

# **William Stallings**

# **Data and Computer**

# **Communications**

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## **Chapter 9**

## **Circuit Switching**

# Switching Networks

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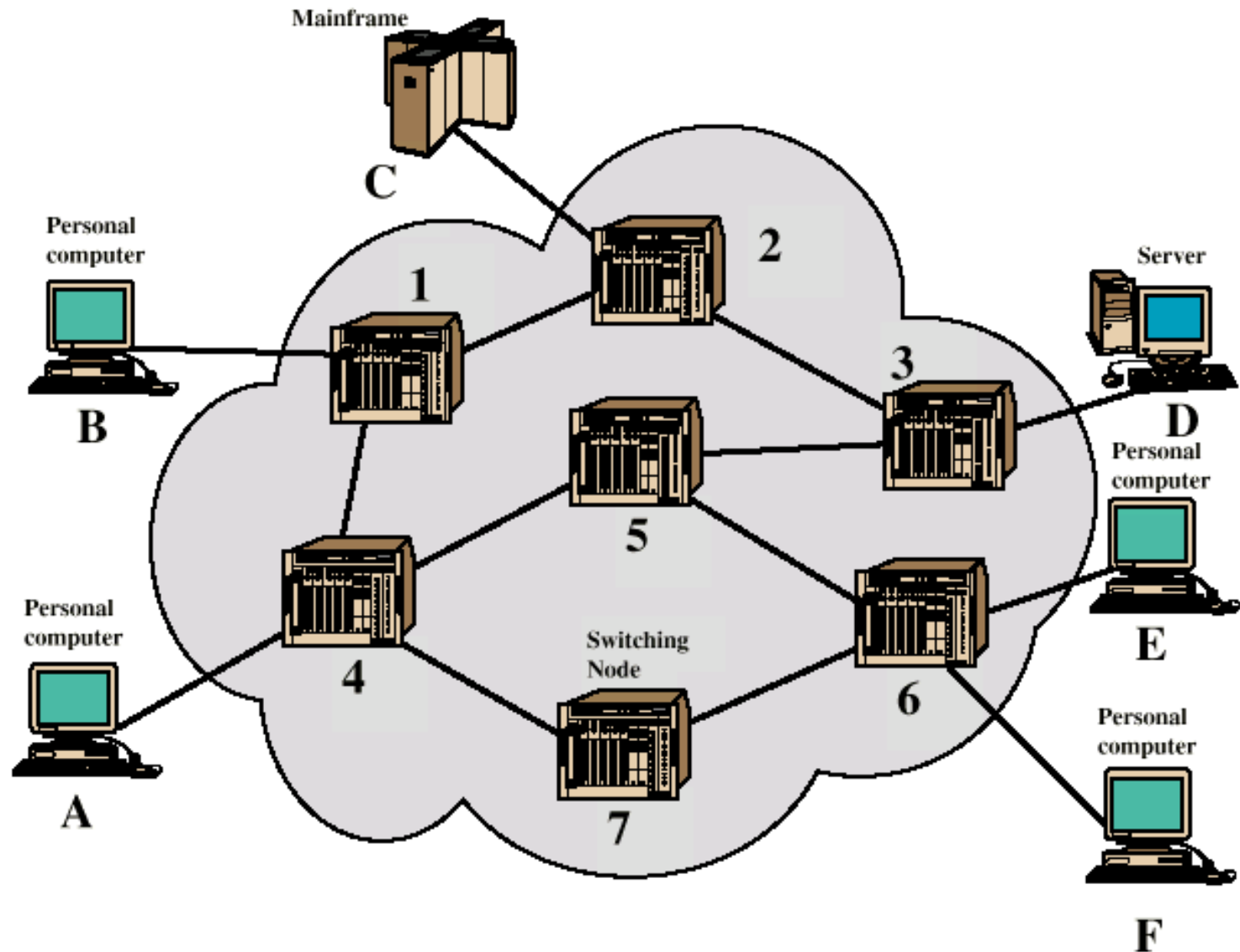
- ⌘ Long distance transmission is typically done over a network of switched nodes
- ⌘ Nodes not concerned with content of data
- ⌘ End devices are stations
  - ☑ Computer, terminal, phone, etc.
- ⌘ A collection of nodes and connections is a communications network
- ⌘ Data routed by being switched from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

# Nodes

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- ⌘ 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

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- ⌘ 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

