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Data and Computer Communications

Chapter 9
Circuit 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
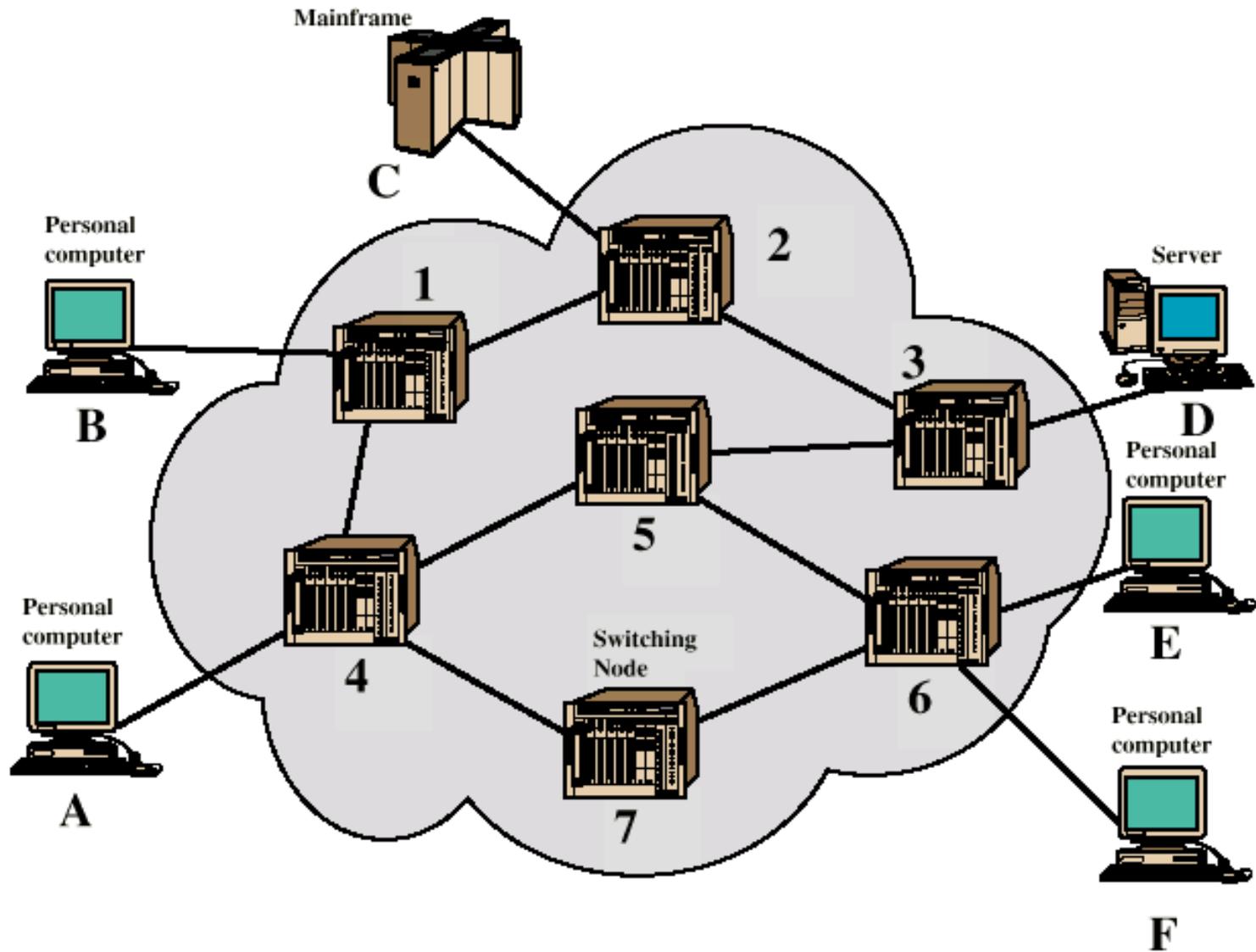
Circuit Switching

