Introduction to Telecommunication Systems
Lecture 10

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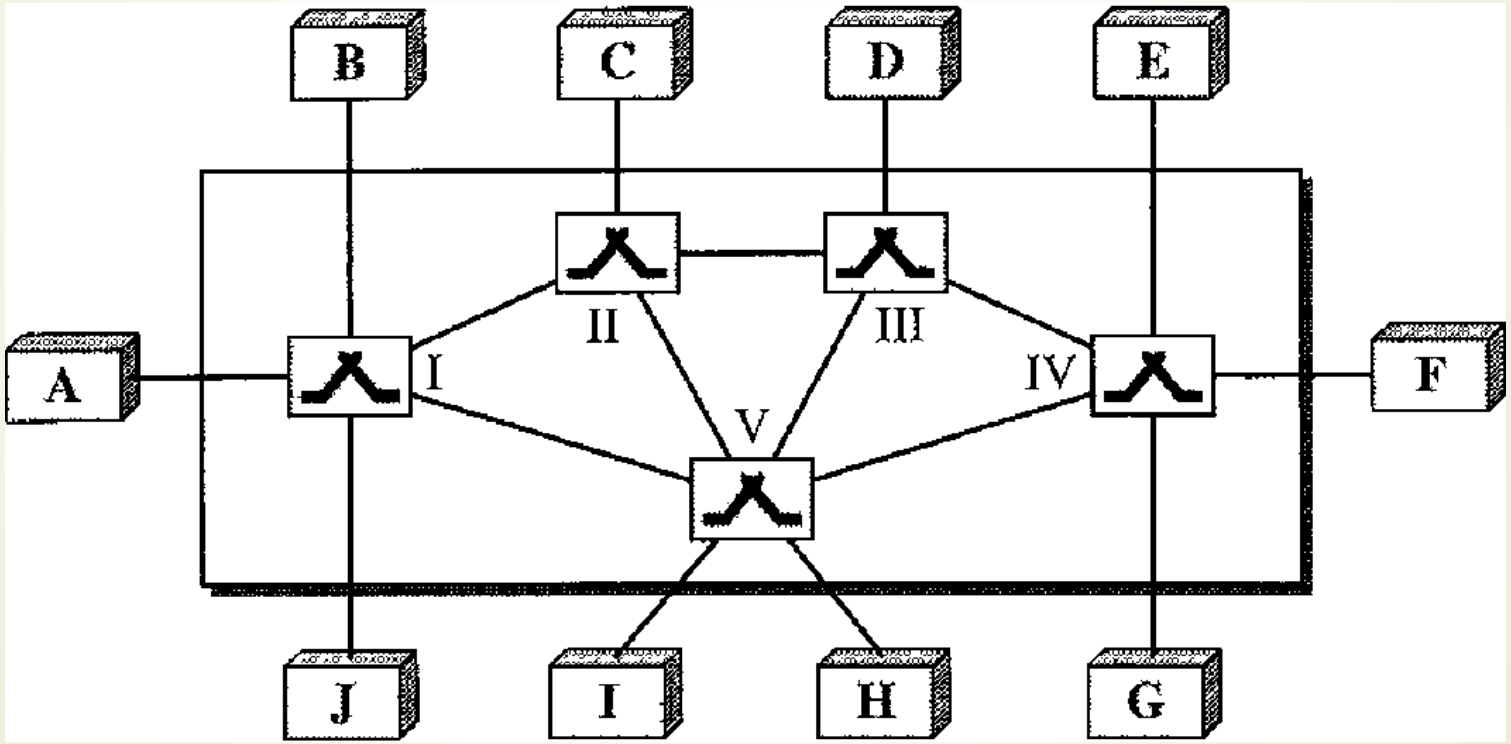
Switching

- A switched network consists of a series of interlinked nodes, called switches.
- Switches are devices capable of creating temporary connections between two or more devices linked to the switch.
- In a switched network, some of these nodes are connected to the end systems (computers or telephones, for example).
- Others are used only for routing.