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## ⌘ Inefficient

- ☒ Channel capacity dedicated for duration of connection

- ☒ If no data, capacity wasted

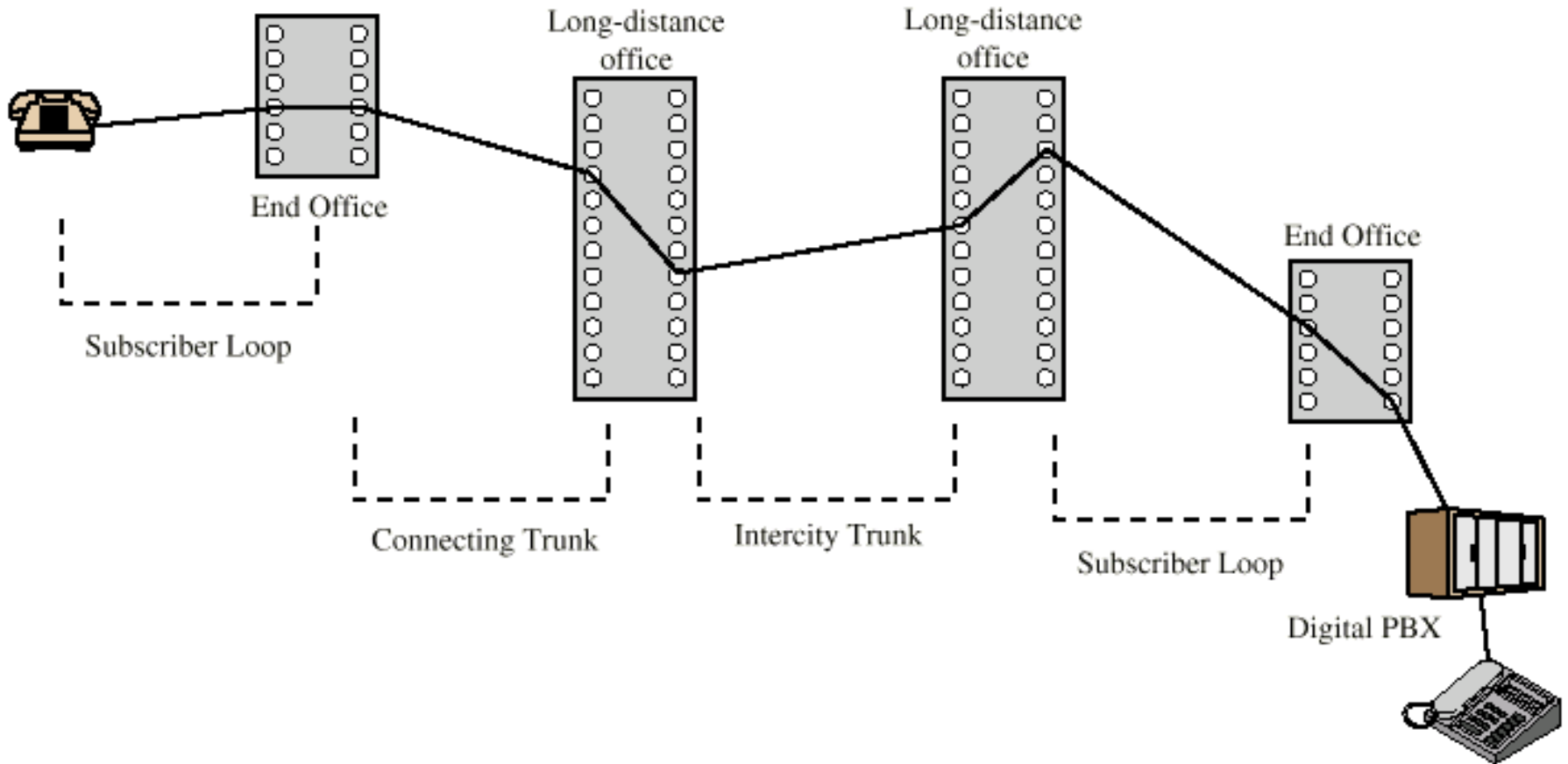
## ⌘ Set up (connection) takes time

## ⌘ Once connected, transfer is transparent

## ⌘ Developed for voice traffic (phone)

# Public Circuit Switched Network

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# Telecomms Components

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## ⌘ Subscriber

- ☑ Devices attached to network

## ⌘ Local Loop

- ☑ Subscriber loop
- ☑ Connection to network

## ⌘ Exchange

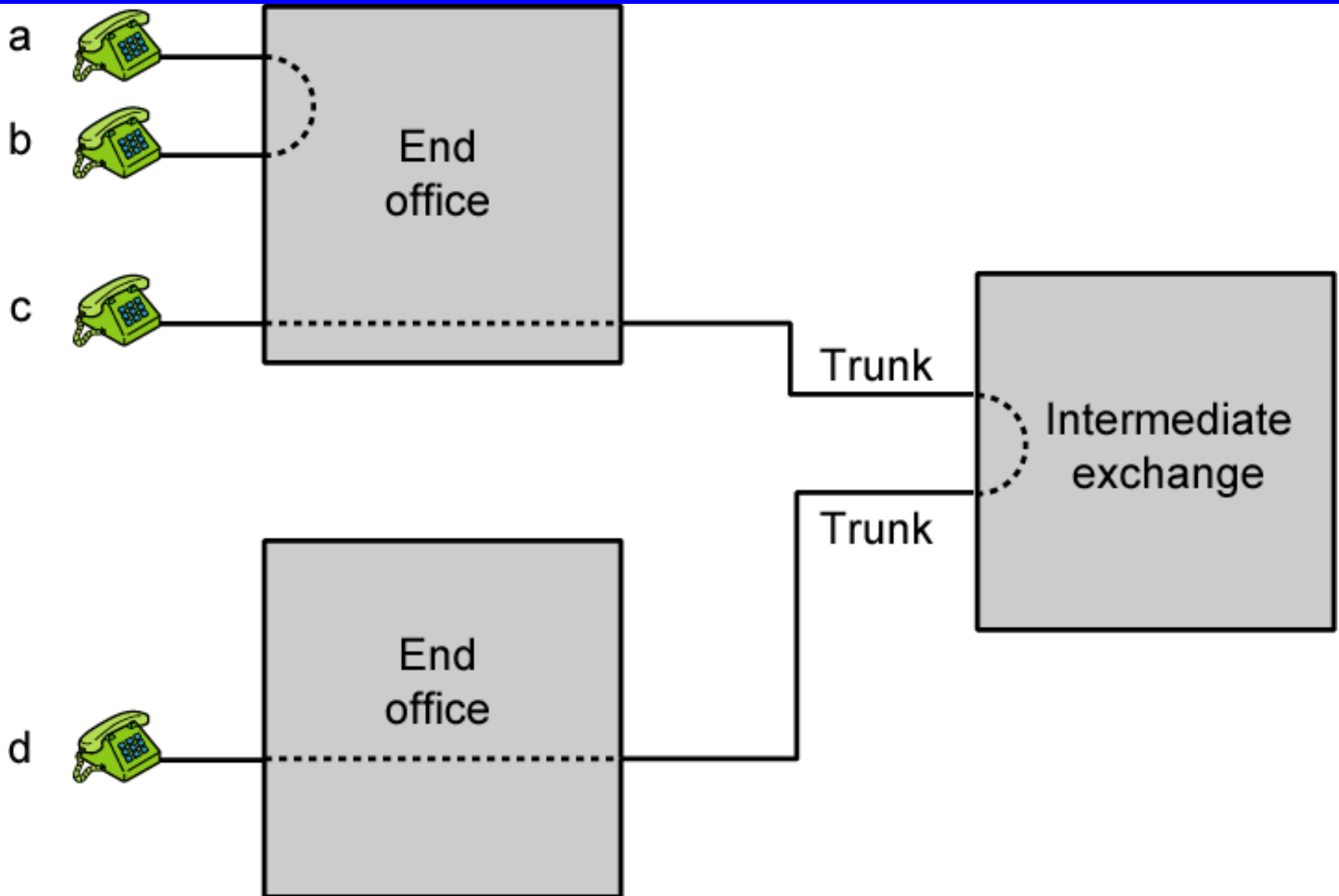
- ☑ Switching centers
- ☑ End office - supports subscribers

## ⌘ Trunks

- ☑ Branches between exchanges
- ☑ Multiplexed

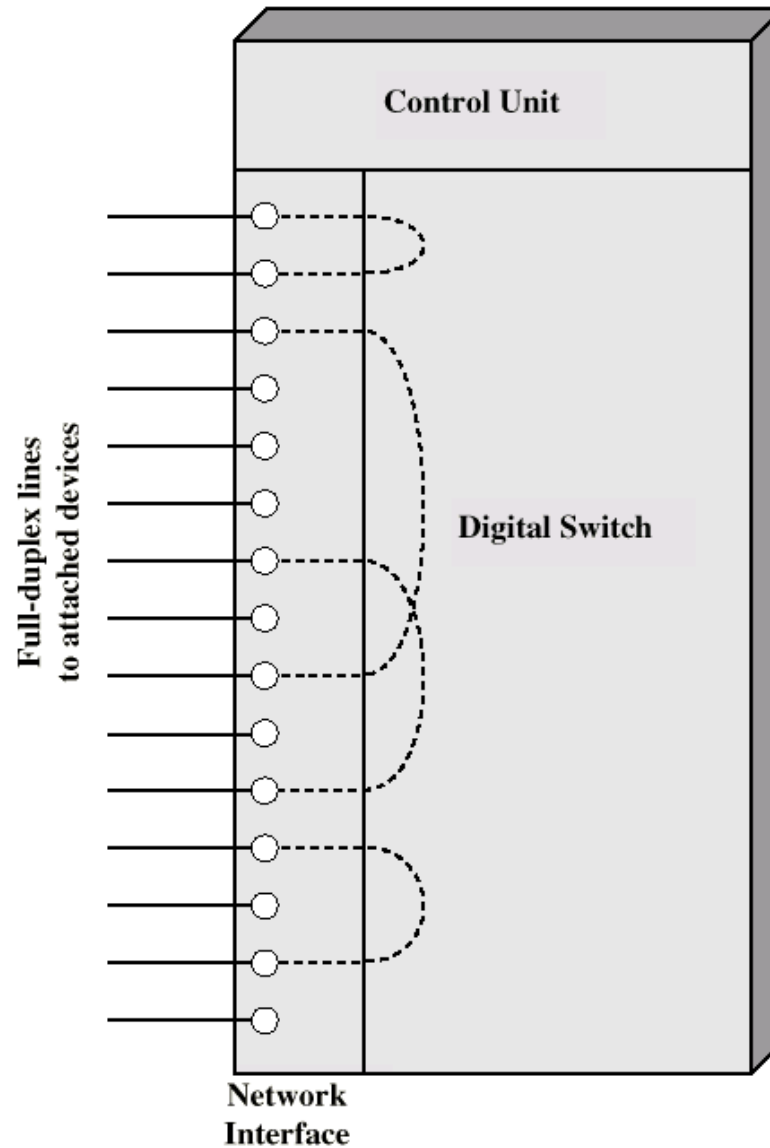
# Circuit Establishment

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# Circuit Switch Elements

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# Circuit Switching Concepts

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## ⌘ 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

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## ⌘ 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

