CNL
Communications & Networking
L a b o r a t o r y

ECE 462 – Data and Computer Communications

Lecture 15/16: Circuit Switching and Packet Switching

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Outline

- Switched Communications Networks

- Circuit-Switched Networks

- Control Signaling

- Packet Switching

- Common Channel Signaling System 7

- X.25 and Frame Relay

- Virtual Circuit and Datagram

Note: Some material adapted from various textbook. In particular, the sequences of slides have been sorted to match closely that of the textbook <u>Data and Computer Communications</u> by W. Stallings, 8th Edition, Prentice Hall, 2007

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

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Simple Switched Network
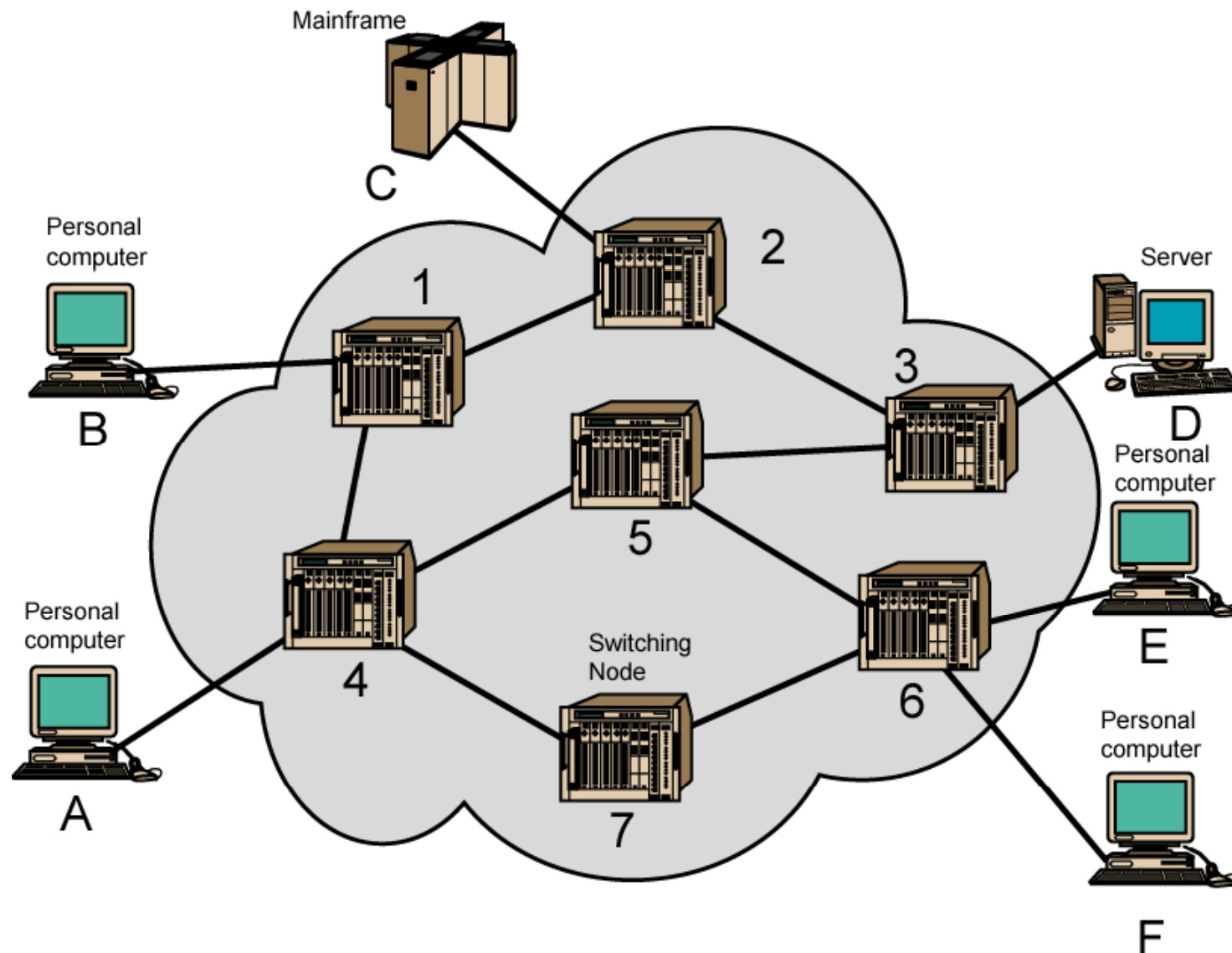
Circuit Switching

- **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**

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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)

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Public Circuit Switched Network

