

Wireless Mobile Communication

Lecture 29, 30

- ***Signaling &
Network Control***

Topics to be Covered

- **What is Signaling? and why it is relevant?**
- **The history of signaling**
- **Public Switched Telephone Network (PSTN)**
- **Channel Associated Signaling (CAS)**
- **Common Channel Signaling (CCS)**
- **The limitations of CAS and CCS**

Common but already covered...

- Flow Control
 - Simplex
 - Stop and Wait
 - Go-Back-N
 - Selective Repeat

What is Signaling?

- The signaling network can be considered the telecommunications network's nervous system. It breathes life into the infrastructure.
- The ITU-T defines signaling as
 - "The exchange of information (other than by speech) specifically concerned with the establishment, release and other control of calls, and network management, in automatic telecommunications operation."**
- 2 Minute Test:
 - Write 5 Reasons why Signaling is relevant?

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The History of Signaling

- **Before 1878:** Star connections between phones
- **1878:** 1st Manual Exchange
 - Less Wires
 - Busy Operators
 - Privacy and Security Allegations
- **1889:** 1st Automatic Exchange (Strowger Exchange)
- **1896:** Pulse Dial
- **1950s-1996s:** Direct Distance Dialing then

Manual Operator Vs Automatic Equivalent

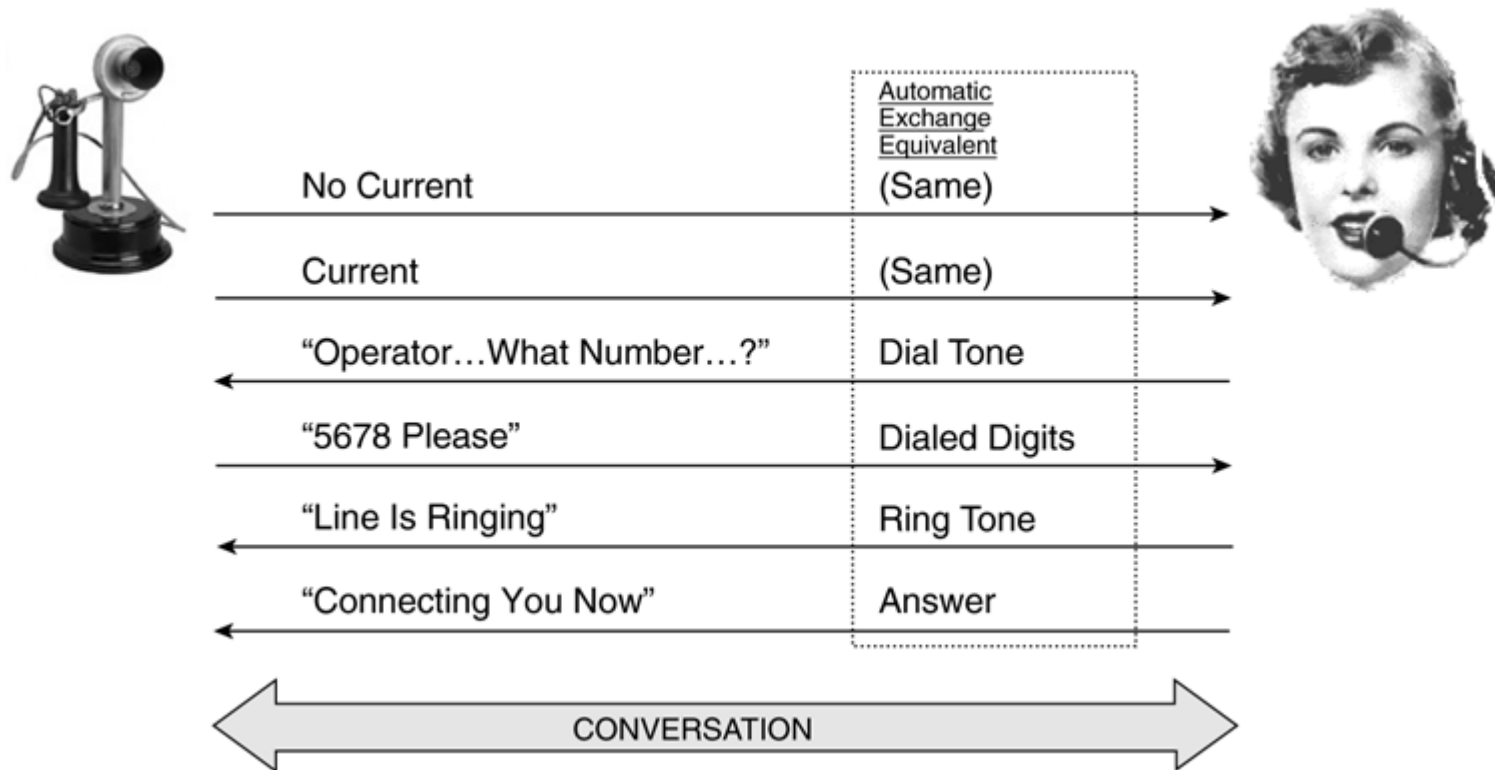


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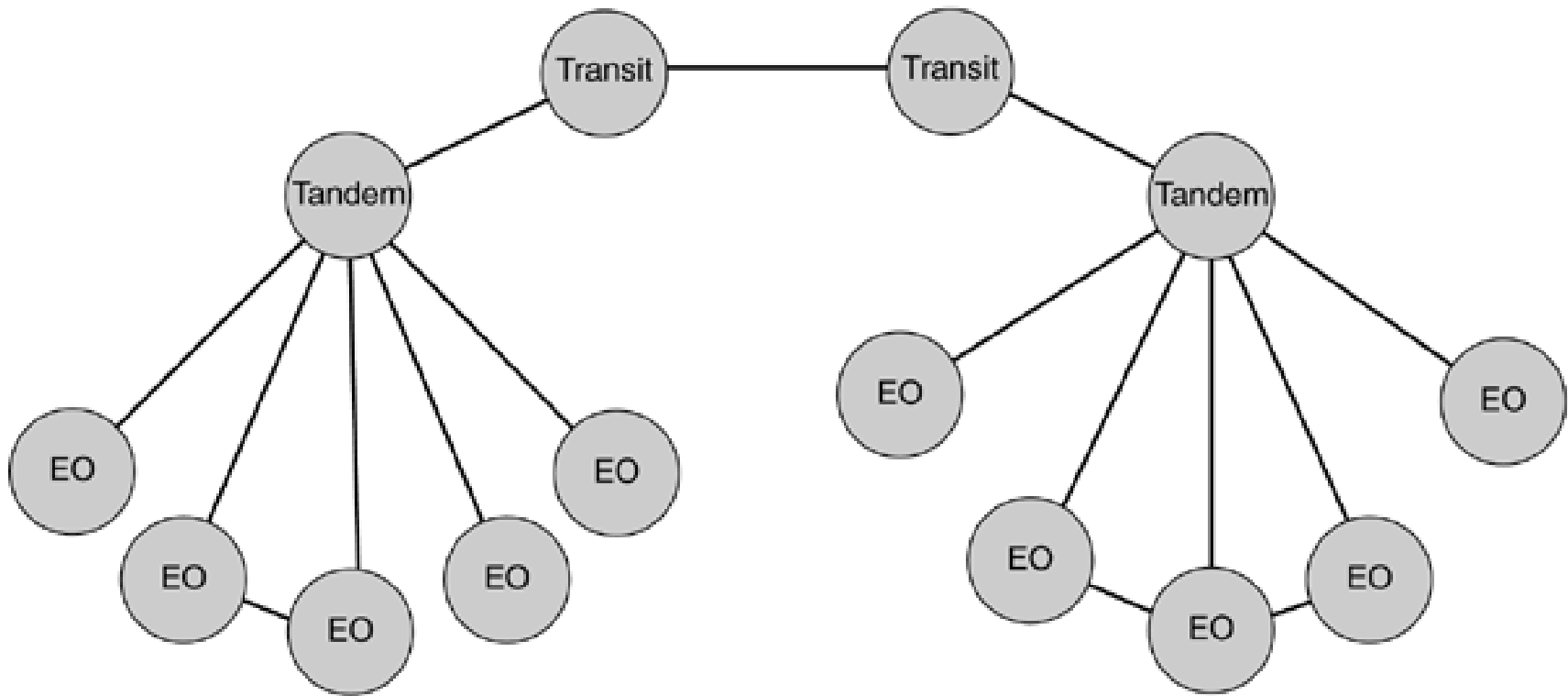
PSTN Network Topology