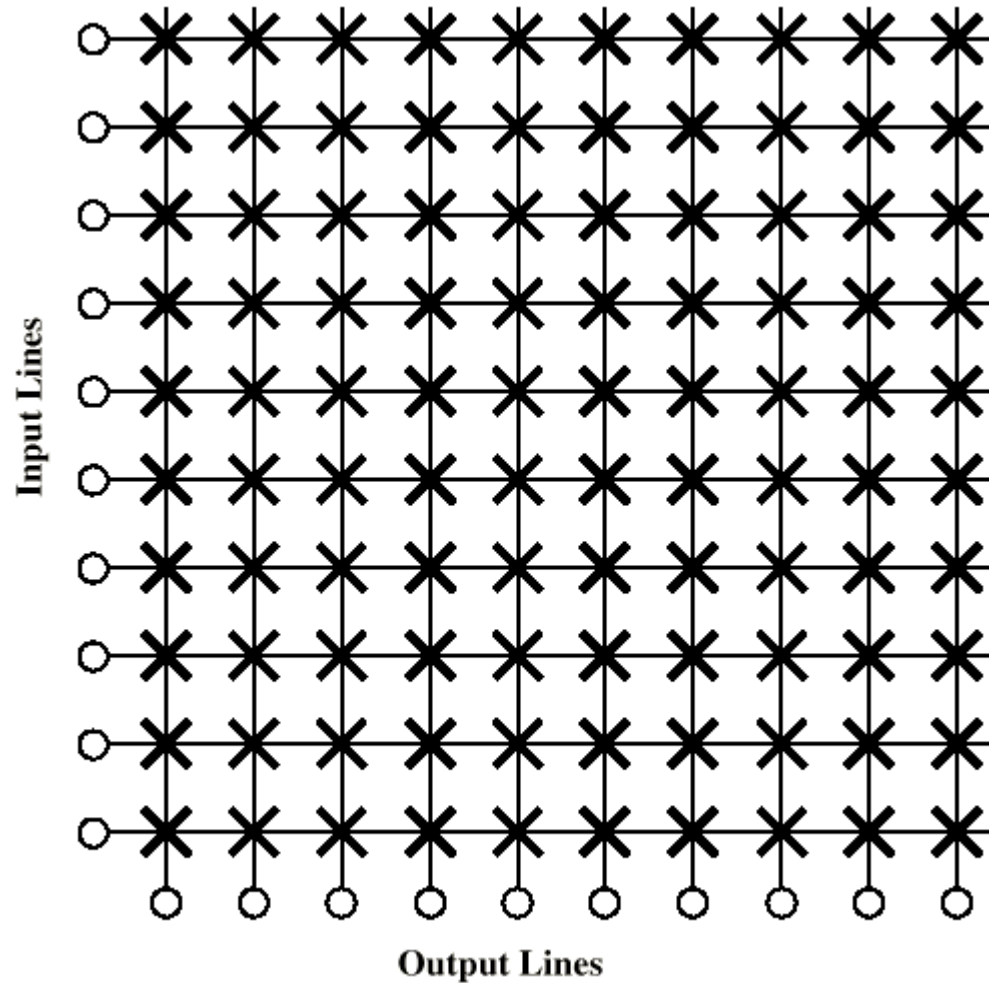
# Space Division Switching

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- ⌘ 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

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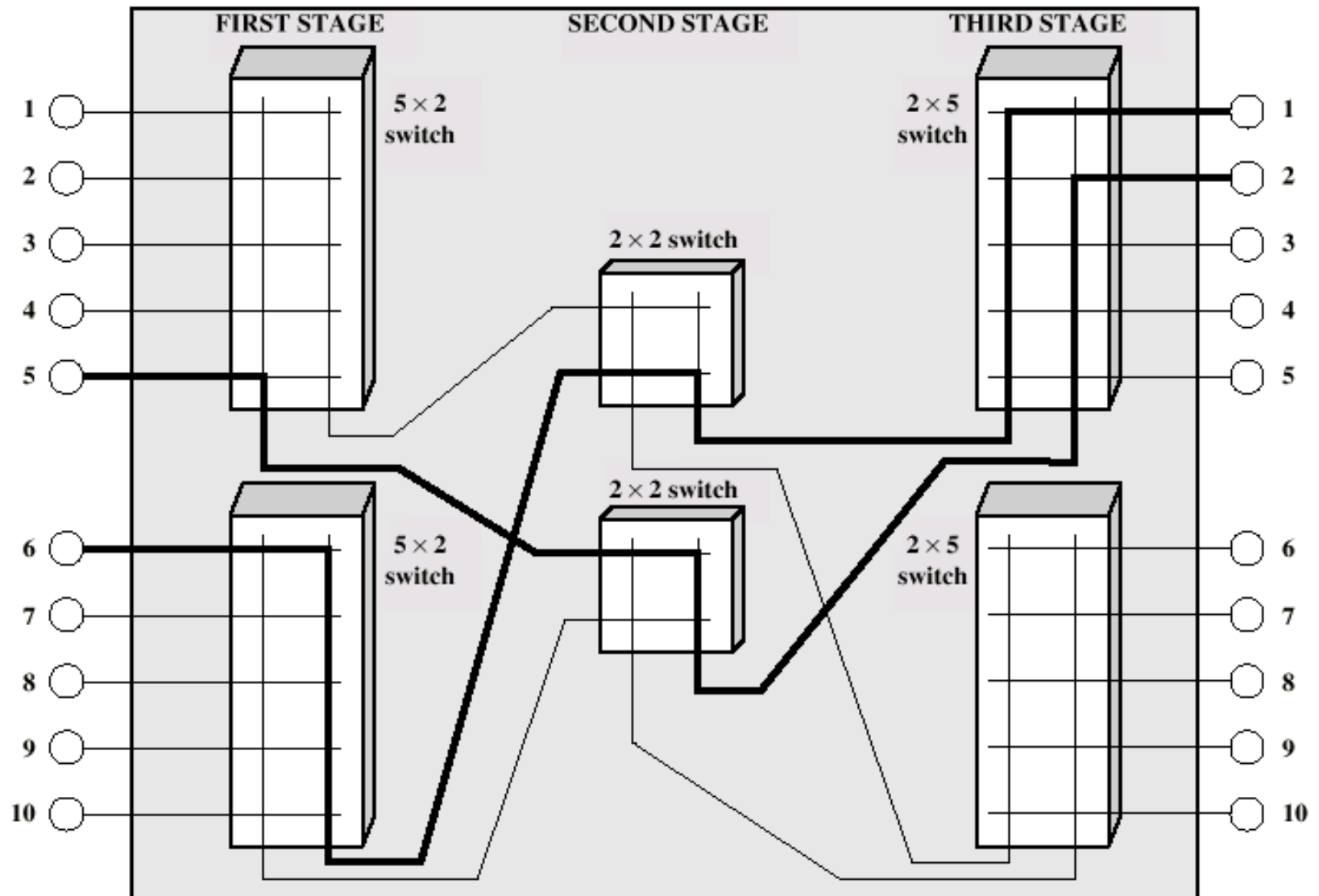


# Multistage Switch

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

# Three Stage Switch



# Time Division Switching

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- ⌘ 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

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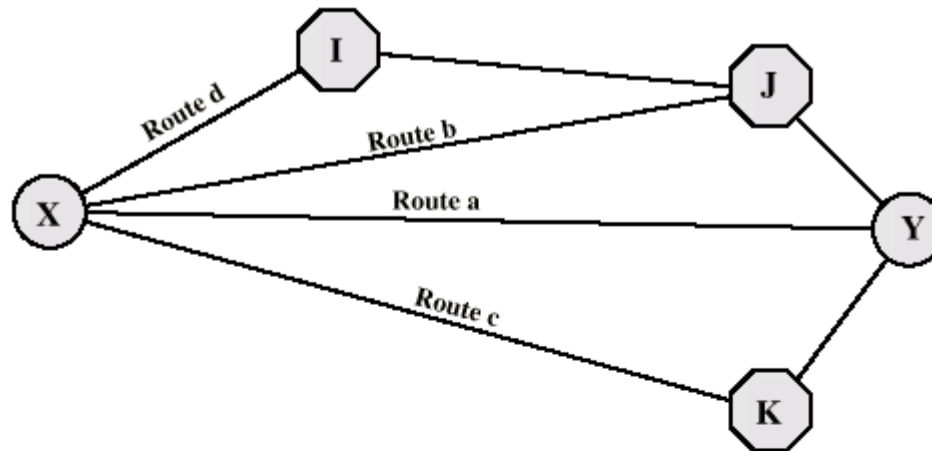
- ⌘ Many connections will need paths through more than one switch
- ⌘ Need to find a route
  - ☑ Efficiency
  - ☑ Resilience
- ⌘ Public telephone switches are a tree structure
  - ☑ Static routing uses the same approach all the time
- ⌘ Dynamic routing allows for changes in routing depending on traffic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

# Alternate Routing

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- ⌘ 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

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- ⌘ 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

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- ⌘ 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

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- ⌘ 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

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## ⌘ Subscriber to network

- ☑ Depends on subscriber device and switch

## ⌘ Within network

- ☑ Management of subscriber calls and network
- ☑ More complex

# In Channel Signaling

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⌘ 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