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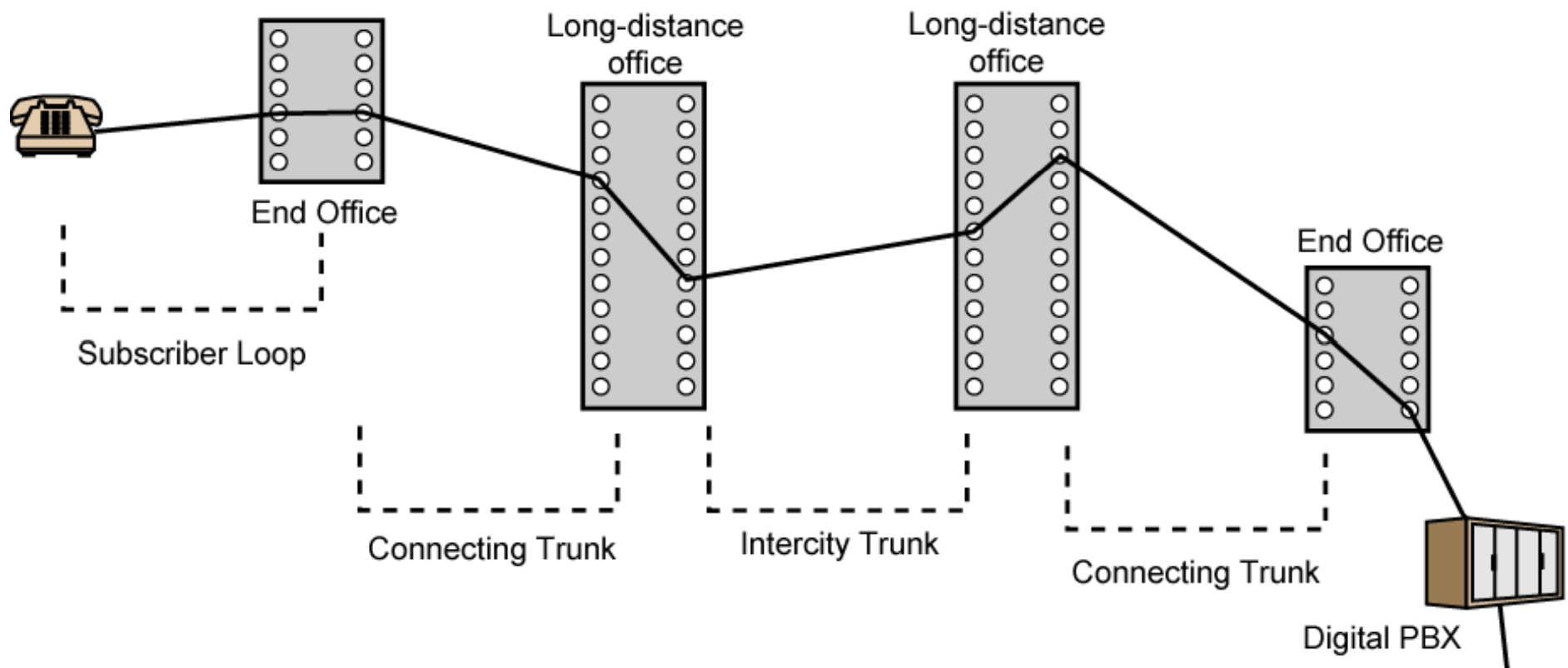
Telecomms Components

- ## 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

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Circuit Establishment
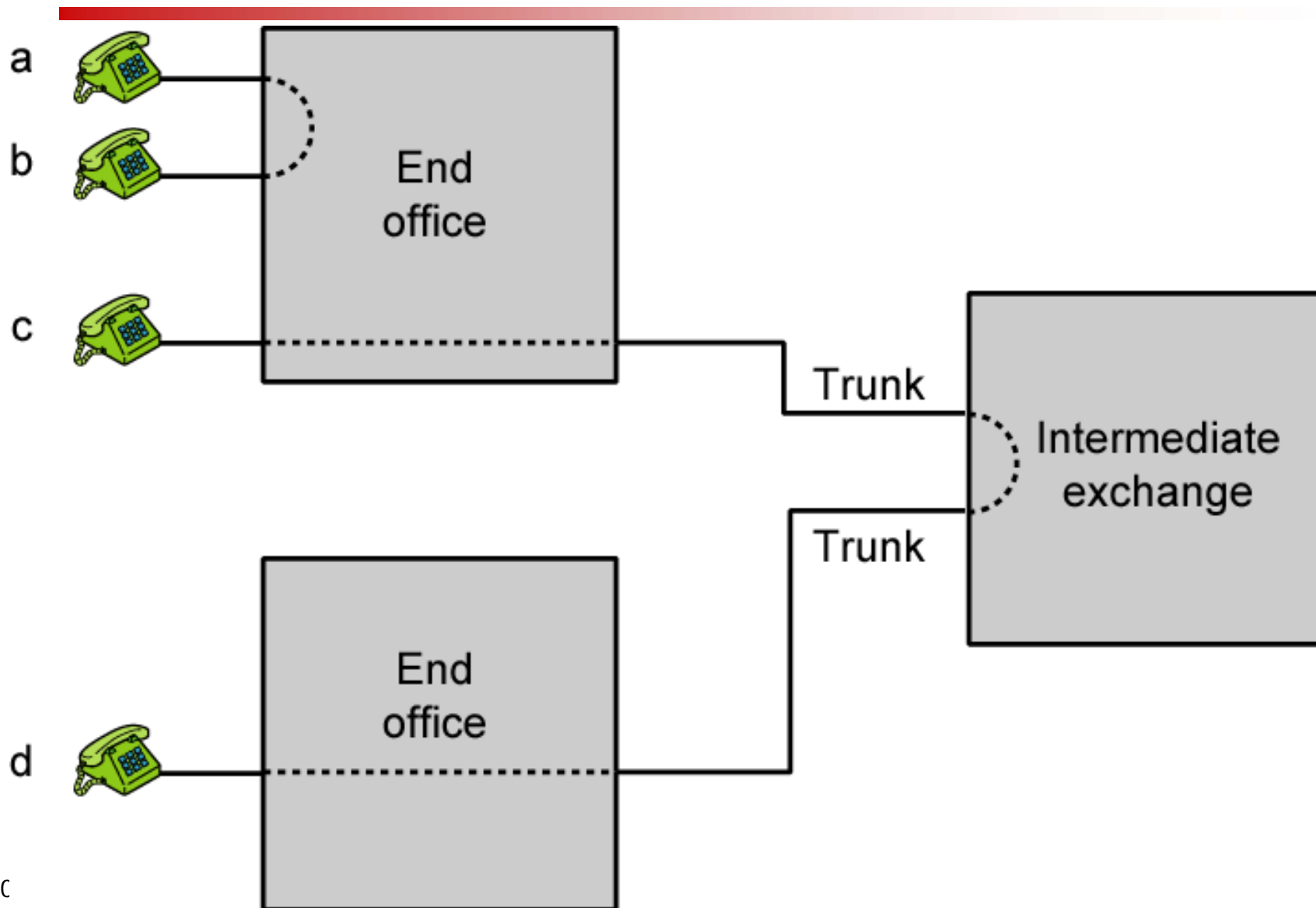
Circuit Switch Elements
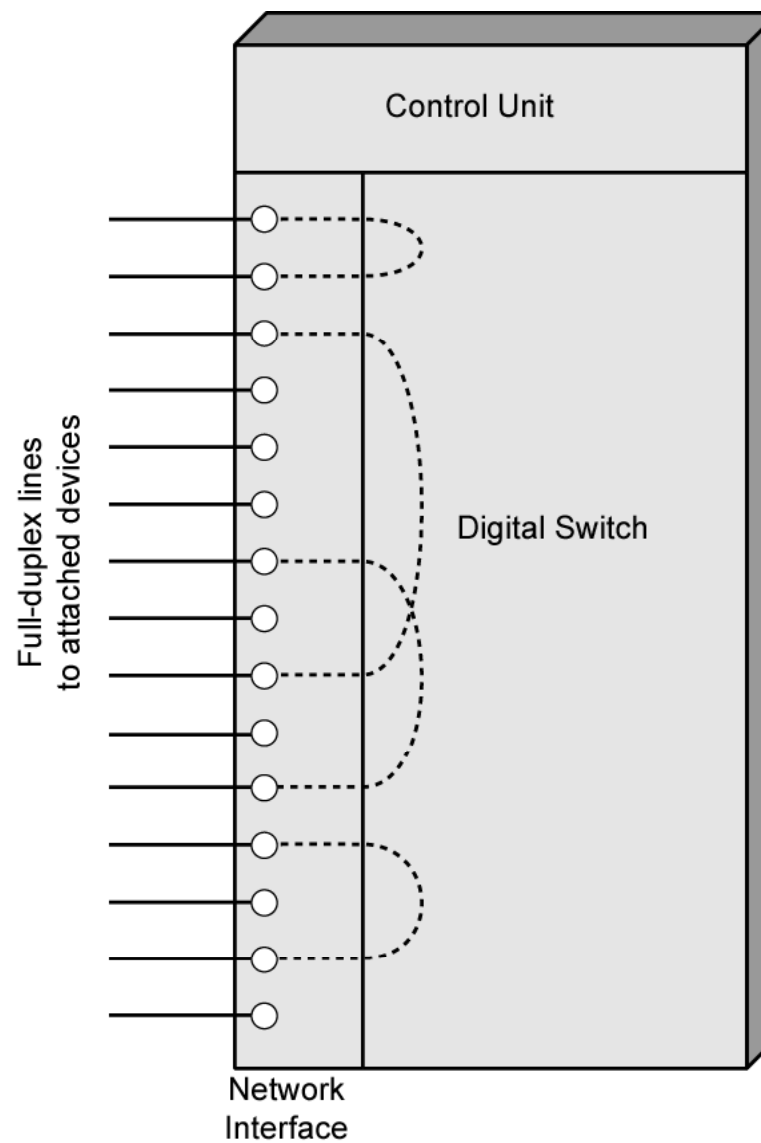
Circuit Switching Concepts