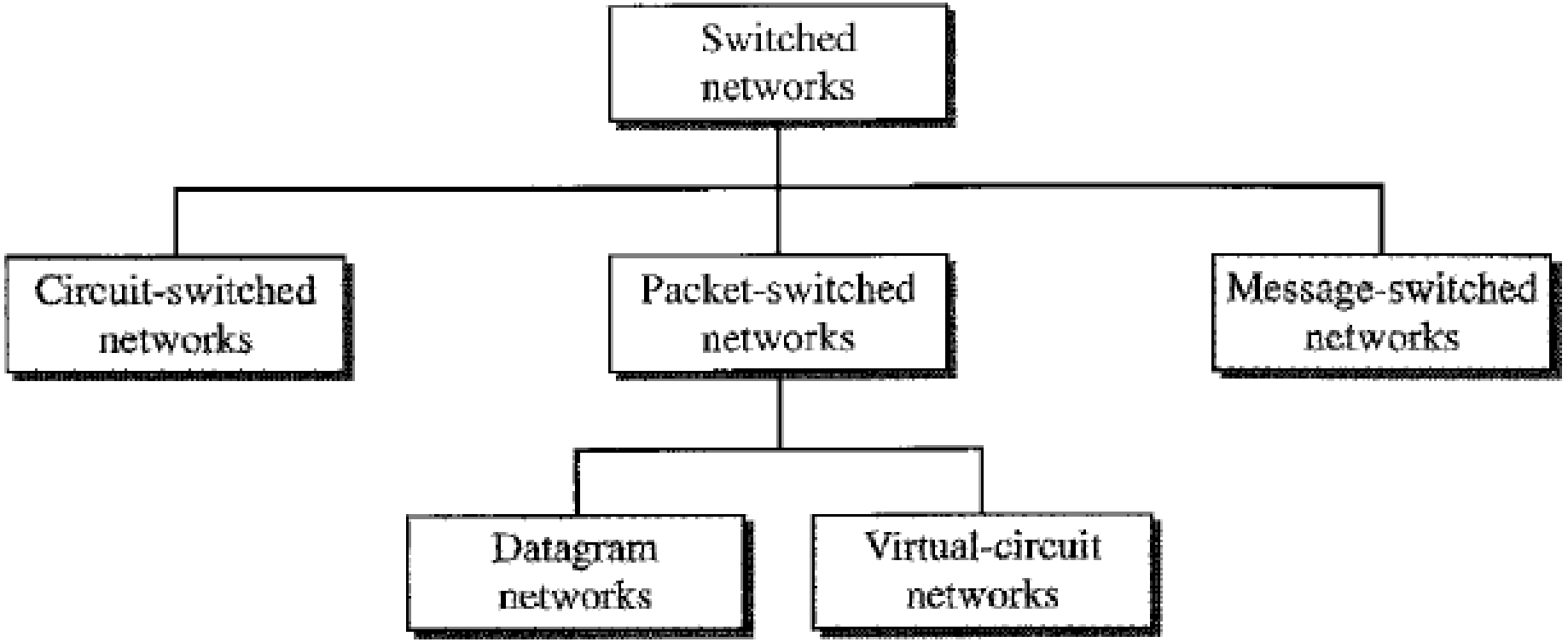
Switching



Switching

- The end systems (communicating devices) are labeled A, B, C, D, and so on, and the switches are labeled I, II, III, IV, and V.
- Each switch is connected to multiple links.
- Traditionally, three methods of switching have been important:
  - Circuit switching,
  - Packet switching,
  - and Message switching.
- The first two are commonly used today.

Switching


Switched networks
Circuit-switched networks
Packet-switched networks
Message-switched networks
Datagram networks
Virtual-circuit networks

Circuit Switching

- A circuit-switched network consists of a set of switches connected by physical links.
- A connection between two stations is a dedicated path made of one or more links.
- In circuit switching, the resources need to be reserved during the setup phase; the resources remain dedicated for the entire duration of data transfer until the teardown phase.

Circuit Switching

- The actual communication in a circuit-switched network requires three phases:
- Setup Phase:
  - Before the two parties (or multiple parties in a conference call) can communicate, a dedicated circuit needs to be established.
  - The end systems are normally connected through dedicated lines to the switches, so connection setup means creating dedicated channels between the switches.

Circuit Switching

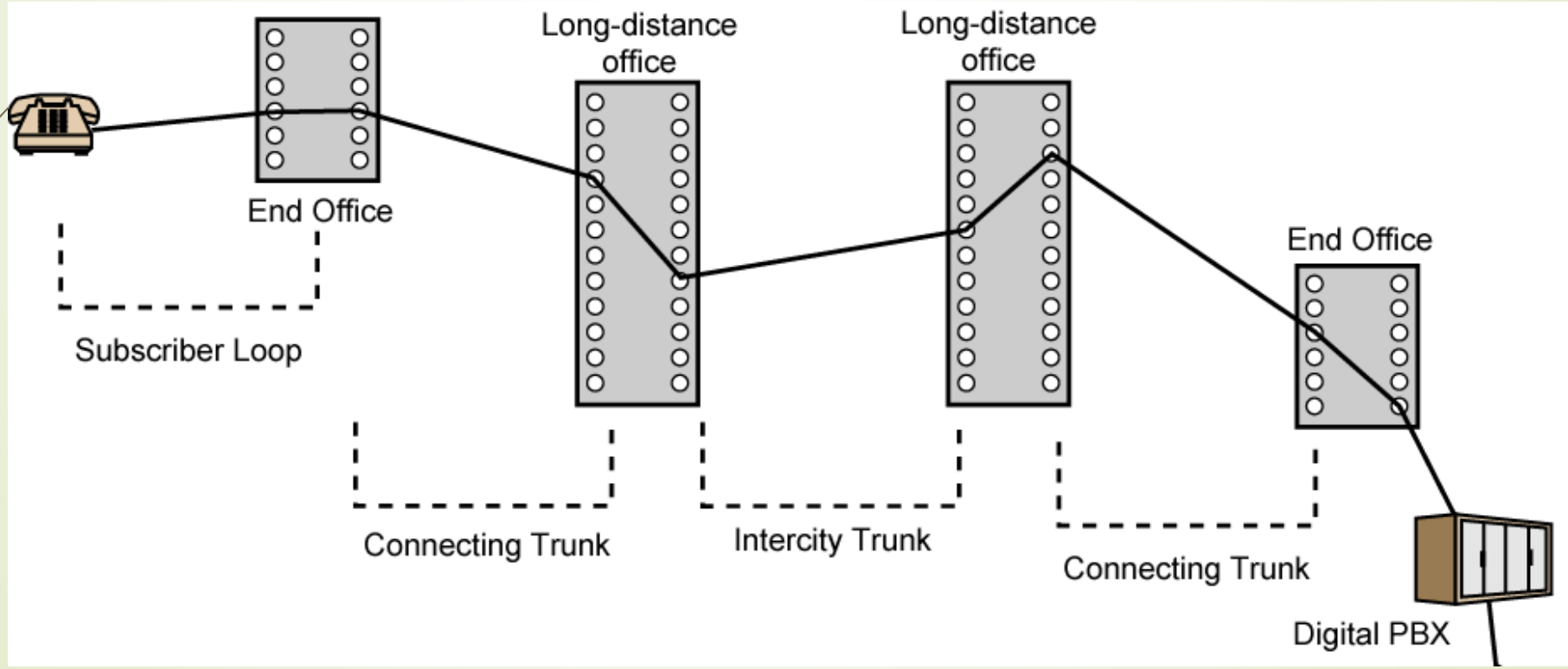
- Data Transfer Phase:
  - After the establishment of the dedicated circuit (channels), the two parties can transfer data.
- Teardown Phase:
  - When one of the parties needs to disconnect, a signal is sent to each switch to release the resources.

