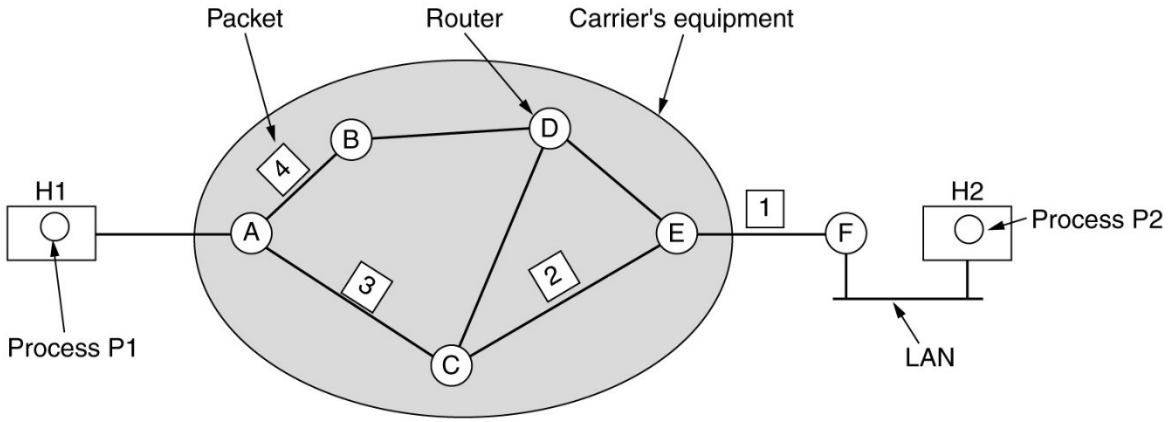
Virtual Circuit



Virtual Circuits vs. 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

Routing in **Datagram** Subnet



A's table

initially		later	
A	–	A	–
B	B	B	B
C	C	C	C
D	B	D	B
E	C	E	B
F	C	F	B

Dest. Line

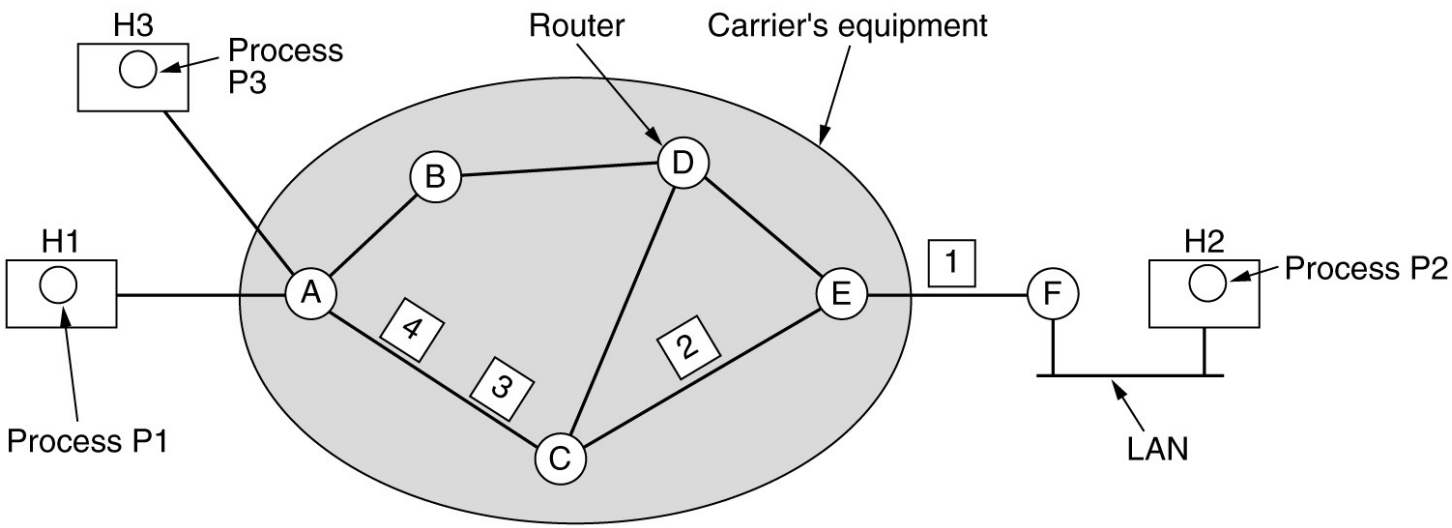
C's table

A	A
B	A
C	–
D	D
E	E
F	E

E's table

A	C
B	D
C	C
D	D
E	–
F	F

Routing in Virtual Circuit



A's table

In		Out	
H1	1	C	1
H3	1	C	2

C's table

A	1	E	1
A	2	E	2

E's table

C	1	F	1
C	2	F	2

Comparison of Virtual-Circuit and Datagram Subnets

Issue	Datagram subnet	Virtual-circuit subnet
Circuit setup	Not needed	Required
Addressing	Each packet contains the full source and destination address	Each packet contains a short VC number
State information	Routers do not hold state information about connections	Each VC requires router table space per connection
Routing	Each packet is routed independently	Route chosen when VC is set up; all packets follow it
Effect of router failures	None, except for packets lost during the crash	All VCs that passed through the failed router are terminated
Quality of service	Difficult	Easy if enough resources can be allocated in advance for each VC
Congestion control	Difficult	Easy if enough resources can be allocated in advance for each VC

Main Tasks of Network Layer

The network layer, or OSI Layer 3, provides services to allow end devices to exchange data across the network. To accomplish this end-to-end transport, the network layer uses four basic processes:

- Addressing end devices --- Already covered
- Encapsulation
- Routing => Will be covered next
- De-encapsulating

Routing Algorithms

- The Optimality Principle
- Shortest Path Routing
- Flooding
- Distance Vector Routing
- Link State Routing
- Hierarchical Routing
- Broadcast Routing
- Multicast Routing
- Routing for Mobile Hosts
- Routing in Ad Hoc Networks