- ## 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
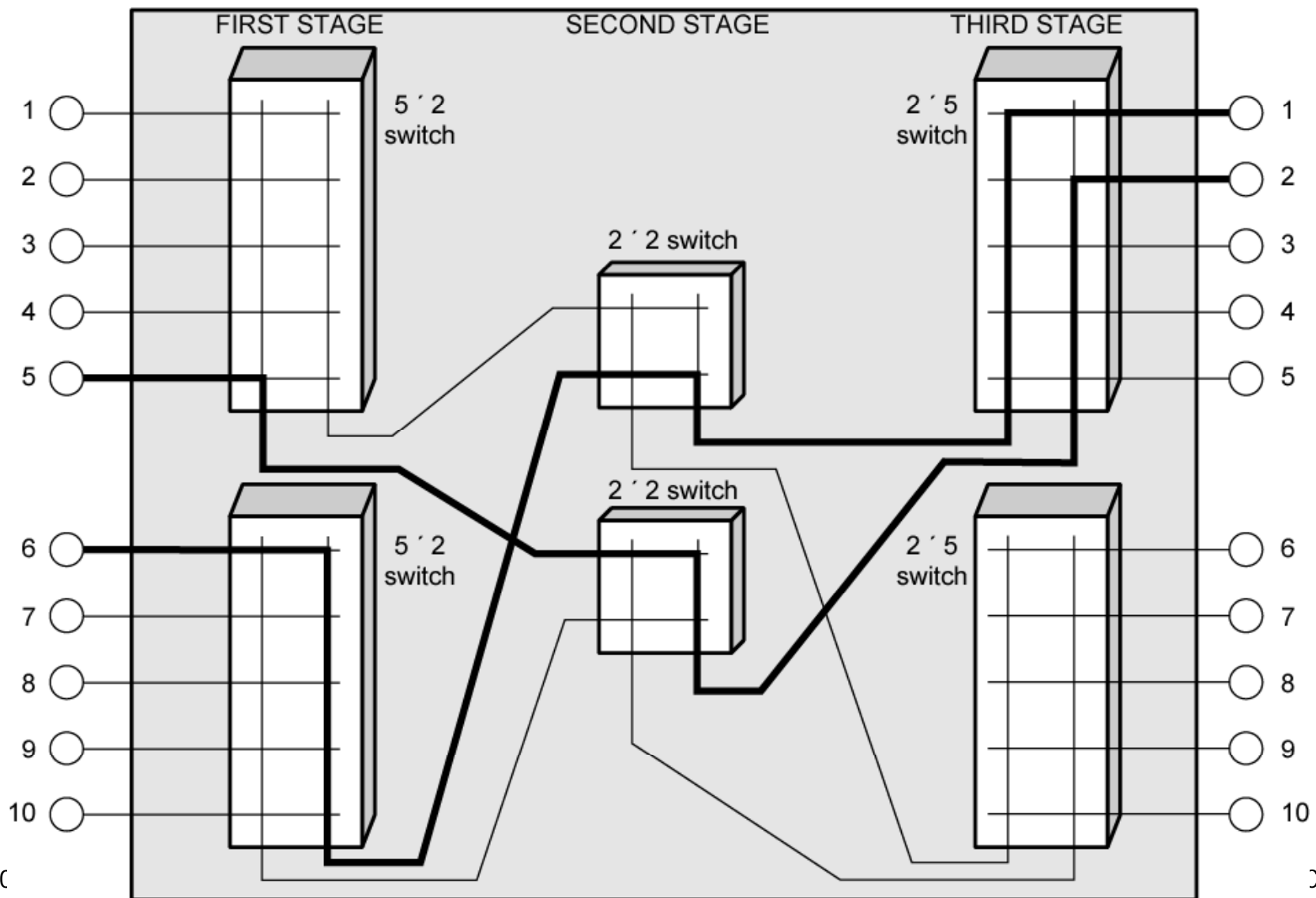 - Non-blocking