Circuit Switching

- Efficiency:
- It can be argued that circuit-switched networks are not as efficient as the other two types of networks because resources are allocated during the entire duration of the connection.
- Minimum Delay:
- Although a circuit-switched network normally has low efficiency, the delay in this type of network is minimal.
- During data transfer the data are not delayed at each switch as the resources are allocated for the duration of the connection.

Public Switched Telephone Network(PSTN)

- Switching at the physical layer in the traditional telephone network uses the circuit-switching approach.



Public Telecommunications Network

- Components of a public telecommunication network:
- **Subscribers:**
  - The devices that attach to the network.
  - It is still the case that most subscriber devices to public telecommunications networks are telephones, but the percentage of data traffic increases year by year.
- **Subscriber line:**
  - The link between the subscriber and the network, also referred to as the *subscriber loop* or *local loop*.
  - Almost all local loop connections use twisted-pair wire.
  - The length of a local loop is typically in a range from a few kilometers to a few tens of kilometers.

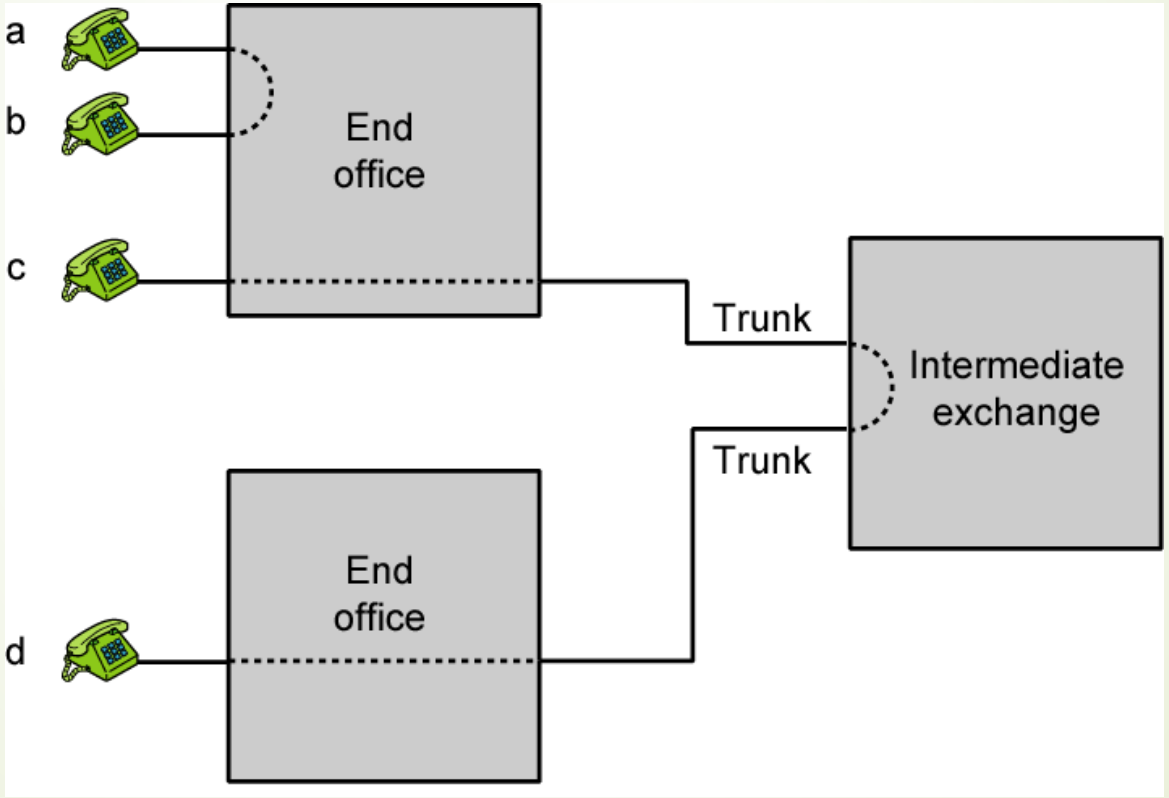
Public Telecommunications Network

- **Exchanges:**
  - The switching centers in the network.
  - A switching center that directly supports subscribers is known as an end office.
  - Typically, an end office will support many thousands of subscribers in a localized area.
- **Trunks:**
  - The branches between exchanges.
  - Trunks carry multiple voice frequency circuits using either FDM or synchronous TDM.

Public Telecommunications Network

- Subscribers connect directly to an end office, which switches traffic between subscribers and between a subscriber and other exchanges.
- The other exchanges are responsible for routing and switching traffic between end offices.
- This distinction is shown in Figure.