- ⌘ 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
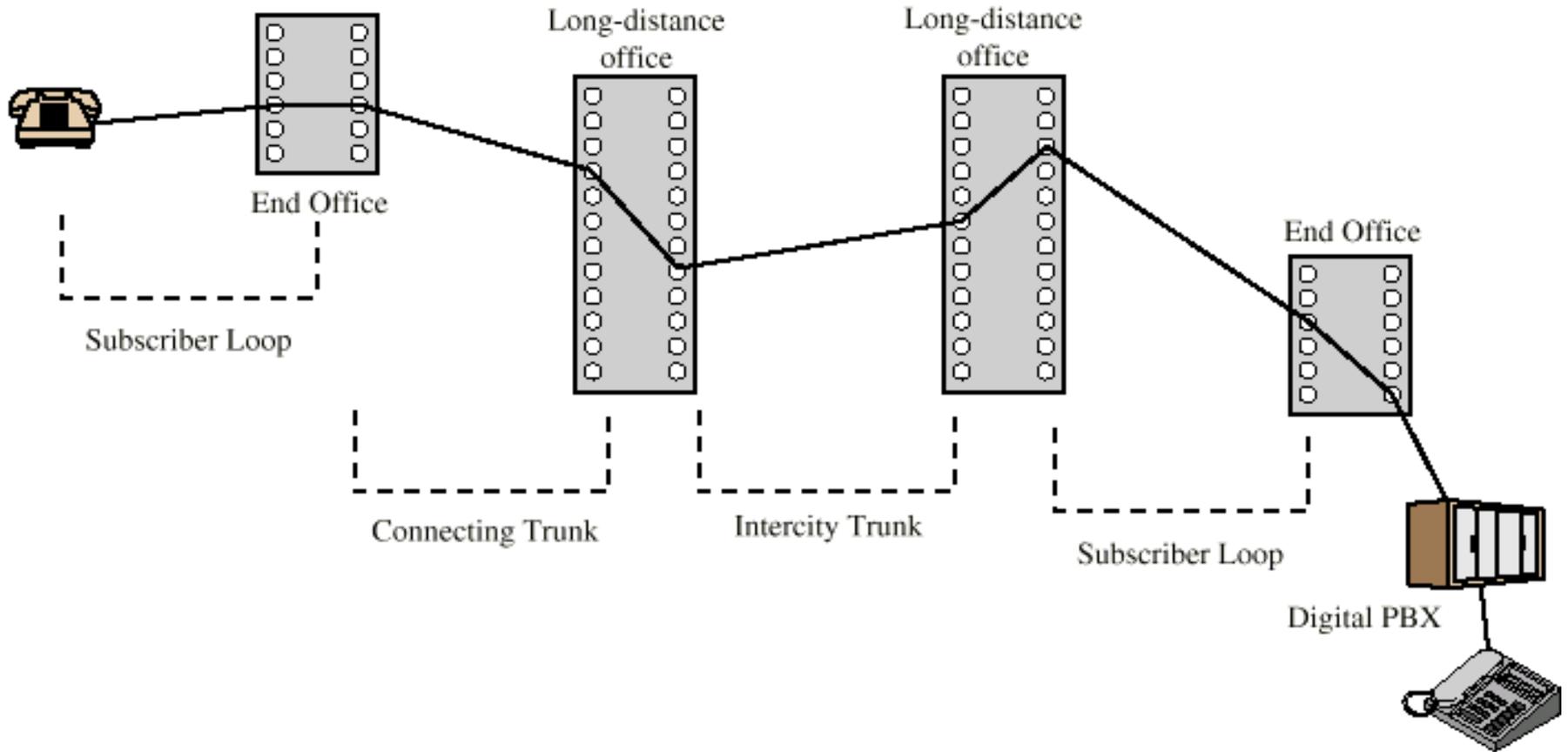- Set up (connection) takes time
- Once connected, transfer is transparent
- Developed for voice traffic (phone)