Space Division Switch

Input Lines

Output Lines
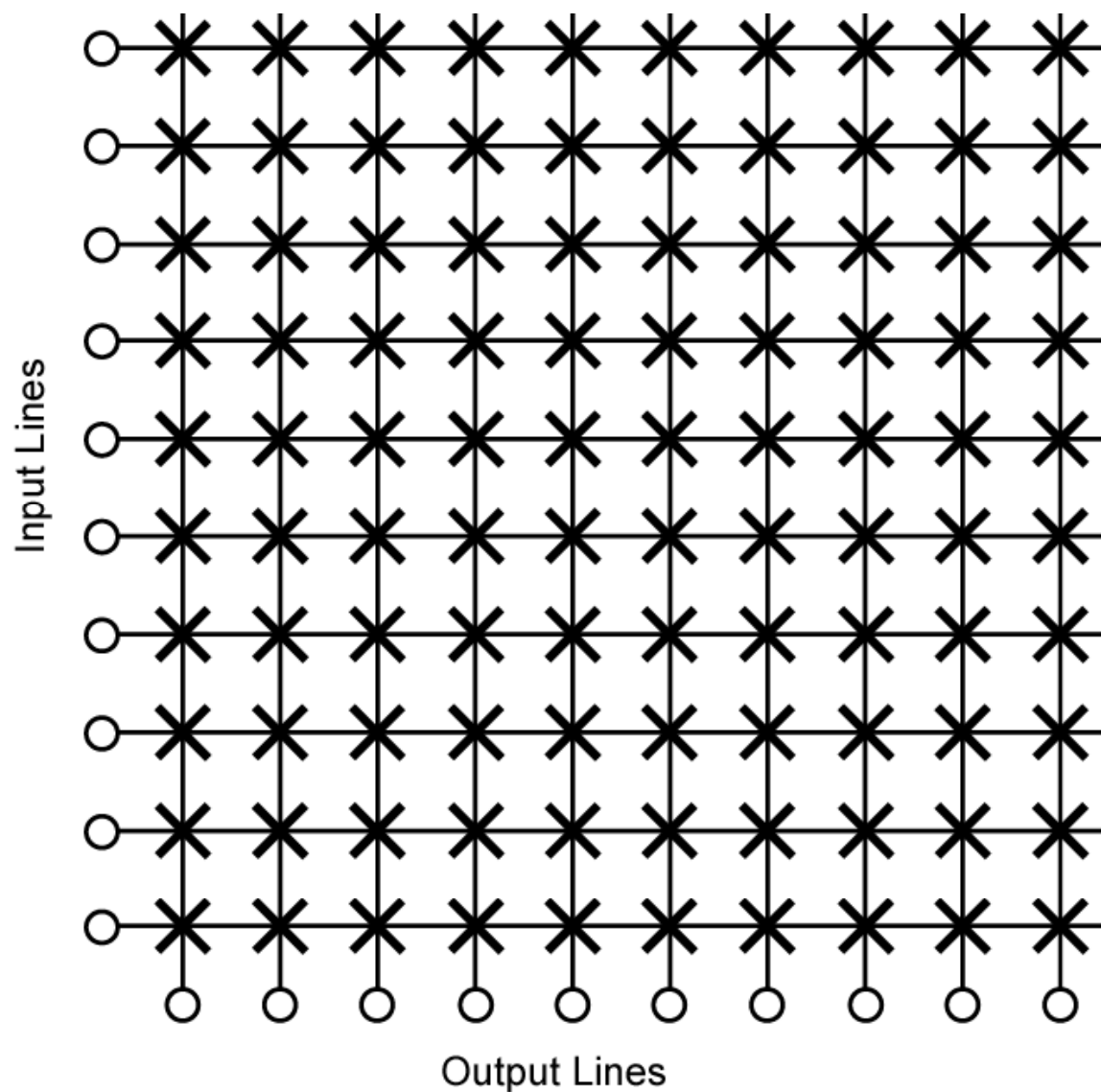
Multistage Switch

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

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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

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

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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**