Public Telecommunications Network



Circuit Establishment

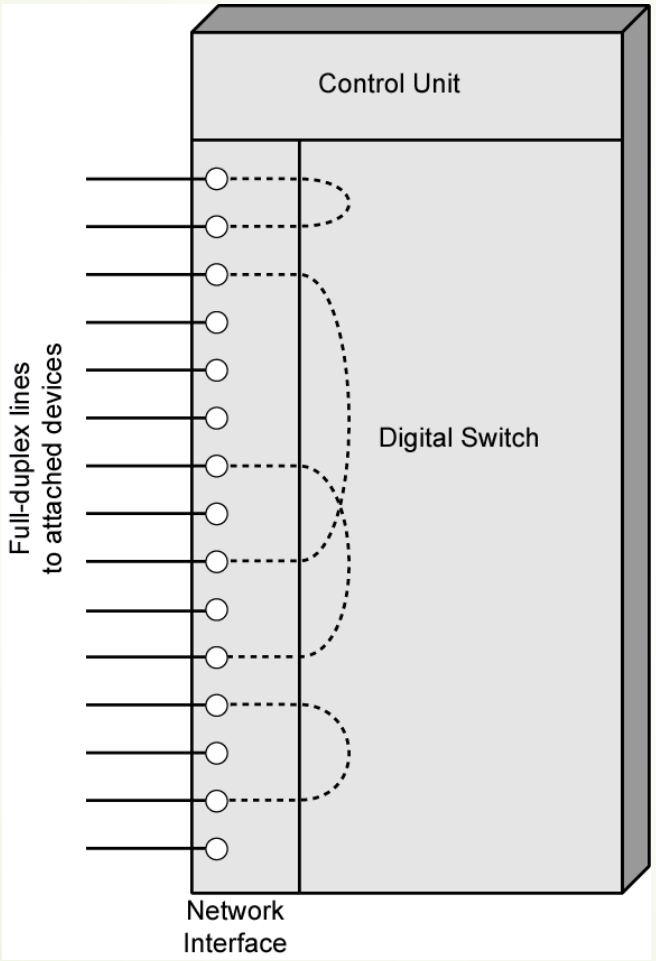
Circuit Switching Elements

- The technology of circuit switching is best approached by examining the operation of a single circuit-switching node.
- **Digital switch:**
- The heart of a modern system is a digital switch.
- The function of the digital switch is to provide a transparent signal path between any pair of attached devices.
- The path is transparent in that it appears to the attached pair of devices that there is a direct connection between them.

Circuit Switching Elements

- **Network Interface:**
  - The network interface element represents the functions and hardware needed to connect digital devices, such as data processing devices and digital telephones, to the network.
- **Control unit:**
  - The control unit performs three general tasks:
  - First, it establishes connections.
  - This is generally done on demand, that is, at the request of an attached device
  - Second, the control unit must maintain the connection.
  - Third, the control unit must tear down the connection, either in response to a request from one of the parties or for its own reasons.

Circuit Switching Elements

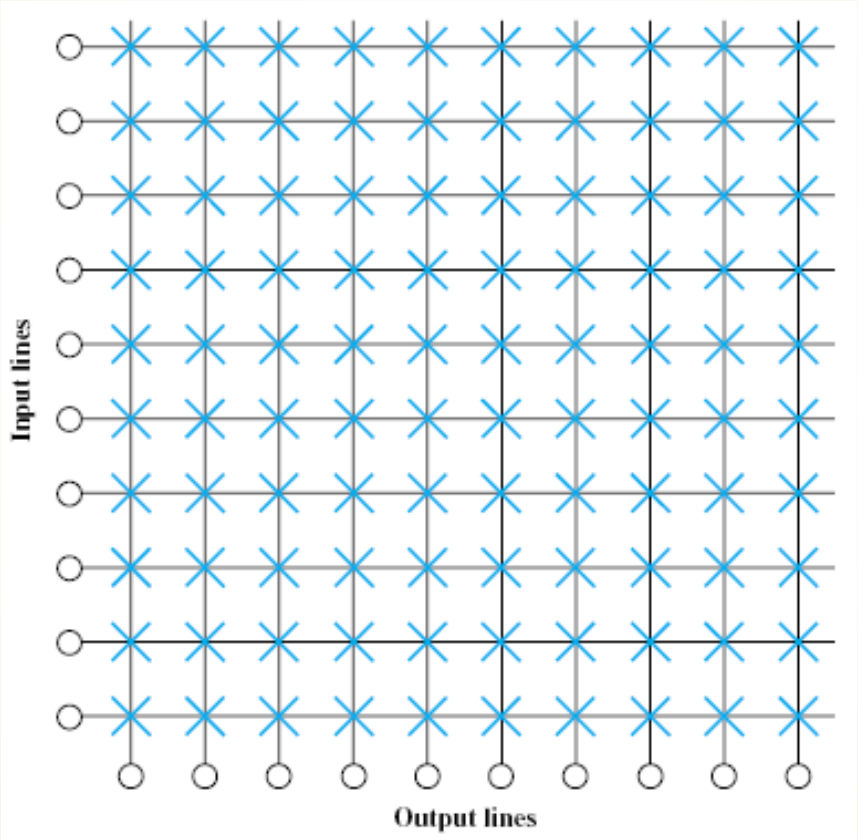


Elements of a Circuit-Switch Node

Space Division Switching

- Space division switching was originally developed for the analog environment.
- A space division switch is one in which the signal paths are physically separate from one another (divided in space).
- Each connection requires the establishment of a physical path through the switch that is dedicated solely to the transfer of signals between the two end points.
- The basic building block of the switch is a metallic cross point or semiconductor gate that can be enabled and disabled by a control unit.