- The topology of a network describes the various network nodes and how they interconnect.
- Types of Nodes in the PSTN:
 - End Office (EO): Also called a Local Exchange. The End Office provides network access for the subscriber.
 - Tandem: Connects EOs together, providing an aggregation point for traffic between them.
 - Transit: Provides an interface to another hierarchical network level. Transit switches are generally used to aggregate traffic that is carried across long geographical distances.

PSTN Network Topology

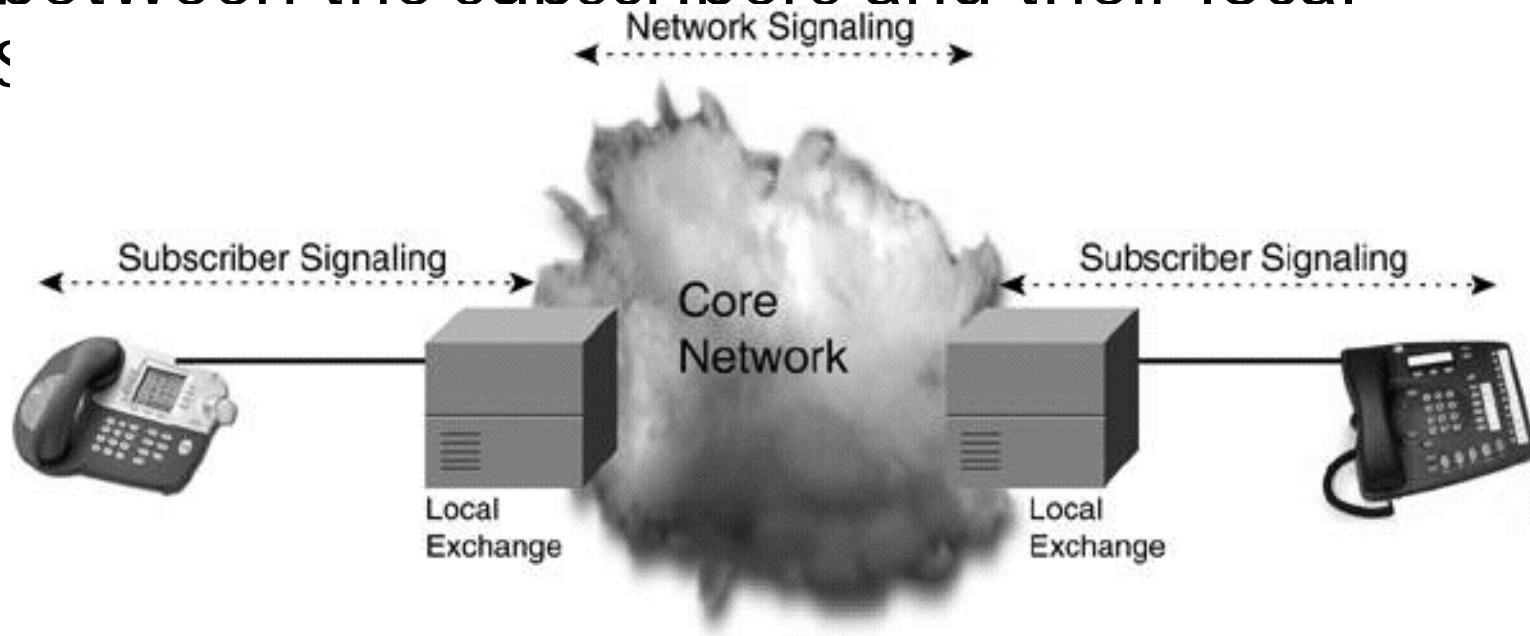
- There are two primary methods of connecting switching nodes.
- The first approach is a mesh topology, in which all nodes are interconnected.
- The second approach is a hierarchical tree in which nodes are aggregated as the hierarchy traverses from the subscriber access points to the top of the tree.
- PSTN networks use a combination of these two methods, which are largely driven by cost and the traffic patterns between exchanges.