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

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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
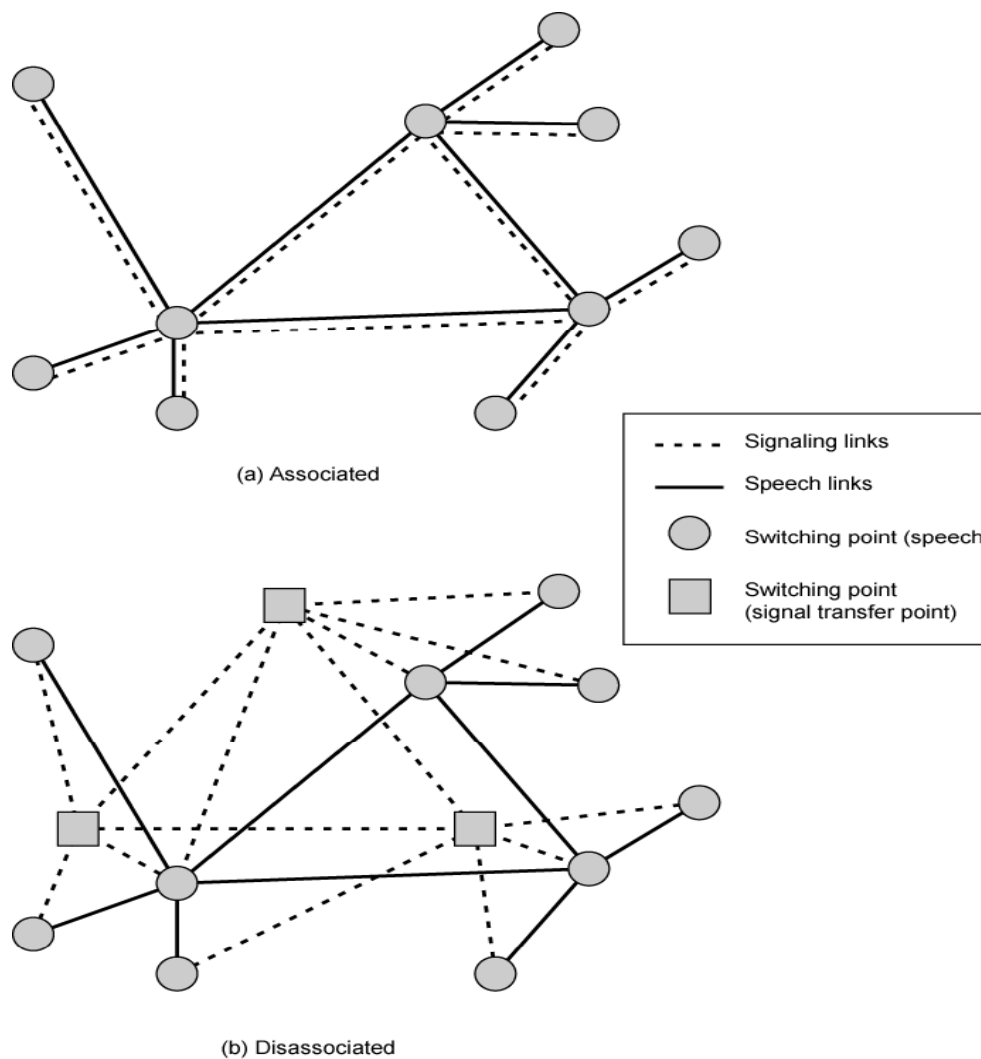
Common v. In Channel Signaling
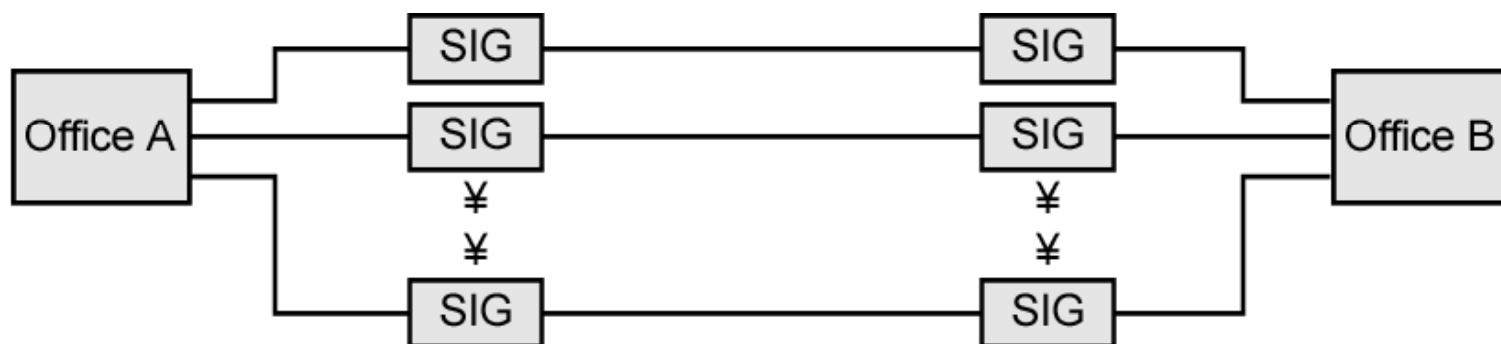
(a) Inchannel
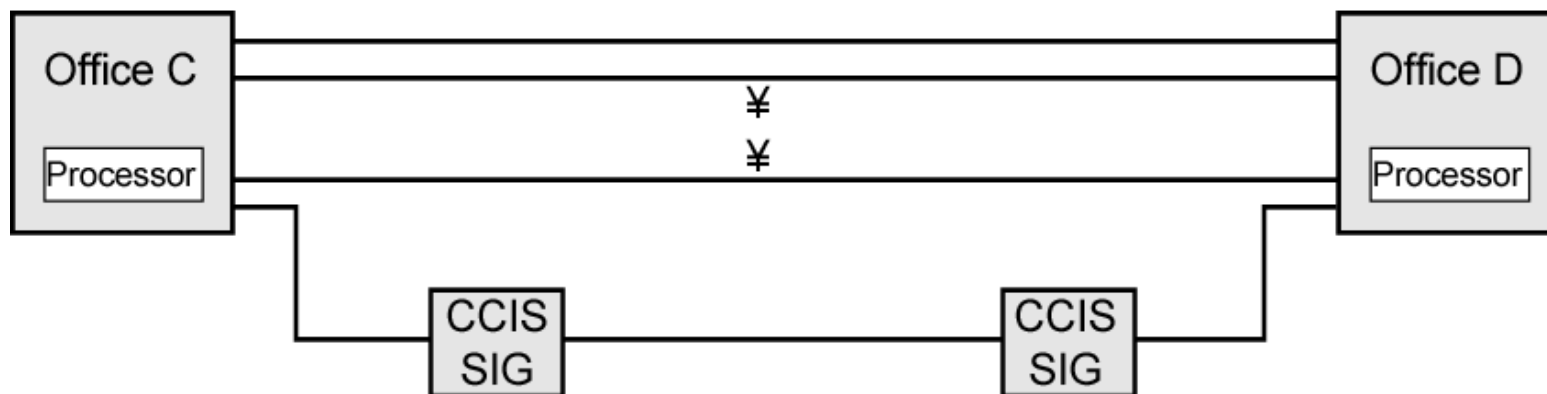
(b) Common channel