Public Circuit Switched Network

Long-distance office

Long-distance office

End Office

Subscriber Loop

Connecting Trunk

Intercity Trunk

End Office

Subscriber Loop

Digital PBX

Telecomms Components

⌘ Subscriber

  ⌃ Devices attached to network

⌘ Local Loop

  ⌃ Subscriber loop

  ⌃ Connection to network

⌘ Exchange
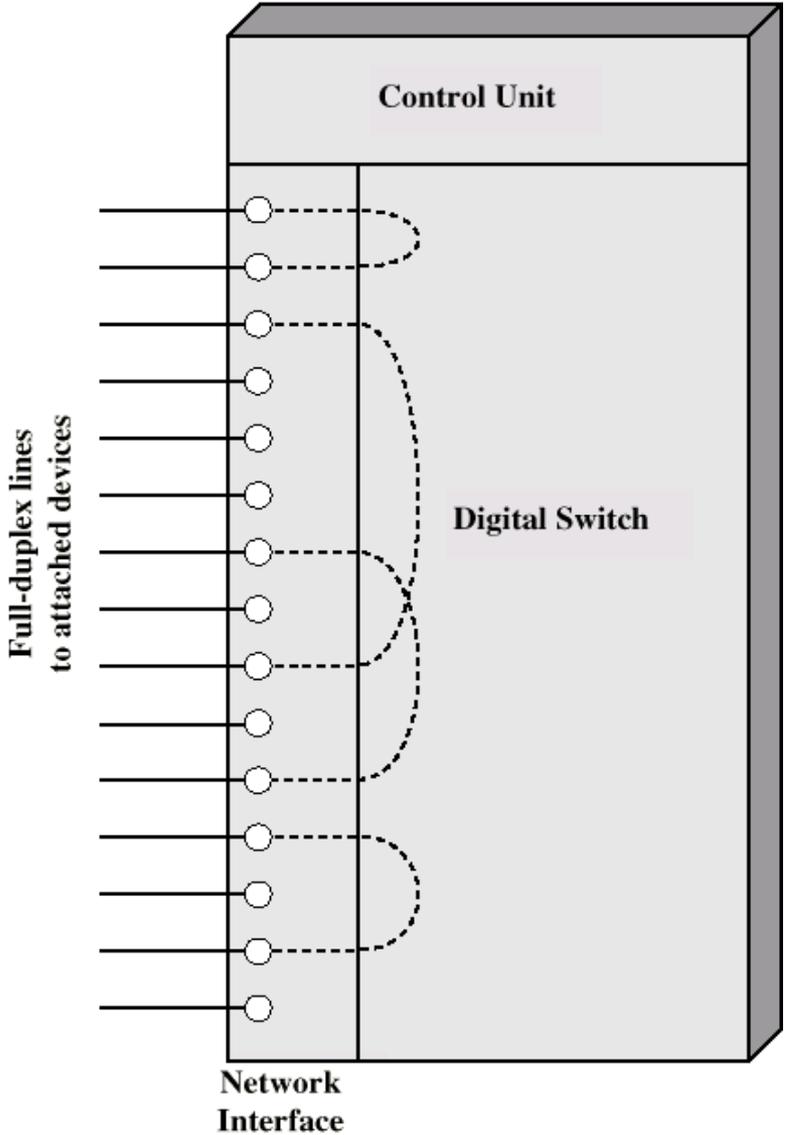
  ⌃ Switching centers

  ⌃ End office - supports subscribers

⌘ Trunks

  ⌃ Branches between exchanges

  ⌃ Multiplexed

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
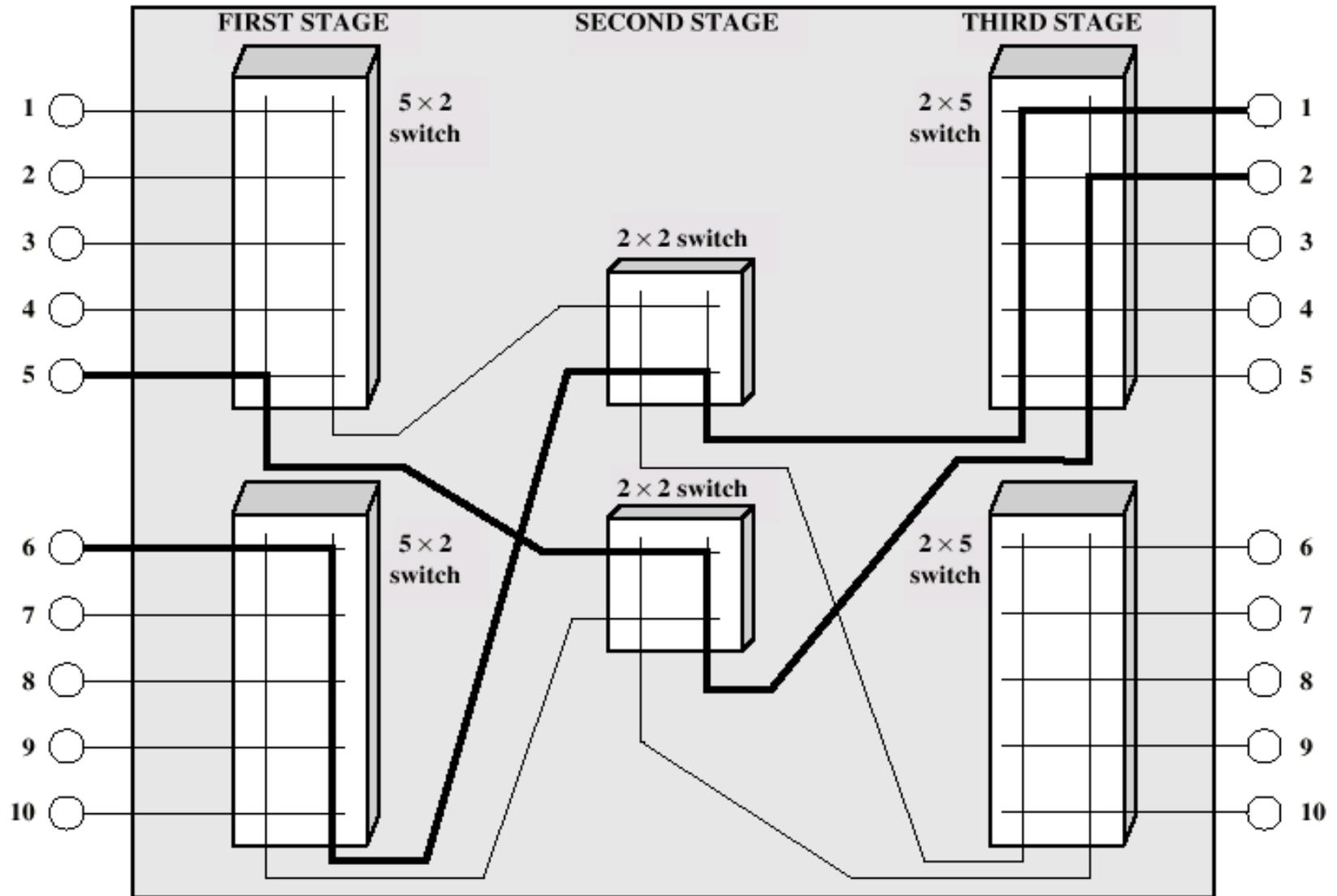 - Non-blocking