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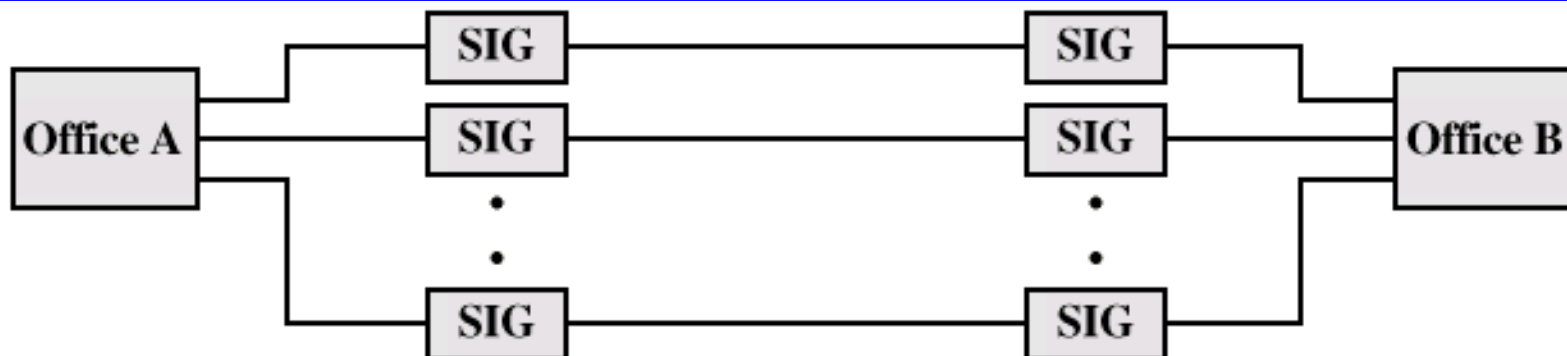
- ⌘ Limited transfer rate
- ⌘ Delay between entering address (dialing) and connection
- ⌘ Overcome by use of common channel signaling

# Common Channel Signaling

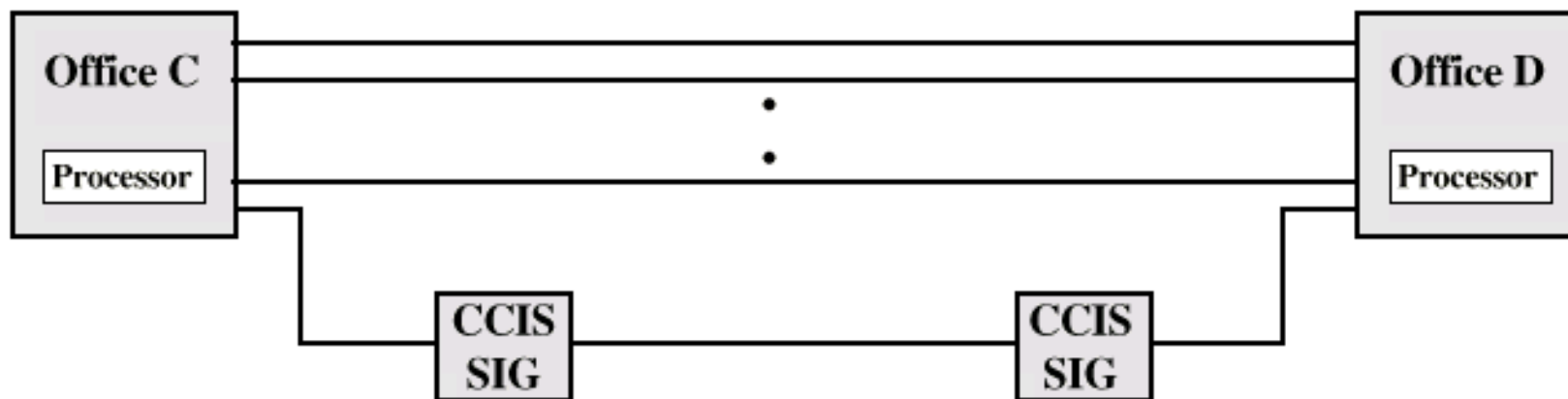
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- ⌘ Control signals carried over paths independent of voice channel
- ⌘ One control signal channel can carry signals for a number of subscriber channels
- ⌘ Common control channel for these subscriber lines
- ⌘ Associated Mode
  - ☑ Common channel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

# Common v. In Channel Signaling



(a) Inchannel



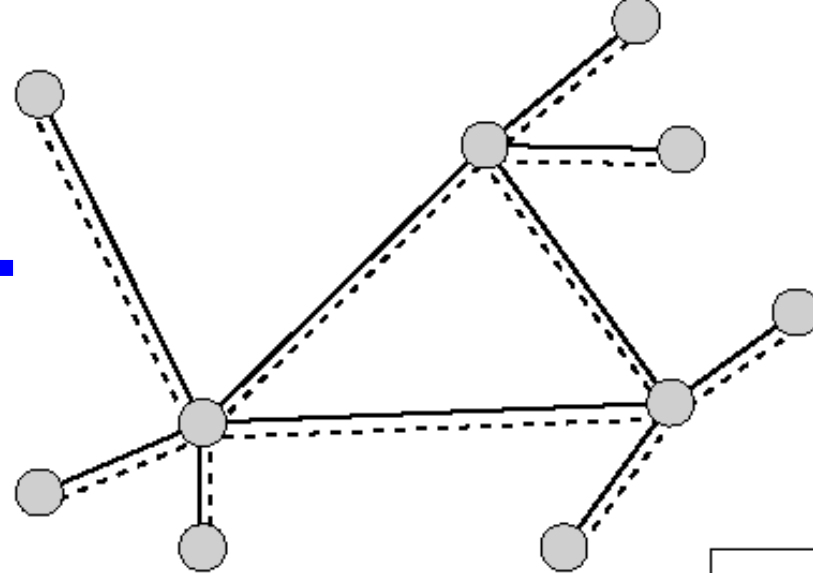
(b) Common channel

CCIS SIG: Common-channel interoffice signaling equipment

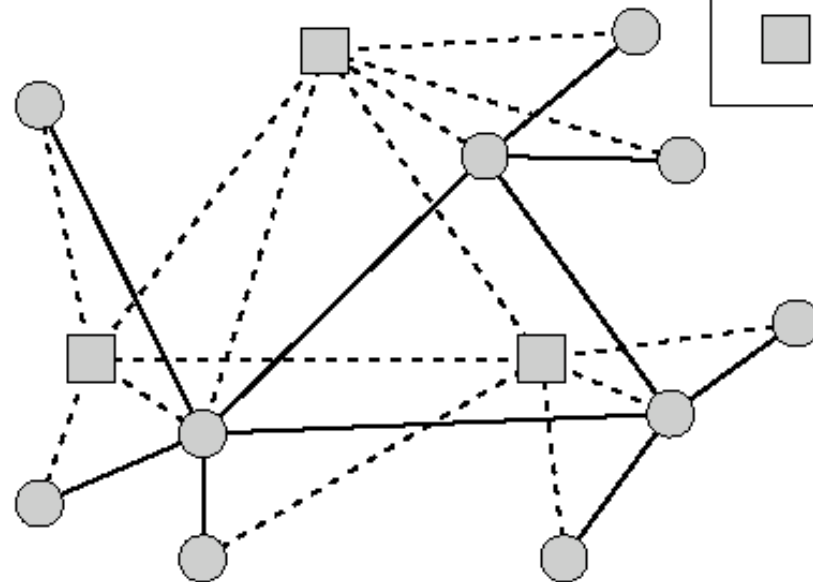
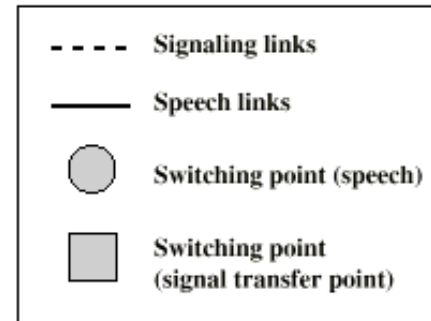
SIG: Per-trunk signaling equipment

# Signaling Modes

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(a) Associated



(b) Disassociated

# Τεχνικές μεταφοράς σήμανσης

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## ⌘ CAS (Channel Associated Signaling)

- ☑ CAS 4bit

- ☑ CAS 2bit

## ⌘ CCS (Common Channel Signaling)

- ☑ Q.931

- ☑ DPNSS (de-facto)

- ☑ QSIG

- ☑ SS7 (PSTN,ISDN,mobile)

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# ΑΡΧΙΤΕΚΤΟΝΙΚΗ ΔΙΚΤΥΟΥ ΣΗΜΑΤΟΔΟΣΙΑΣ



Associated Signaling

# SS7 is used for

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- ⌘ Basic call setup ,management and tear down
- ⌘ wireless services, wireless roaming, and mobile subscriber authentication
- ⌘ Local Number Portability (LNP)
- ⌘ toll free (800/888)
- ⌘ enhanced call features such as call forwarding, calling party name/number display, and three-way calling

# ΣΥΝΙΣΤΩΣΕΣ SS7

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- **Signal switching points (SSPs)**

SSPs are telephone switches (end offices or tandems) equipped with SS7-capable software and terminating signaling links. They generally originate, terminate, or switch calls.