PSTN Network Topology



Network and Subscriber Signaling

- Network signaling takes place between nodes in the core network.
- Subscriber signaling takes place on the line between the subscribers and their local



Network and Subscriber Signaling

- The subscriber must only generate a limited number of signals: on or off hook, called party digits, and possibly a few commands for supplementary services. In comparison, a modern core network must perform very complex signaling, such as those to support database driven services like Local Number Portability (LNP), credit or calling card validation, and cellular roaming.
- Network signaling was previously implemented using Channel Associated Signaling (CAS) techniques and systems.
- It has been replaced with ¹⁴Common Channel

Forward and Backward signals

- Forward signals refer to signals that transfer in the direction of call establishment, or from the calling party to the called party.
- Backward signals refer to signals that transfer in the reverse direction.

Subscriber Signaling

- Most subscribers are connected to their local switch by analog subscriber lines.
- Subscriber signaling has evolved less rapidly than network signaling.
- Subscriber signals can be broken down into the following four categories:
 - Address Signals
 - Supervisory Signals
 - Tones and Announcements
 - Ringing

Supervisory Signals

- A telephone has two possible supervision states:
 - on-hook: On-hook is the condition in which the telephone is not in use.
 - off-hook: The telephone enters the off-hook condition when the handset is lifted from its cradle.
- The presence or absence of direct current in the subscriber's local switch line determines the telephone's supervision state.

Tones and Announcements

- Tones and announcements are audible backward signals, such as dial tone, ring back, and busy-tone, that are sent by a switch to the

Tone	Frequency (Hz)	On Time (Sec)	Off Time (Sec)
Dial	350+440	Continuous	
Busy	480+620	0.5	0.5
Ring back, Normal	440+480	2	4
Ring back, PBX	440+488	1	3
Congestion (Local)	480+620	0.3	0.2
Congestion (Toll)	480+620	0.2	0.3
Howler (Receiver wrongly off-hook)	1400+2060+2450+2600	0.1	0.1

Ringling

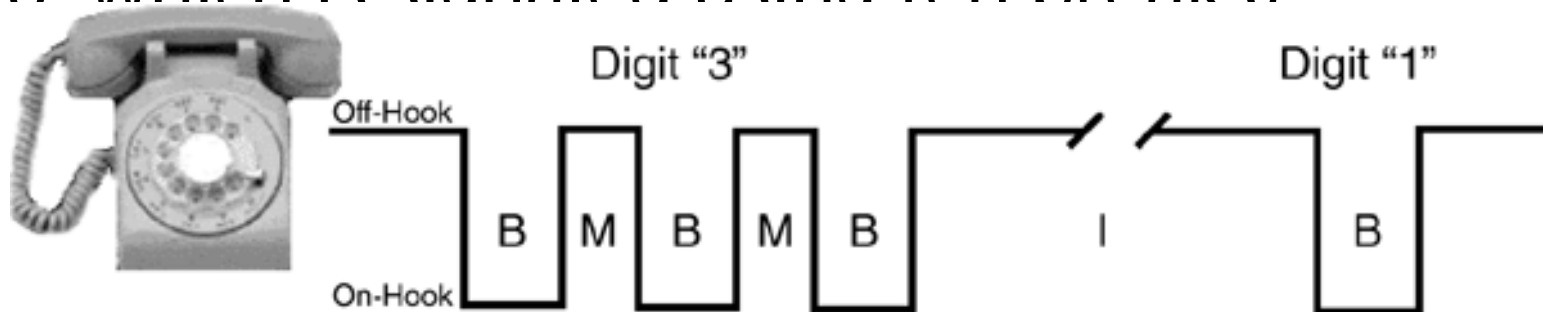
- Ringling is a forward signal sent by the switch to the called subscriber to indicate the arrival of a call.
- It is known more specifically as power ringling to distinguish it from audible ringling, which is played to the calling party to alert him that the called party phone is ringling.
- Note:
 - Audible and power ringling are not synchronized. This is why, on a rare occasion, a caller is already on the line when you lift the handset.
 - This problem occurs because the caller's switch does not generate an independent ringling signal for each line. Instead, it generates one signal that is applied to whichever lines are to be played audible ringling.