Crossbar Matrix
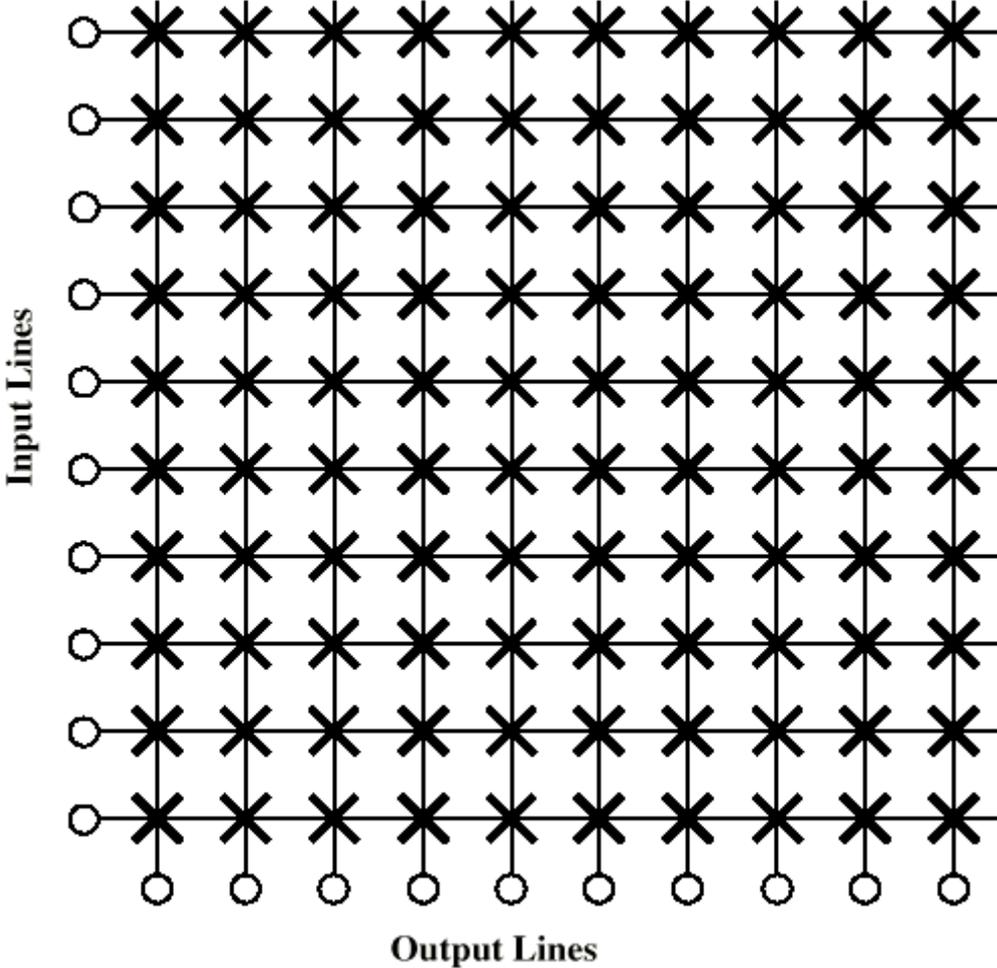
Multistage Switch

⌘ Reduced number of crosspoints

⌘ More than one path through network

◻ Increased reliability

⌘ More complex control

⌘ May be blocking

Three Stage Switch

Time Division Switching

- Partition low speed bit stream into pieces that share higher speed stream
- e.g. TDM bus switching
  - based on synchronous time division multiplexing
  - Each station connects through controlled gates to high speed bus
  - Time slot allows small amount of data onto bus
 - Another line's gate is enabled for output at the same time