- **Signal Transfer points (STPs)**

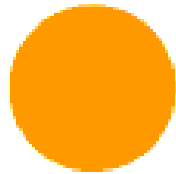
STPs are the packet switches of the SS7 network. They receive and route incoming signaling messages towards the proper destination. They also perform specialized routing functions.

- **Signal control points (SCPs)**

SCPs are databases that provide information necessary for advanced call-processing capabilities.

# Συμβολισμοί SS7

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**SSP**  
Signaling Switching  
Point



**STP**  
Signaling Transfer  
Point



**SCP**  
Signaling Control  
Point

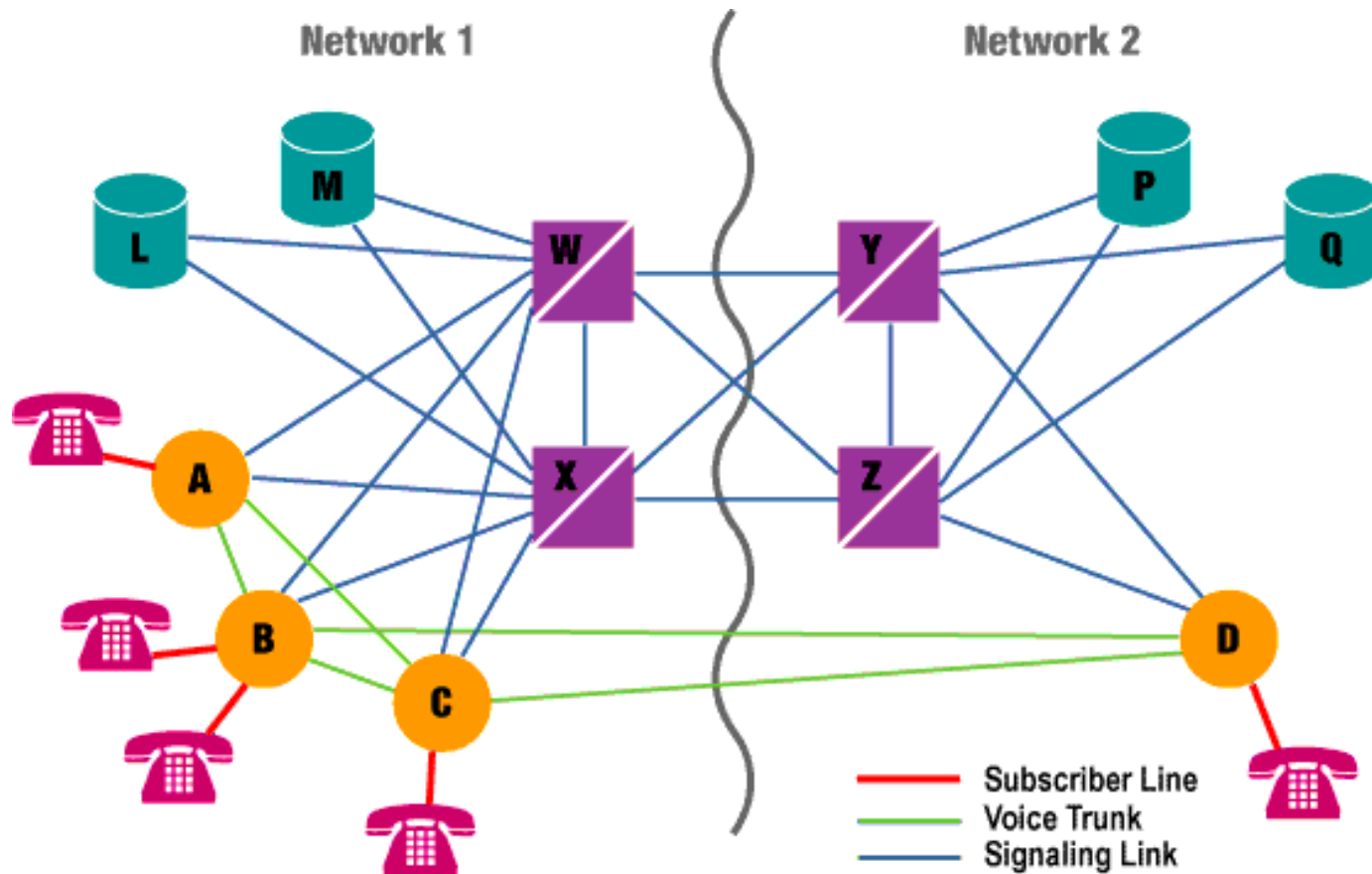


**STP Pair**

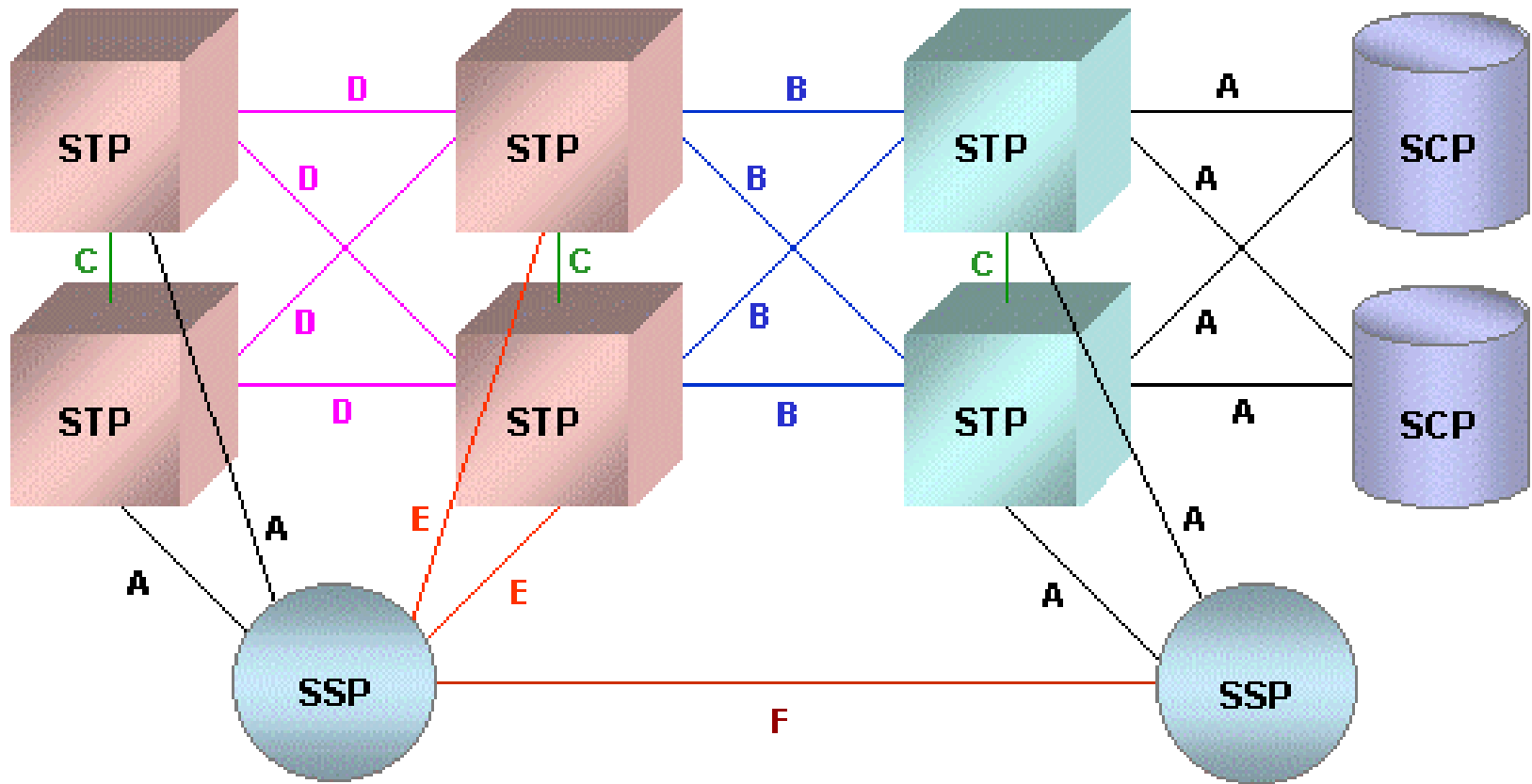


**SCP Pair**

# Αρχιτεκτονική SS7



# SS7 Link Types



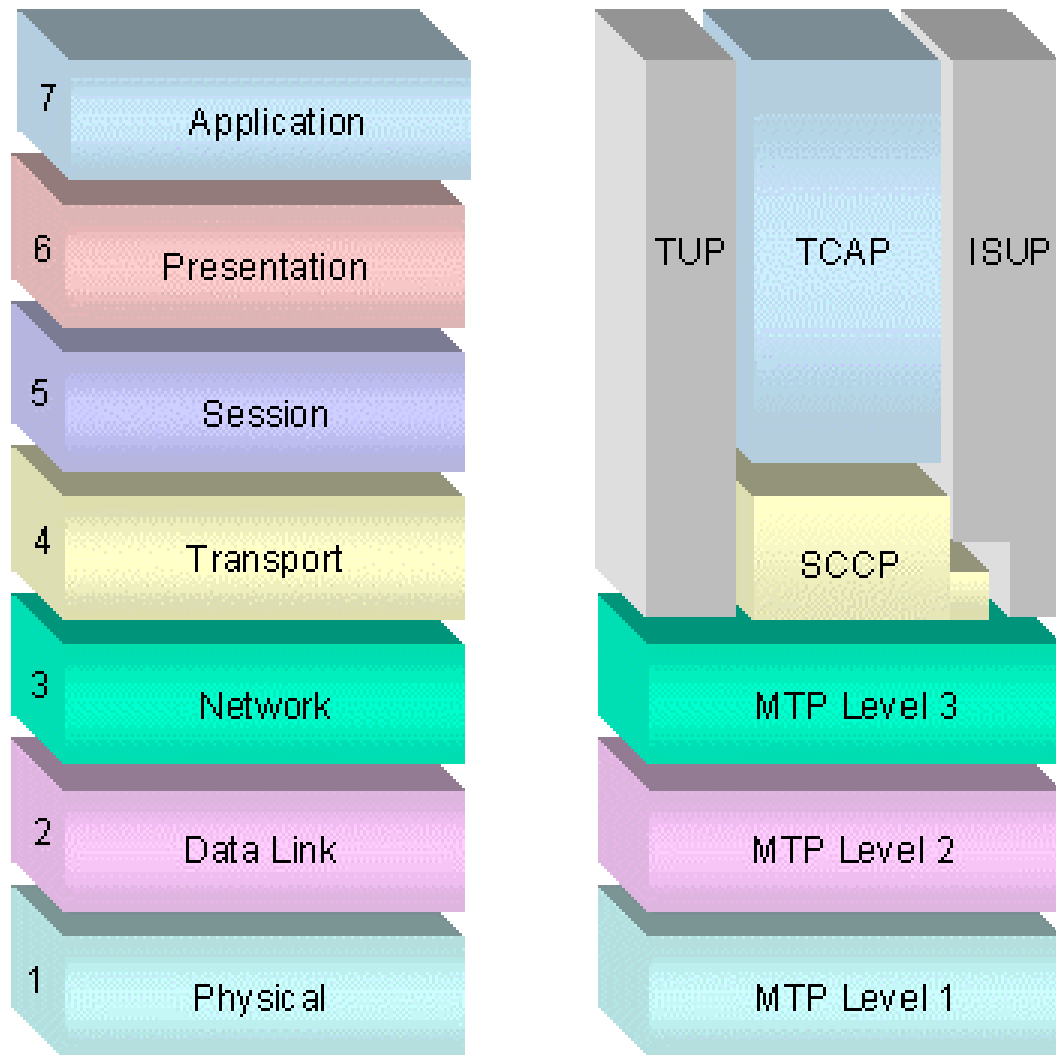
# SS7 Link Types

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- ⌘ A links (Access) between STP and SSP or SCP
- ⌘ B links (Bridge), D (diagonal) between two pairs of STPs
- ⌘ C links (Cross) between mated STPs enhance reability
- ⌘ E links (extended) SSP to a second STP pair
- ⌘ F links (Fully associated) between SSPs

# SS7 Layers

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# SS7 Layers

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- ⌘ MTP 1 (Message Transfer Part) Physical raw data 64 or 56 Kbps
- ⌘ MTP level 2 error checking ,flow control, sequence checking
- ⌘ MTP level 3 node addressing ,routing ,alternate routing between signaling points (Destination PC,Originating PC, SLS ANSI 24bit ITU 14bit)
- ⌘ Singnaling ATM Adaptation Layer