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

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Common Channel Signaling Modes

(a) Associated

Legend:
- - - - Signaling links
- ——— Speech links
- ⬤ Switching point (speech)
- ▢ Switching point (signal transfer point)

(b) Disassociated

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

Signaling Transfer Points

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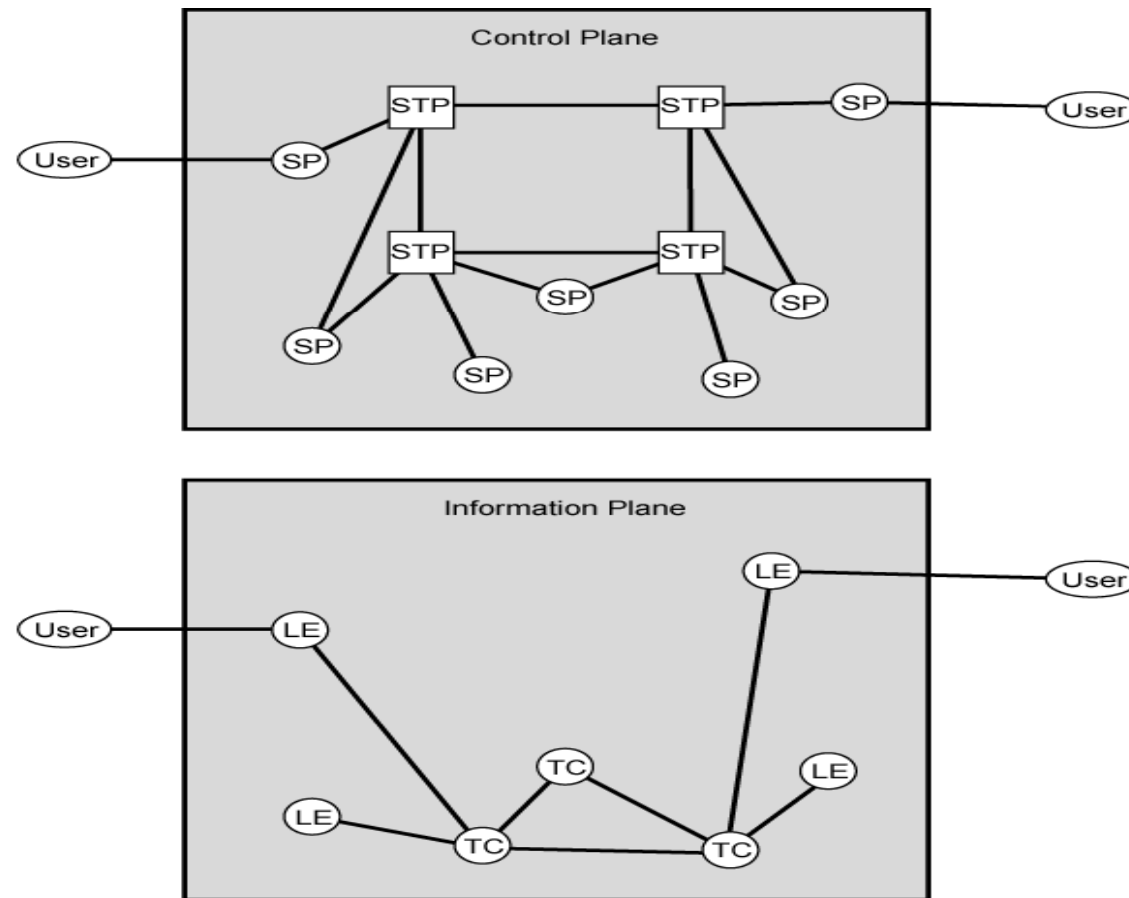
STP = Signaling transfer point
SP = Signaling point
TC = Transit center
LE = Local Exchange