Routing

- Many connections will need paths through more than one switch
- Need to find a route
  - Efficiency
  - Resilience
- Public telephone switches are a tree structure
  - Static routing uses the same approach all the time
- Dynamic routing allows for changes in routing depending on traffic
  - Uses a peer structure for nodes

Alternate Routing

- Possible routes between end offices predefined
- Originating switch selects appropriate route
- Routes listed in preference order
- Different sets of routes may be used at different times

Alternate Routing Diagram
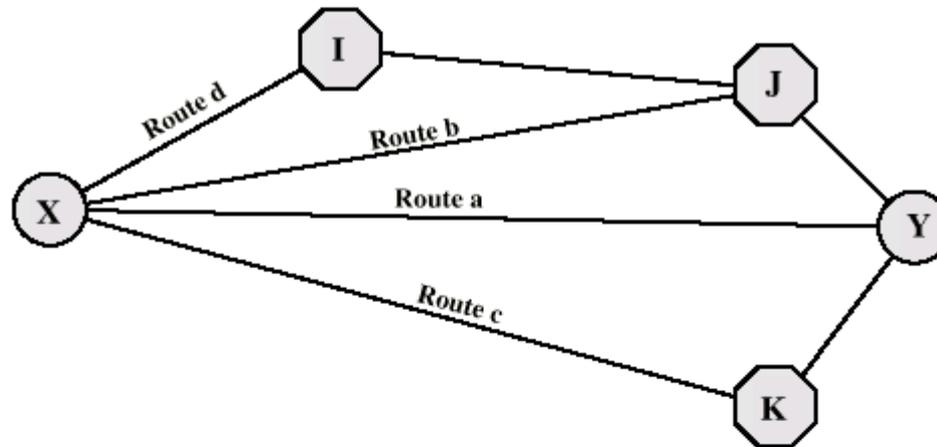
Route a: X → Y
Route b: X → J → Y
Route c: X → K → Y
Route d: X → I → J → Y

⬡ = end office

⬡ = intermediate switching node

(a) Topology

Time Period	First route	Second route	Third route	Fourth and final route
Morning	a	b	c	d
Afternoon	a	d	b	c
Evening	a	d	c	b
Weekend	a	c	b	d

(b) Routing table

Control Signaling Functions

- Audible communication with subscriber
- Transmission of dialed number
- Call can not be completed indication
- Call ended indication
- Signal to ring phone
- Billing info
- Equipment and trunk status info
- Diagnostic info
- Control of specialist equipment

Control Signal Sequence

- ⌘ Both phones on hook
- ⌘ Subscriber lifts receiver (off hook)
- ⌘ End office switch signaled
- ⌘ Switch responds with dial tone
- ⌘ Caller dials number
- ⌘ If target not busy, send ringer signal to target subscriber
- ⌘ Feedback to caller
  - ⬚ Ringing tone, engaged tone, unobtainable
- ⌘ Target accepts call by lifting receiver
- ⌘ Switch terminates ringing signal and ringing tone
- ⌘ Switch establishes connection
- ⌘ Connection release when Source subscriber hangs up

Switch to Switch Signaling

- Subscribers connected to different switches
- Originating switch seizes interswitch trunk
- Send off hook signal on trunk, requesting digit register at target switch (for address)
- Terminating switch sends off hook followed by on hook (wink) to show register ready
- Originating switch sends address

Control Signals

Name of Signal	Calling Station	Originating End Office	Intermediate Exchanges(s)	Terminating End Office	Called Station
Connect	→	→	→ →	→ →	→
Disconnect	→	→	→ →	→ →	→
Answer (off-hook)		←	←	←	
Hang-up (on-hook)		←	←	←	
Delay-dial (delay pulsing)		←	←		
Wink-start		←	←		
Start dial (start pulsing)		←	←		
Dial tone	←	←			
Called station identity					
DTMF pulsing	→	→			
Dial pulsing	→	→	→ →	→	
Multifrequency pulsing		→	→ →	→	
Calling station identity					
Verbal	→	→ Operator identification			
MF pulsed digits	→	→ Automatic identification			
Line busy	←			←	
Reorder	←			←	
No circuit	←		←		
Ringing				→	→
Audible ringing	←			←	
Ringing start			→	→	
Recorder warning tone	→				→
Announcements	←			←	

Note: A broken line indicates repetition of a signal at each office, whereas a solid line indicates direct transmittal through intermediate offices.