Space Division Switching

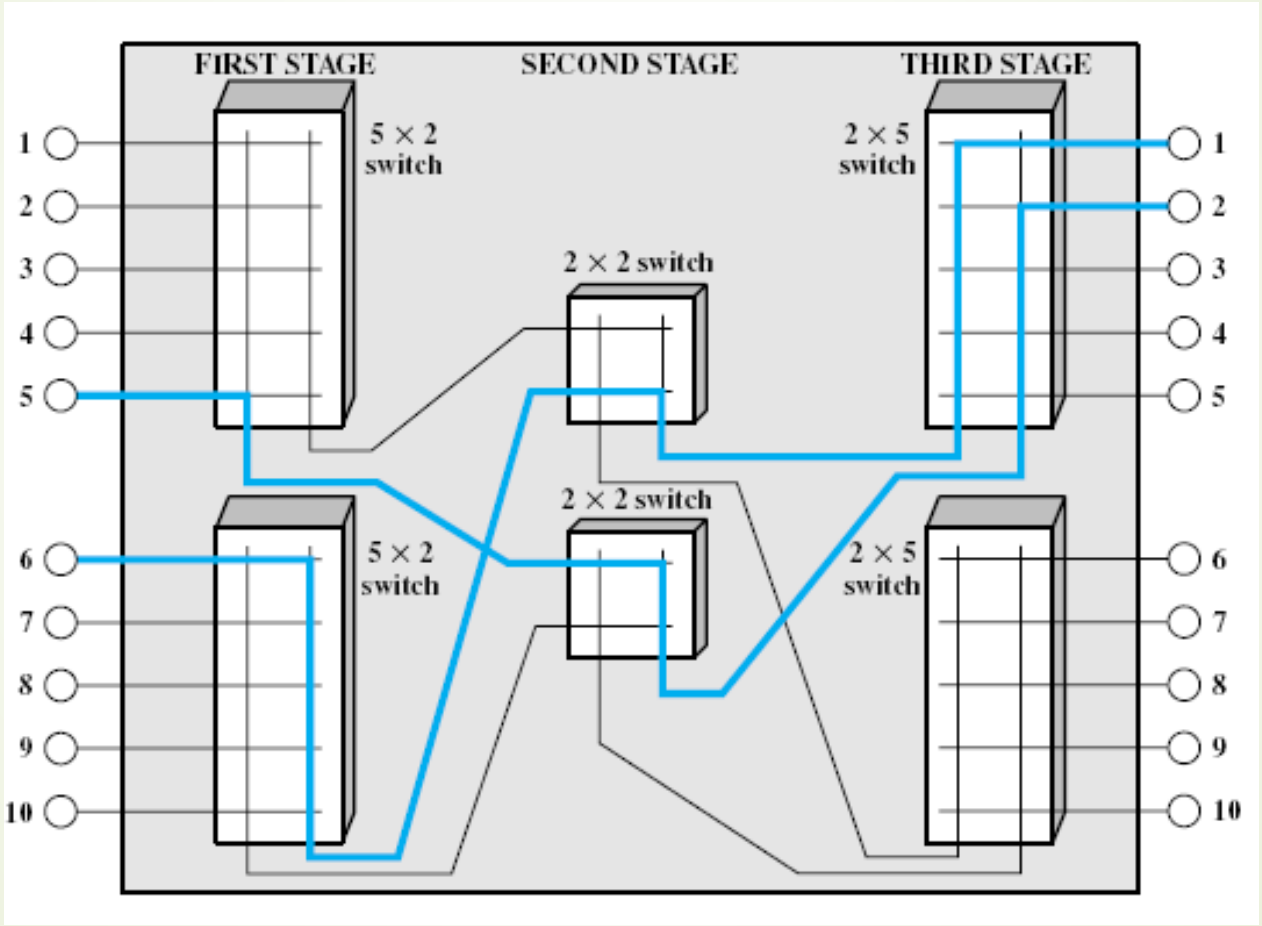


Space Division Switch

Multistage Switch

- The multistage switch has two advantages over a single-stage switch:
  - The number of cross points is reduced, increasing crossbar utilization.
  - In the figure below, the total number of cross points for 10 stations is reduced from 100 to 48.
  - There is more than one path through the network to connect two endpoints, increasing reliability.
- Of course, a multistage network requires a more complex control scheme.