# 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

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

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Softswitch

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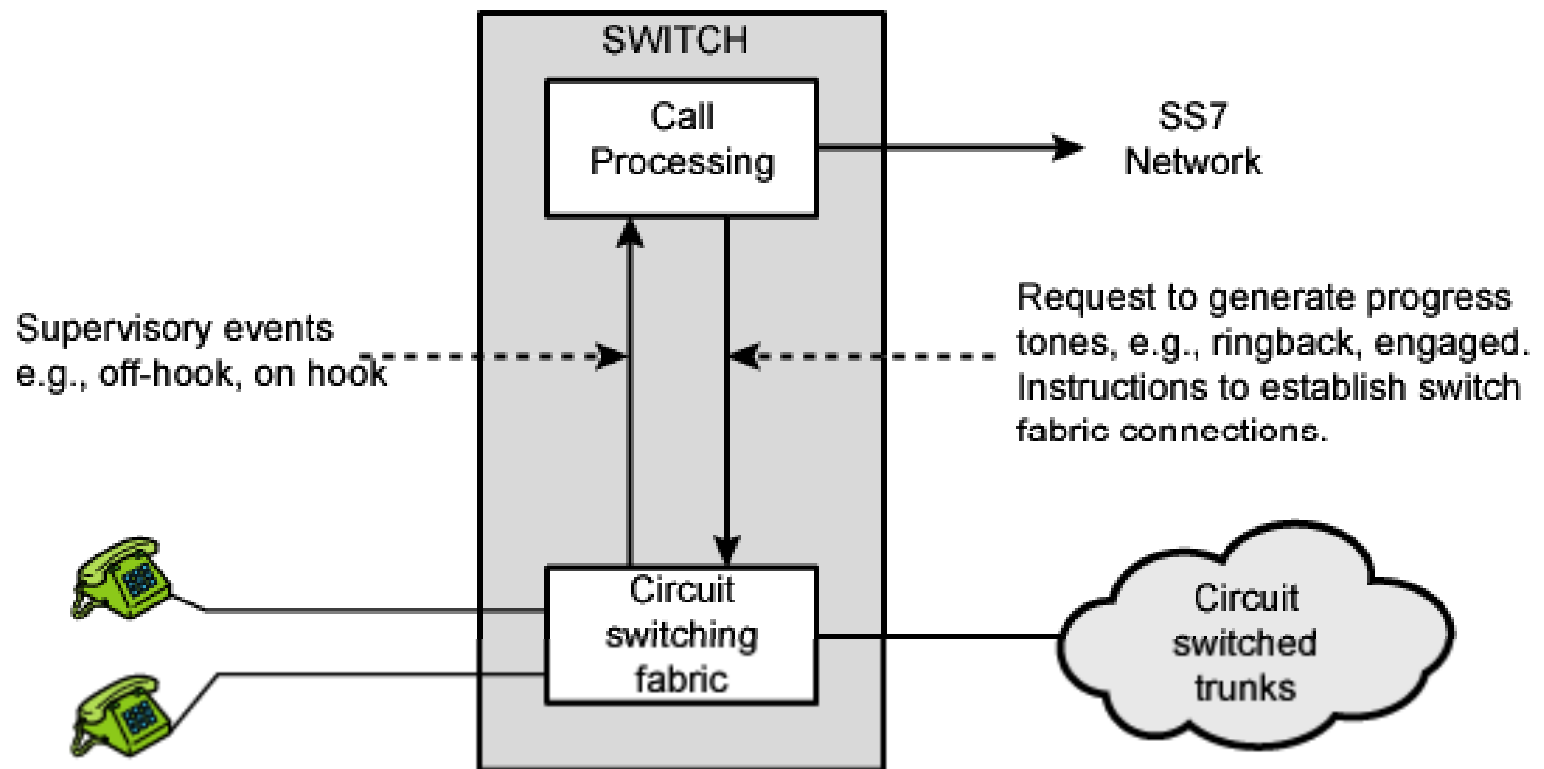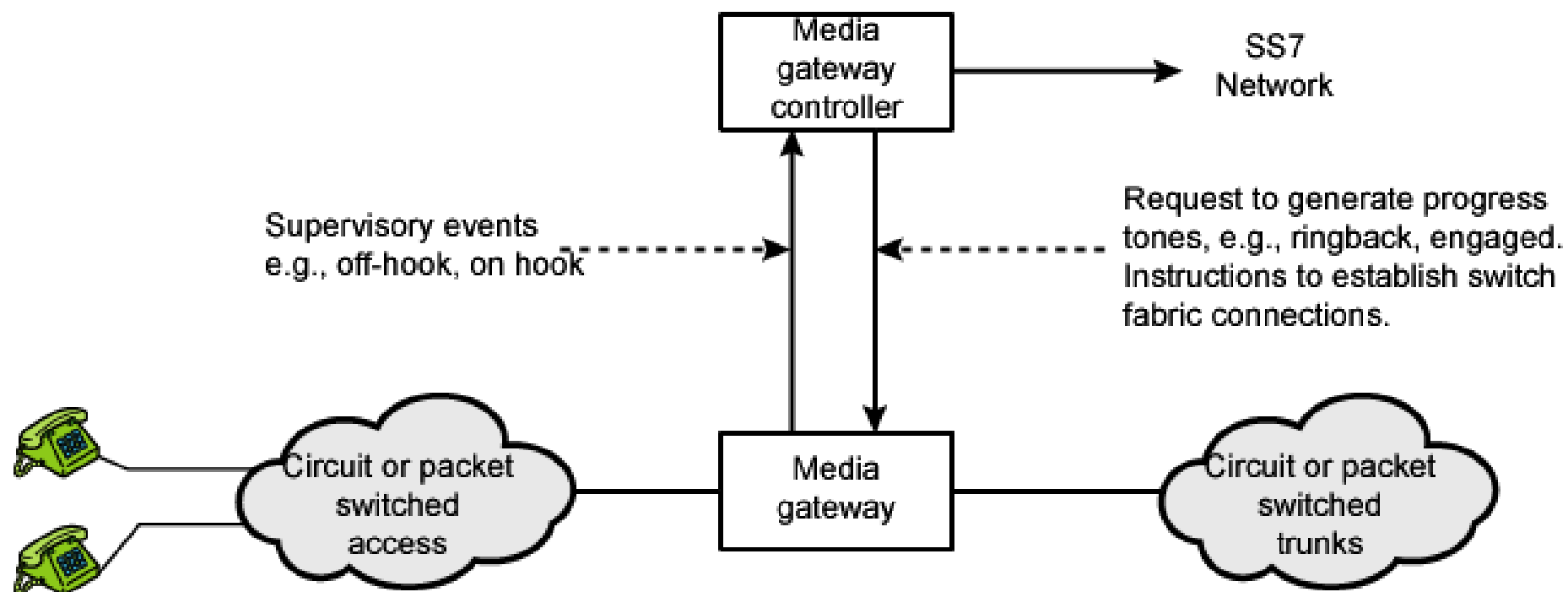
Packet Switching Principles