Location of Signaling

⌘ Subscriber to network

⌃ Depends on subscriber device and switch

⌘ Within network

⌃ Management of subscriber calls and network

⌃ ore complex

In Channel Signaling

- Use same channel for signaling and call
  - Requires no additional transmission facilities
- Inband
  - Uses same frequencies as voice signal
  - Can go anywhere a voice signal can
  - Impossible to set up a call on a faulty speech path
- Out of band
  - Voice signals do not use full 4kHz bandwidth
  - Narrow signal band within 4kHz used for control
  - Can be sent whether or not voice signals are present
  - Need extra electronics
 - Slower signal rate (narrow bandwidth)

Drawbacks of In Channel Signaling

⌘ Limited transfer rate

⌘ Delay between entering address (dialing) and connection

⌘ Overcome by use of common channel signaling

Common Channel Signaling

- Control signals carried over paths independent of voice channel
- One control signal channel can carry signals for a number of subscriber channels
- Common control channel for these subscriber lines
- Associated Mode
  - Common channel closely tracks interswitch trunks
- Disassociated Mode
  - Additional nodes (signal transfer points)
  - Effectively two separate networks
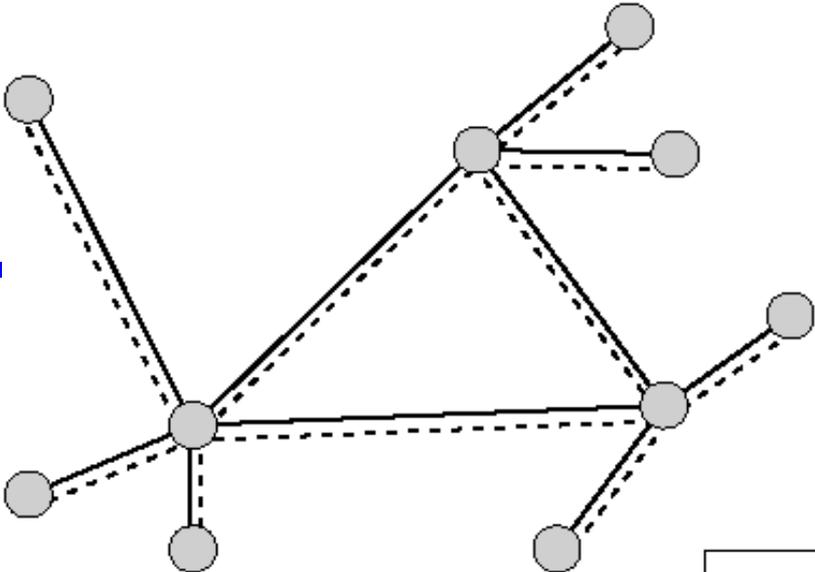
Common v. In Channel Signaling
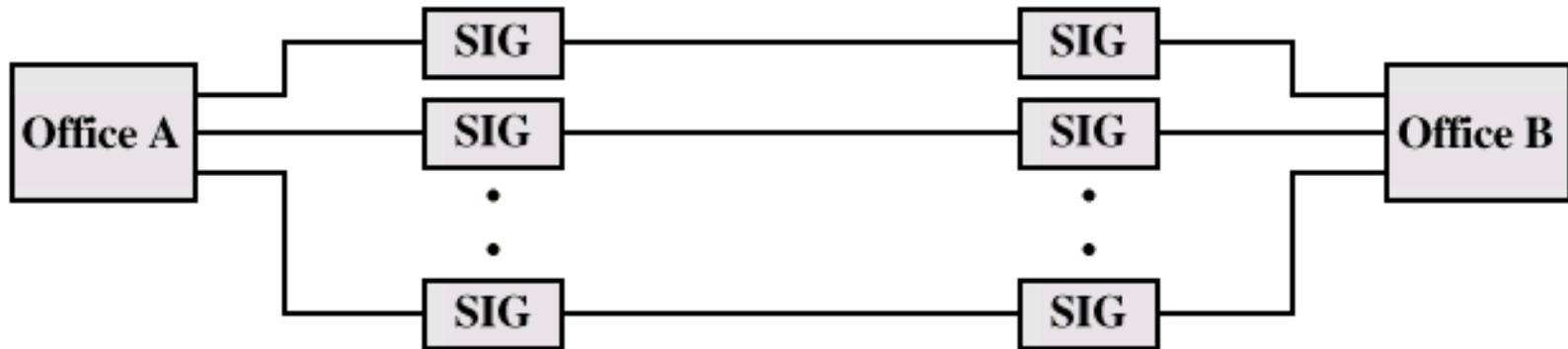
(a) Inchannel
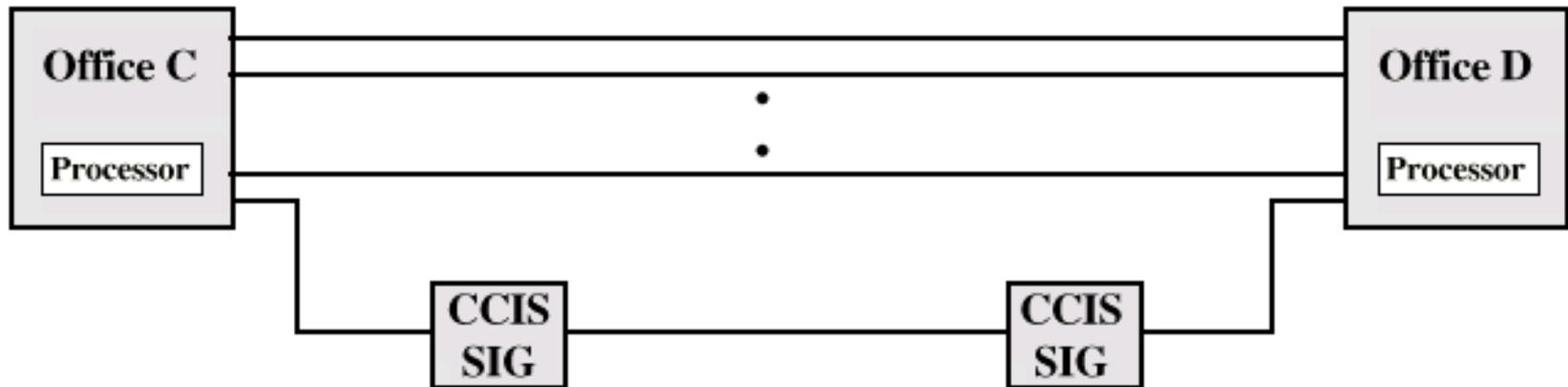
(b) Common channel