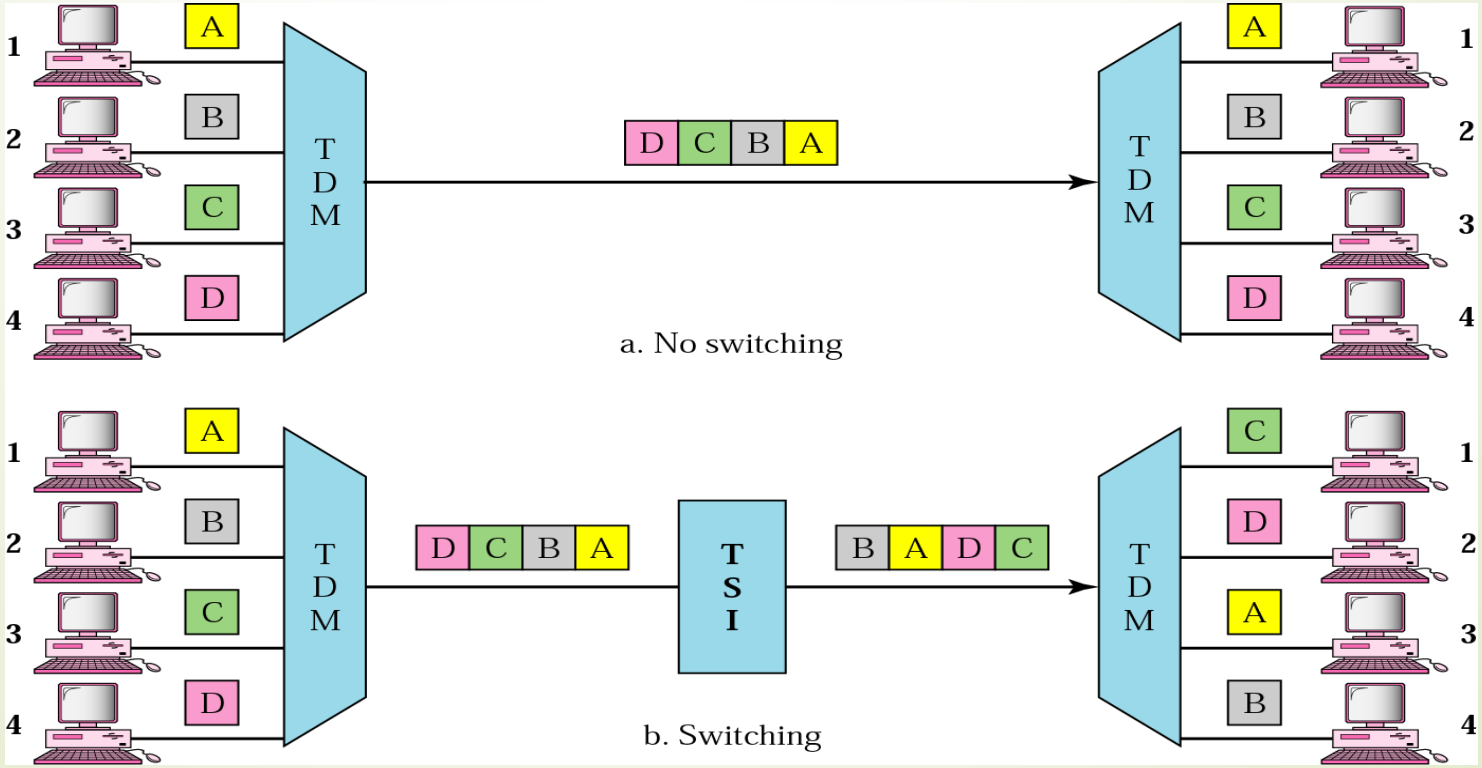
Multistage Switch



Three-Stage Space Division Switch

Time Division Switching

- Modern digital systems rely on intelligent control of space and time division elements
- No Switching
- Time-Slot Interchange (TSI)



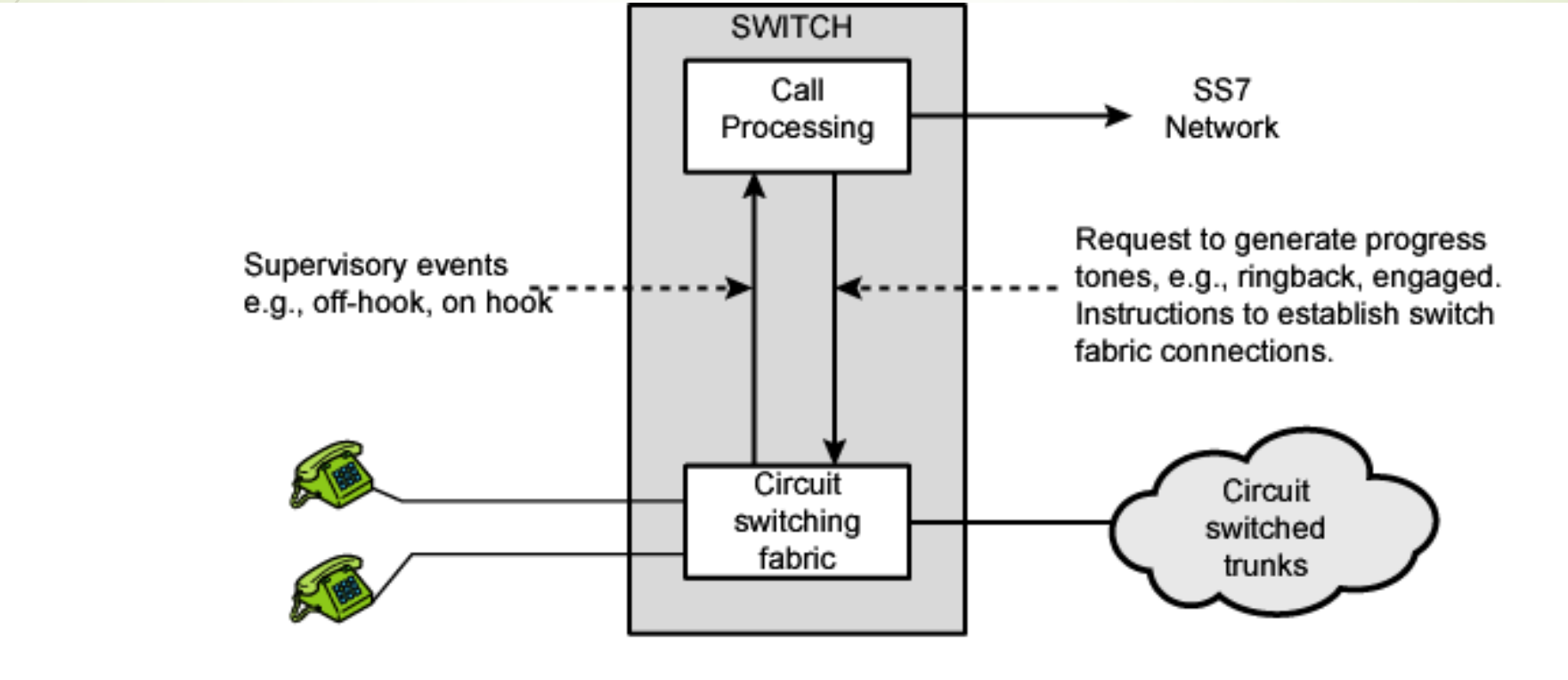
Softswitch Architecture

- The latest trend in the development of circuit-switching technology is generally referred to as the soft switch.
- General purpose computer running software to make it a smart phone switch.
- Soft switches cost significantly less than traditional circuit switches and can provide more functionality.
- A soft switch can convert a stream of digitized voice bits into packets.
- This opens up a number of options for transmission, including the increasingly popular voice over IP (Internet Protocol) approach.