Address Signals

- Address signals represent the called party number's dialed digits.
- Address signaling occurs when the telephone is off-hook.
- For analog lines, address signaling is either conveyed by the dial pulse or Dual-Tone Multiple Frequency (DTMF) methods.

Dial Pulse

- The number of breaks in the string represents the digits: one break for value 1, two breaks for value 2, and so on (except for the value of 0 which is signaled using ten breaks)



DTMF

- A DTMF signal is created using a pair of tones, each with a different frequency.
- It is much faster than the previous pulse method and can be used for signaling after

	1209 Hz	1336 Hz	1477 Hz	1633 Hz
697 Hz	1	2	3	A
770 Hz	4	5	6	B
852 Hz	7	8	9	C
941 Hz	*	0	#	D

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Channel Associated Signaling

- The key feature that distinguishes Channel Associated Signaling (CAS) from Common Channel Signaling (CCS) is that a dedicated fixed signaling capacity is set aside for each and every trunk in a fixed, pre-determined way.
- CAS can be implemented using the following related systems:
 - Bell Systems MF, R2, R1, and C5.
 - Single-frequency (SF) in-band and out-of-band signaling
 - Robbed bit signaling

Limitations of CAS

- **Susceptibility to Fraud:** CAS employing in-band supervisory signaling is extremely susceptible to fraud because the subscriber can generate these signals by simply using a tone generator down a handset mouthpiece.
- **Limited Signaling Information:** CAS is limited by the amount of information that can be signaled using the voice channel. Because only a small portion of the voice band is used for signaling.
- **Inefficient Use of Resources:** CAS systems are inefficient because they require either continuous signaling or, in the case of digital CAS, at regular intervals even without new signals.
- **Signaling is limited:** to call set-up and release phases only. This means that signaling cannot take place during the call connection phase.

Common Channel Signaling (CCS)

- CCS refers to the situation in which the signaling capacity is provided in a common pool, with the capacity being used as and when necessary.
- The signaling channel can usually carry signaling information for thousands of traffic circuits.
- CCS systems are packet-based, transferring over 200 bytes in a single SS7 packet, as opposed to a few bits allocated to act as indicators in digital CAS. The signaling information is transferred by means of messages, which is a block of information that

Circuit-Related & Non-Circuit-Related

- **Circuit-Related Signaling:** refers to the original functionality of signaling, which is to establish, supervise, and release trunks. In other words, it is used to set up, manage, and clear down basic telephone service calls.
- **Non-Circuit-Related Signaling:** refers to signaling that is not related to the establishment, supervision, and release of trunks. Due to the advent of supplementary services and the need for database communication in cellular networks and Intelligent Networks.
- Non-circuit-related signaling²⁷ allows the