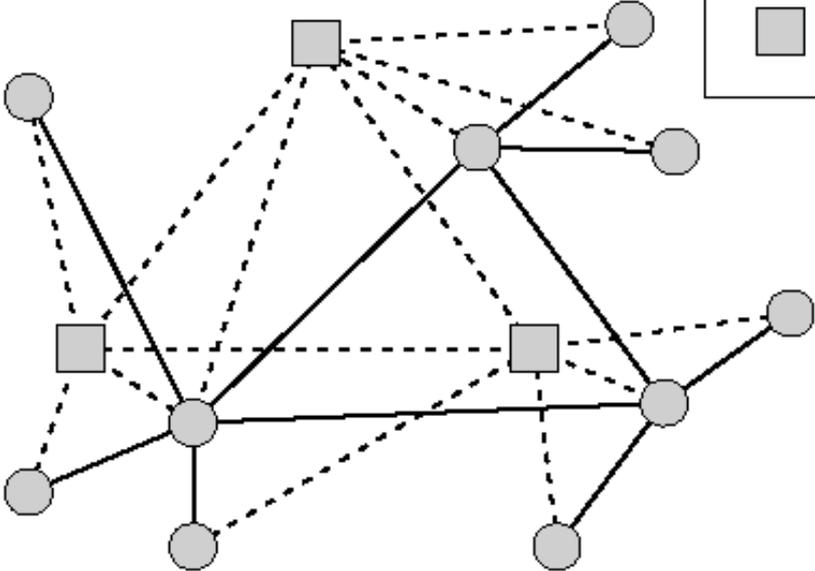CCIS SIG: Common-channel interoffice signaling equipment
SIG: Per-trunk signaling equipment

Signaling Modes

(a) Associated

(b) Disassociated

- - - - Signaling links
——— Speech links

⬤ Switching point (speech)

■ Switching point (signal transfer point)

Signaling System Number 7

- SS7
- Common channel signaling scheme
- ISDN
- Optimized for 64k digital channel network
- Call control, remote control, management and maintenance
- Reliable means of transfer of info in sequence
- Will operate over analog and below 64k
- Point to point terrestrial and satellite links