- 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

Application data

control information
(packet header)

packet

Packet-Switching
Network

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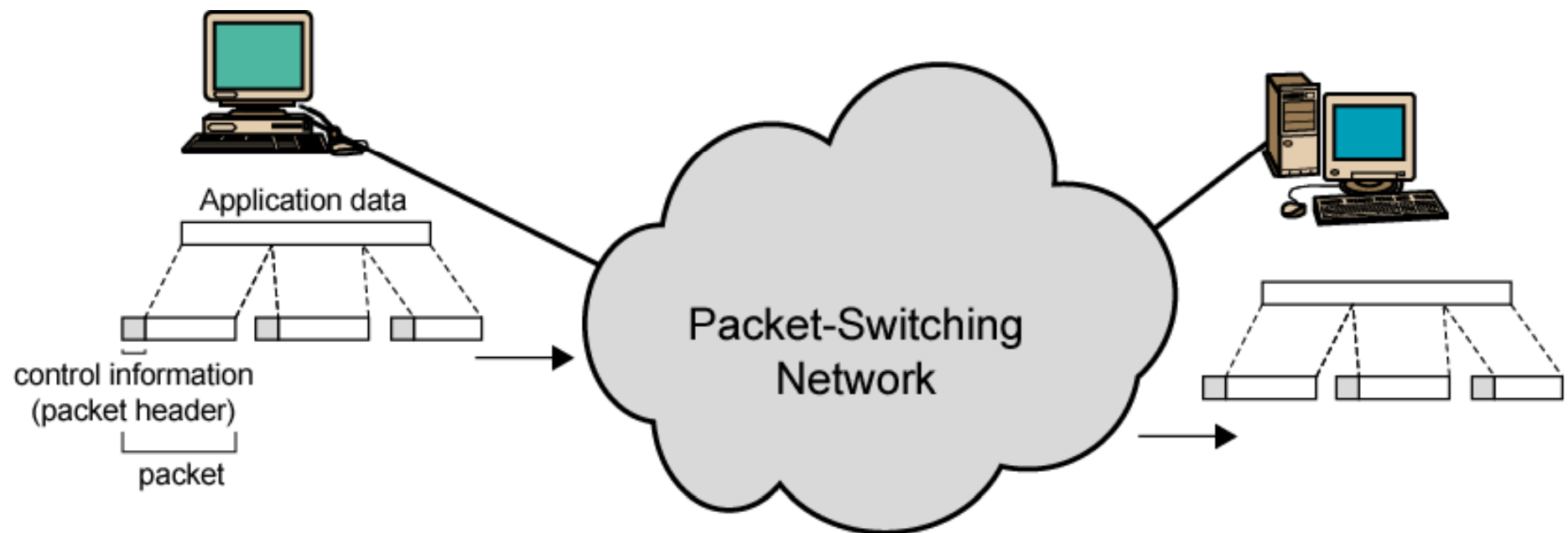
Advantages

- **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 Operation

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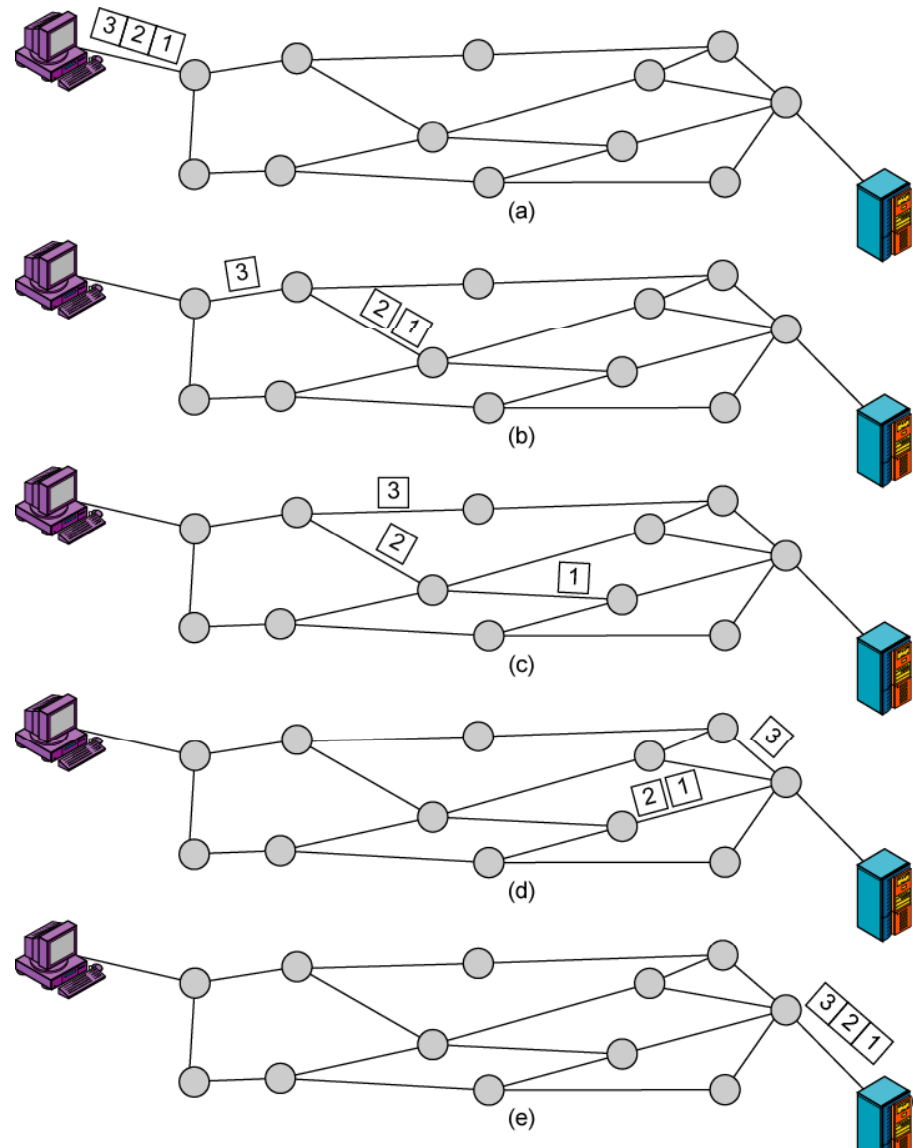
Virtual Circuit

- 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