# SS7 Layers

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⌘ **ISDN User Part (ISUP)** defines the protocol used to set-up, manage, and release trunk circuits that carry voice and data between terminating line exchanges. ISUP is used for both **ISDN** and **non-ISDN** calls. Calls that originate and terminate at the same switch do not use ISUP signaling.

# SS7 Layers

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- ⌘ **Telephone User Part (TUP)** In some parts of the world (e.g., China, Brazil), the Telephone User Part (TUP) is used to support basic call setup and tear-down. TUP handles analog circuits only. In many countries, ISUP has replaced TUP for call management.

# SS7 Layers

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## ⌘ Signaling Connection Control Part (SCCP)

SCCP provides connectionless and connection-oriented network services and **global title translation (GTT)** capabilities. A global title is an address (e.g., a dialed 800 number, calling card number, or mobile subscribe identification number) which is translated by SCCP into a destination point code and subsystem number.

# SS7 Layers

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- ⌘ **Transaction Capabilities Applications Part** (TCAP) supports the exchange of non-circuit related data between applications across the SS7 network using the SCCP connectionless service. Queries and responses sent between SSPs and SCPs are carried in TCAP messages. An SSP sends a TCAP query to determine **800/888 number**. mobile networks TCAP carries **Mobile Application Part (MAP)**