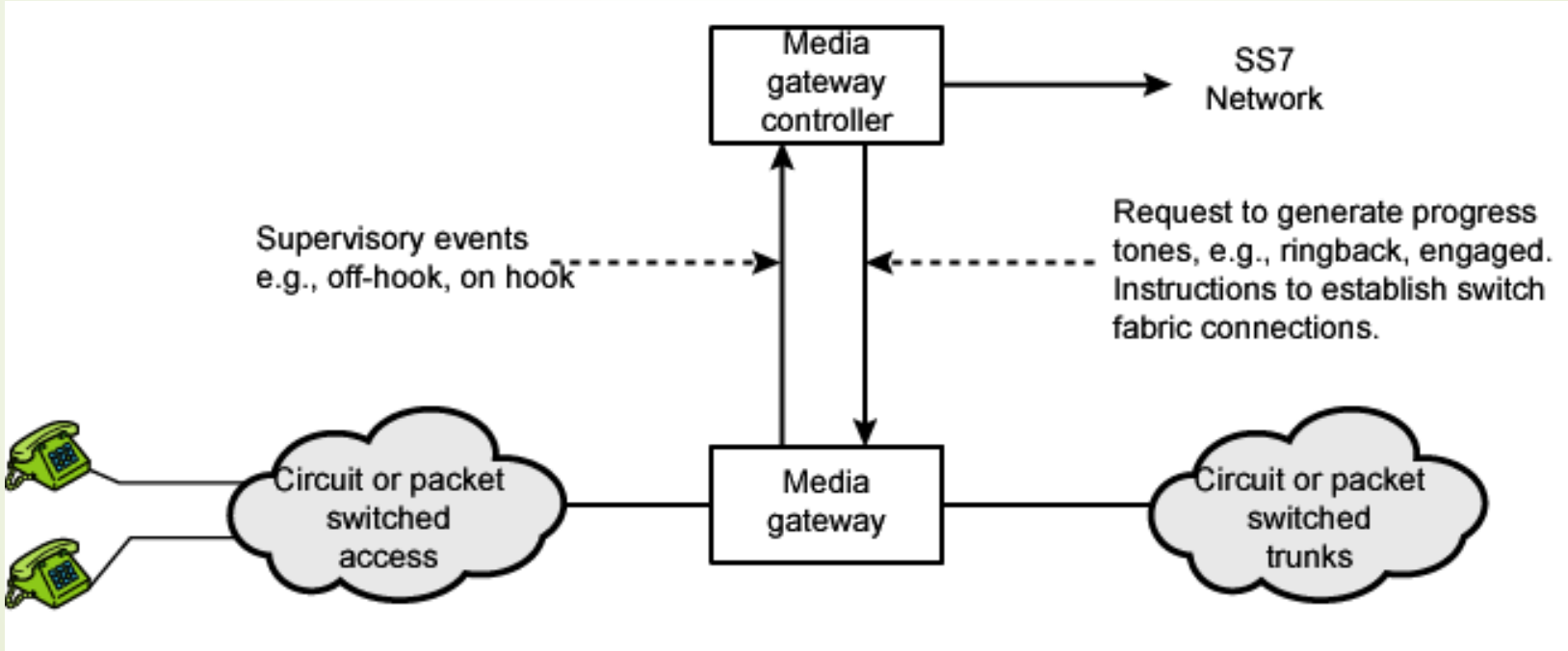
Softswitch Architecture

- 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.
- In softswitch terminology, the physical switching function is performed by a media gateway (MG).
- The call processing logic resides in a media gateway controller (MGC).