SS7 Signaling Network Elements

- ⌘ Signaling point (SP)
  - ⊡ Any point in the network capable of handling SS7 control message
- ⌘ Signal transfer point (STP)
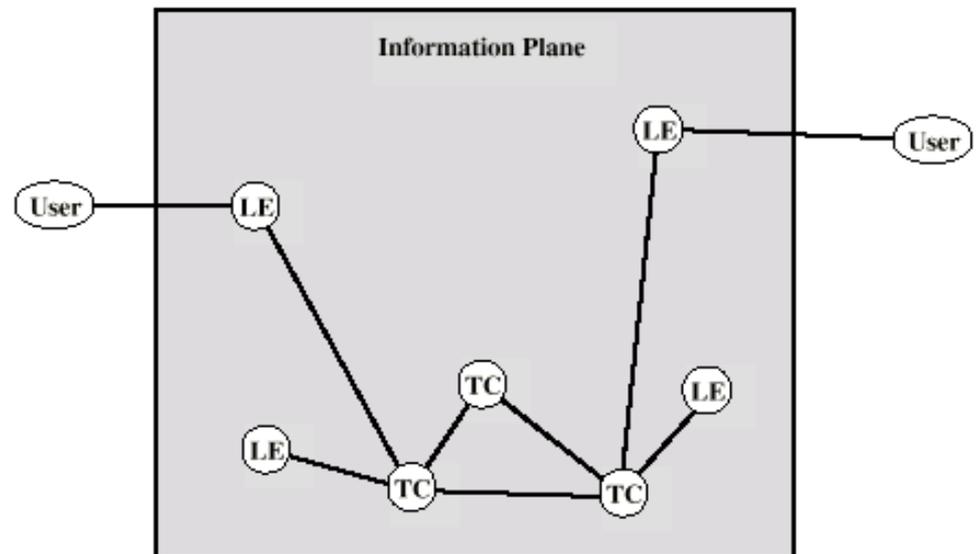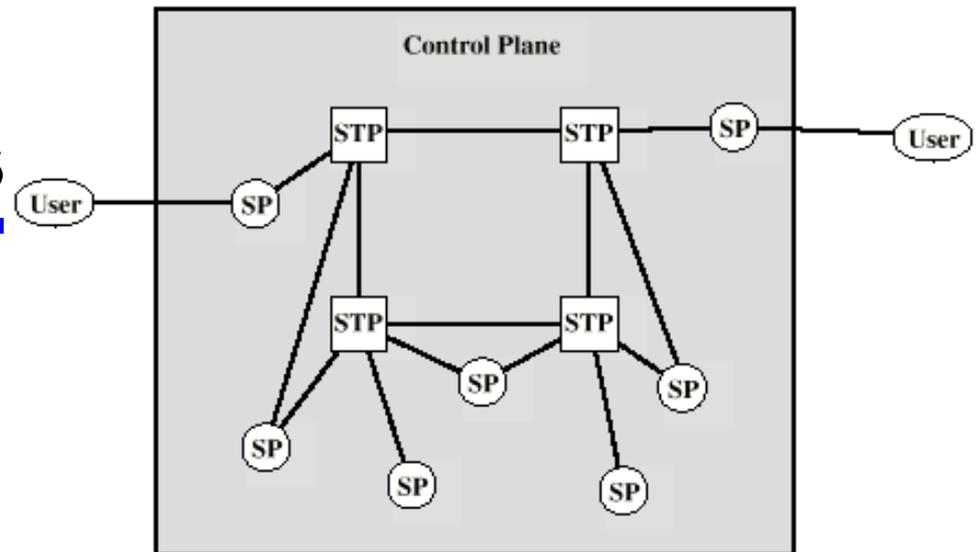 - ⊡ A signaling point capable of routing control messages
- ⌘ Control plane
  - ⊡ Responsible for establishing and managing connections
- ⌘ Information plane
  - ⊡ Once a connection is set up, info is transferred in the information plane

Transfer Points

STP = Signaling transfer point
SP = Signaling point
TC = Transit center
LE = Local Exchange

Signaling Network Structures

- ⌘ STP capacities
  - ⊟ Number of signaling links that can be handled
  - ⊟ Message transfer time
  - ⊟ Throughput capacity
- ⌘ Network performance
  - ⊟ Number of SPs
  - ⊟ Signaling delays
- ⌘ Availability and reliability
  - ⊟ Ability of network to provide services in the face of STP failures

Required Reading

- Stallings chapter 9
- ITU-T web site
- Telephone company web sites (not much technical info - mostly marketing)