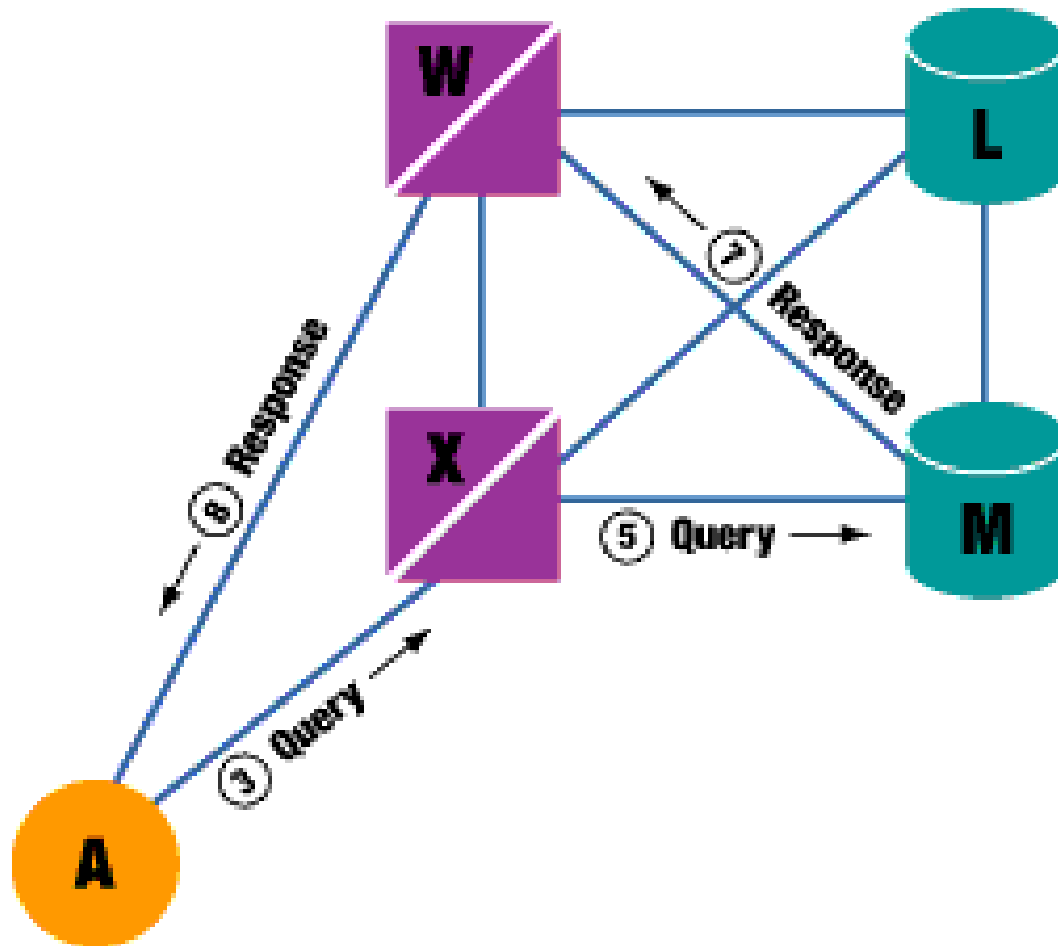
# SS7 Layers

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- ⌘ **Operations, Maintenance and Administration Part (OMAP)** defines messages and protocol designed to assist administrators of the SS7 network. To date, the most fully developed and deployed of these capabilities are procedures for validating network routing tables and for diagnosing link troubles.

# Database Query Example

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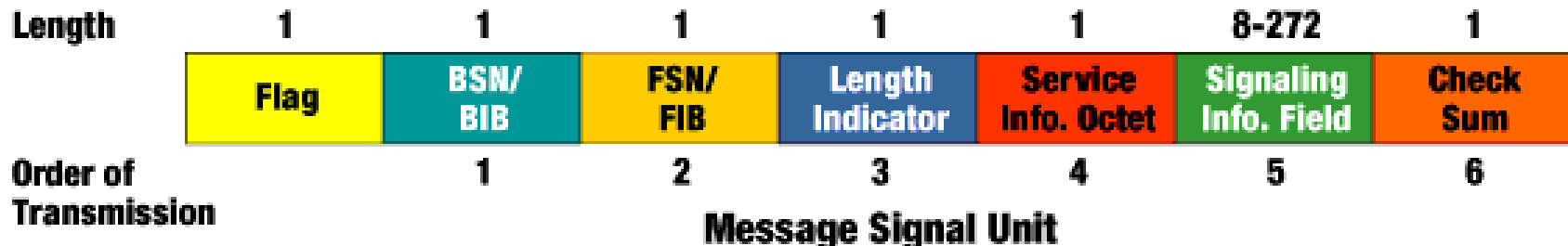
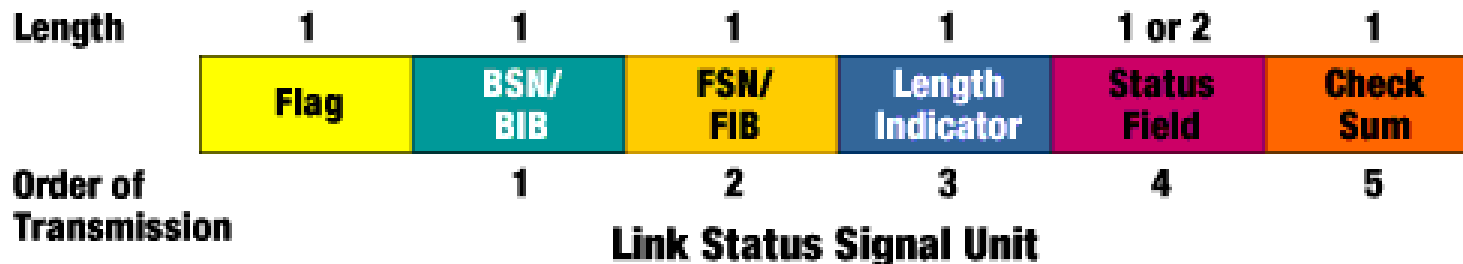
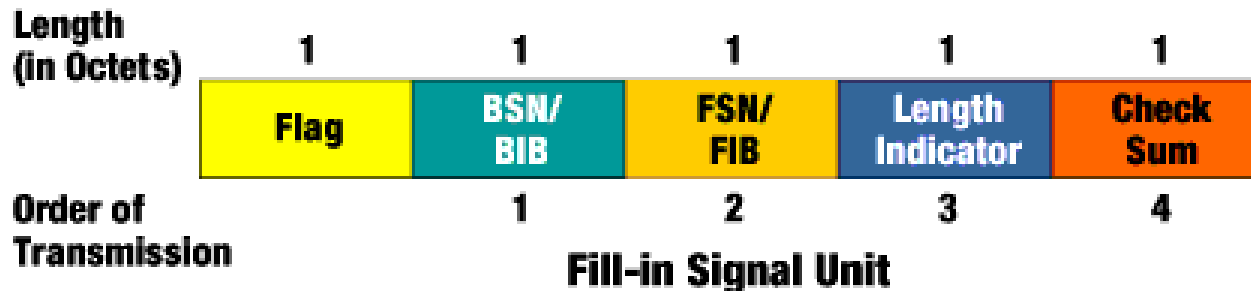
# Signal Units

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- ⌘ Message signal Units (**MSUs**) call setup ,database query and response ,SS7 management
- ⌘ Link status signal Units (**LSSUs**) information about the signaling link between the nodes
- ⌘ Fill in signal Units (**FISUs**) no information occupy the link

# Signal Units

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# Signaling System Number 7

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⌘ 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

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### ⌘ 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

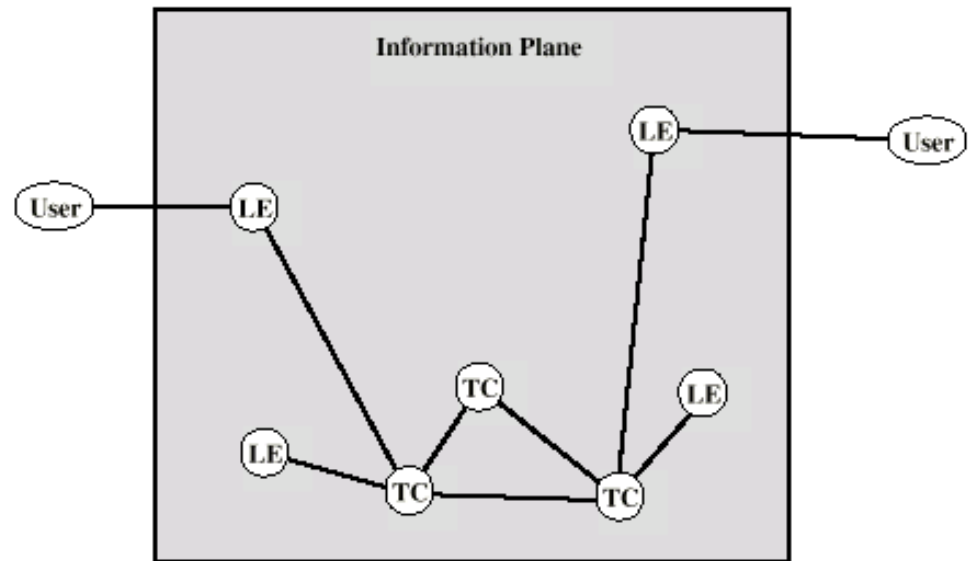
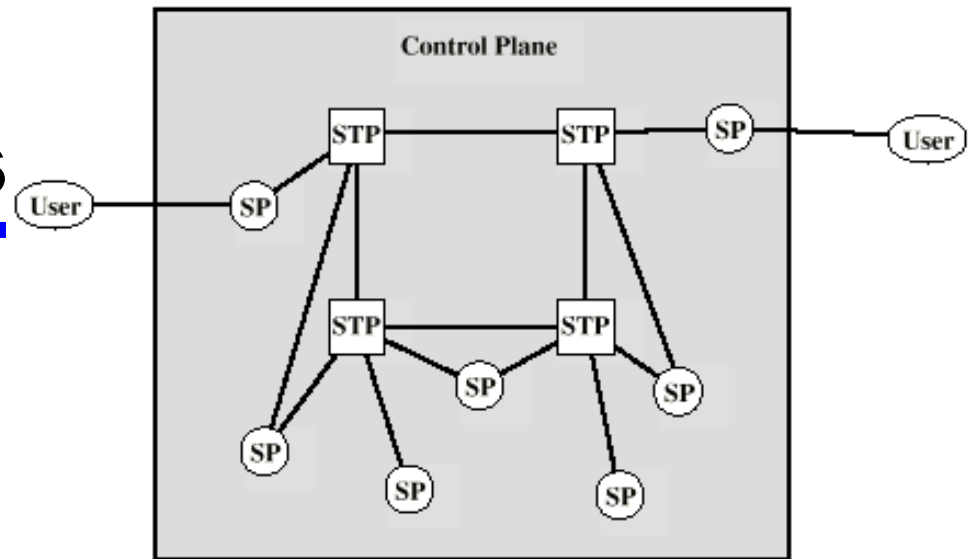
### ⌘ Control plane