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

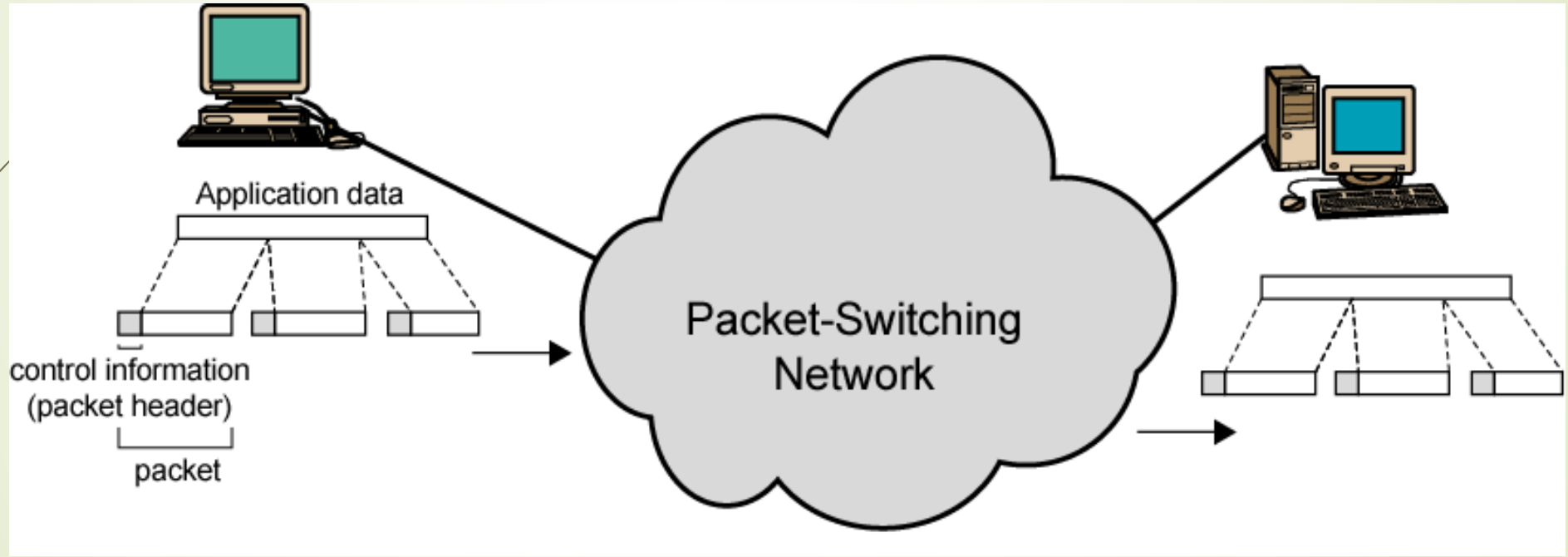
Packet Switching

- Circuit-switching was originally designed to handle voice traffic, and the majority of traffic on these networks continues to be voice.
- As the circuit-switching network began to be used increasingly for data connections, two shortcomings became apparent:
  - In a typical user/host data connection much of the time the line is idle.
  - Thus, with data connections, a circuit-switching approach is inefficient.
  - In a circuit-switching network, the connection provides for transmission at a constant data rate.
  - This limits the utility of the network in interconnecting a variety of host computers and workstations.

Packet Switching

- 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

Packet Switching



Advantages of Packet Switching

- Line efficiency :
  - Line efficiency is greater, because a single node-to-node link can be dynamically shared by many packets over time.
- Data-Rate Conversion:
  - A packet-switching network can perform data-rate conversion.
  - Two stations of different data rates can exchange packets because each connects to its node at its proper data rate.

Advantages of Packet Switching

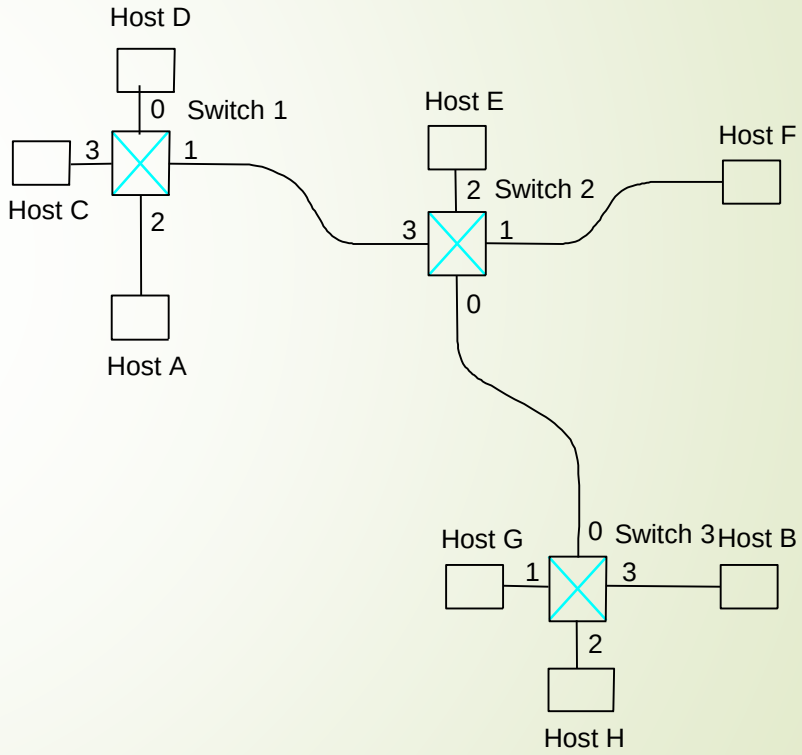
- Continuous Traffic:
  - When traffic becomes heavy on a circuit-switching network, some calls are blocked until the load on the network decreases.
  - On a packet-switching network, packets are still accepted, but delivery delay increases.
- Priorities can be used:
  - If a node has a number of packets queued for transmission, it can transmit the higher-priority packets first.
  - These packets will therefore experience less delay than lower-priority packets.

Packet Switching Techniques

- Station breaks long message into packets.
- Packets sent one at a time to the network.
- Two switching techniques are used:
  - Datagram
  - Virtual circuit

Datagram Switching

- No connection setup phase, Sometimes called a connectionless model.
- Each packet forwarded independently, with no reference to packets that have gone before.
- In this technique, each packet, treated independently, is referred to as a datagram.
- Each switch maintains a forwarding (routing) table.



Datagram Switching

Destination	Port
A	3
B	0
C	3
D	3
E	2
F	1
G	0
H	0

Forwarding Table for Switch 2

Datagram Switching

- There is no round trip time delay waiting for connection setup; a host can send data as soon as it is ready.
- Source host has no way of knowing if the network is capable of delivering a packet or if the destination host is even up.
- Since packets are treated independently, it is possible to route around link and node failures.
- Since every packet must carry the full address of the destination, the overhead per packet is higher than for the connection-oriented model.

Virtual Circuit Switching

- Explicit connection setup (and tear-down) phase
- Subsequence packets follow same circuit
- Sometimes called connection-oriented model
- Analogy: phone call
- Each switch maintains a VC table

Virtual Circuit Model

- Typically wait full RTT for connection setup before sending first data packet.
- While the connection request contains the full address for destination, each data packet contains only a small identifier, making the per-packet header overhead small.
- If a switch or a link in a connection fails, the connection is broken and a new one needs to be established.
- Connection setup provides an opportunity to reserve resources.

End of Slides