- ☑ 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

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## ⌘ 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

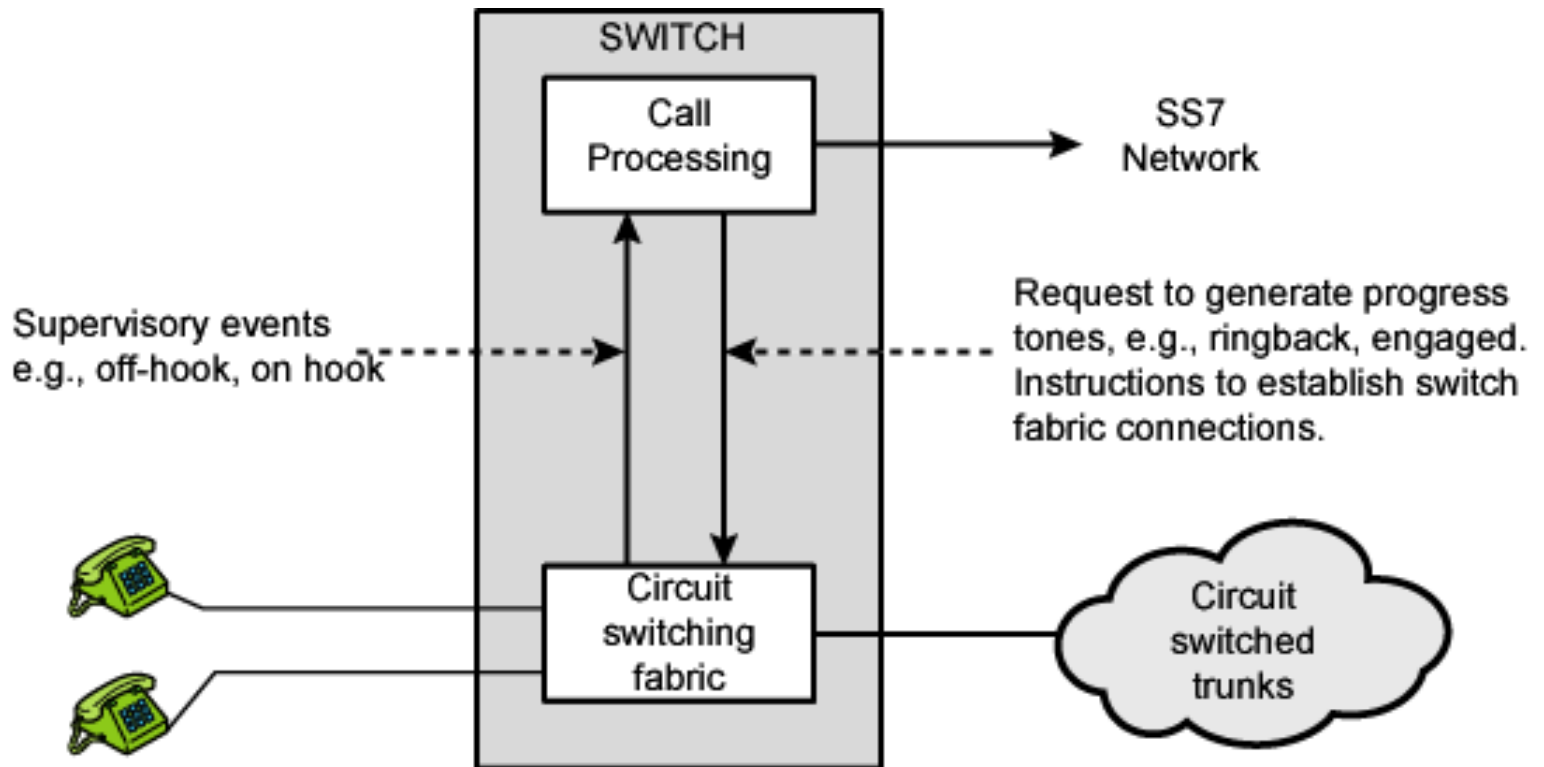
- ☒ Ability of network to provide services in the face of STP failures

# Softswitch Architecture

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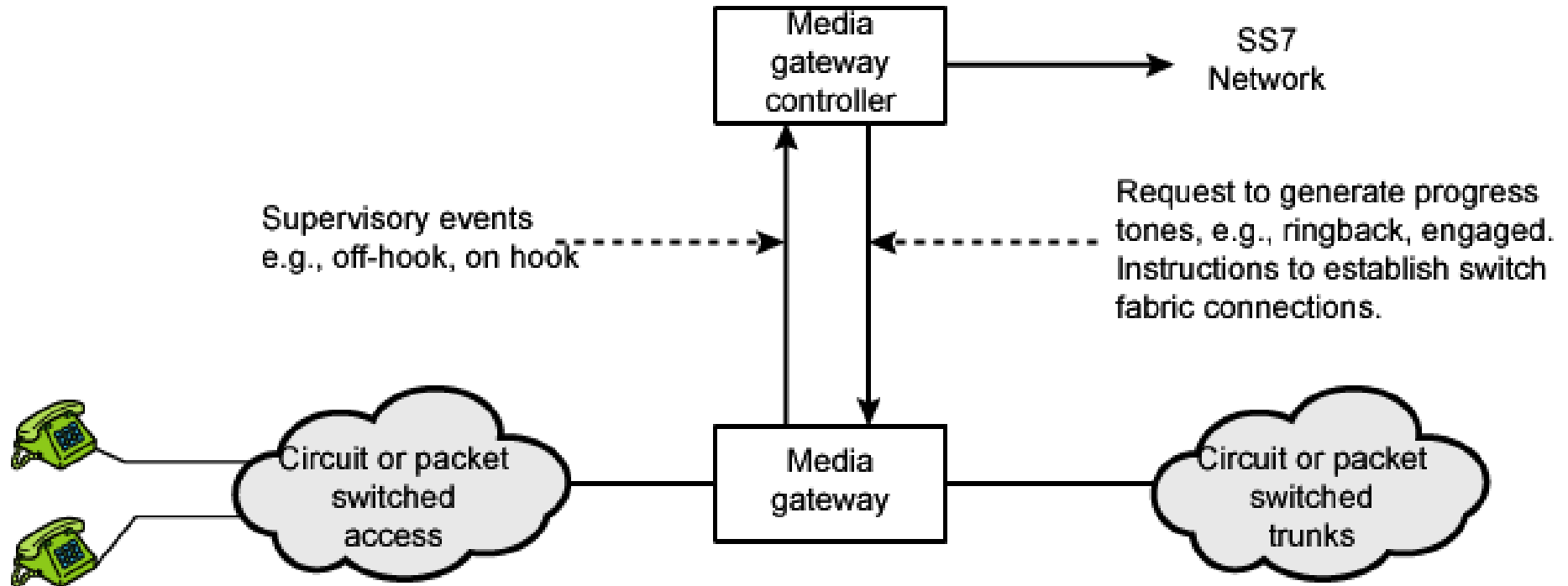
- ⌘ General purpose computer running software to make it a smart phone switch
- ⌘ Lower costs
- ⌘ Greater functionality
  - ☒ Packetizing of digitized voice data
  - ☒ Allowing voice over IP
- ⌘ Most complex part of telephone network switch is software controlling call process
  - ☒ Call routing
  - ☒ 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

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# Required Reading

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