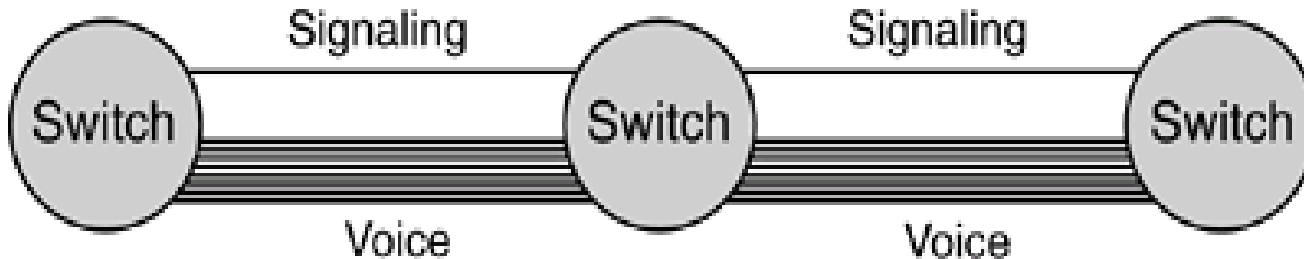
Common Channel Signaling Modes

- There are three types of CCS signaling modes:
 - Associated
 - Quasi-associated
 - Non-associated
- SS7 runs in associated or quasi-associated mode, but not in non-associated mode. Associated and quasi-associated signaling modes ensure sequential delivery, while non-associated does not. SS7 does not run in non-associated mode because it does not have procedures for reordering out-of-sequence messages.

Associated Signaling

- both the signaling and the corresponding user traffic take the same route through the network.

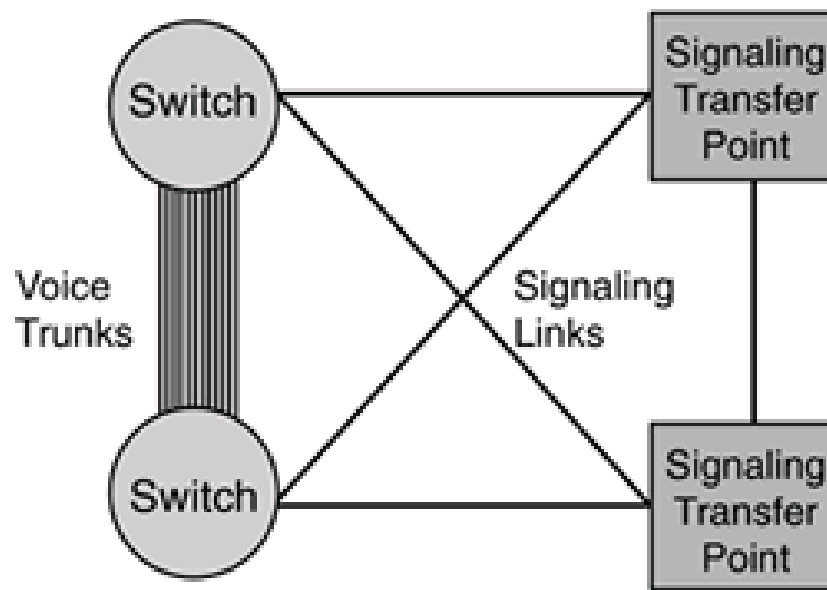
- Associated mode requires every network switch to have signaling links to every other switch fully



Quasi-Associated Signaling

- In quasi-associated mode, signaling follows a different route than the switched traffic to which it refers, requiring the signaling to traverse at least one intermediate node.

Quasi-ass
better use



make

Non-Associated Signaling

- Because the path is not fixed at a given point in time in non-associated mode, the signaling has many possible routes through the network for a given call or transaction. Therefore, the packets might arrive out of sequence because different routes might have been traversed.
- SS7 does not run in non-associated mode because no procedures exist for reordering out-of-sequence messages. Associated and quasi-associated signaling modes assure sequential delivery, while non-associated signaling does not.

CCS Limitations

- CSS has the following disadvantages in comparison to CAS:
 - CCS links can be a single point of failure—a single link can control thousands of voice circuits, so if a link fails and no alternative routes are found, thousands of calls could be lost.
 - There is no inherent testing of speech path by call set-up signaling, so elaborate Continuity Test procedures are required.

Signaling System 7

- SS7/C7 is the protocol suite that is employed globally, across telecommunications networks, to provide signaling.
- It is a packet-switched network, as well as a service platform. Being a signaling protocol, it provides the mechanisms to allow the telecommunication network elements to exchange control information.
- SS7/C7 is the key enabler of the public switched telephone network (PSTN), the integrated services digital network (ISDN), intelligent networks (INs), and public land mobile networks (PLMNs).

Signaling System 7

- Each time a cellular phone is powered up, SS7/C7-based transactions identify, authenticate, and register the subscriber.
- SS7/C7 network tracks the cellular subscriber to allow call delivery, as well as to allow a call that is already in progress to remain connected, even when the subscriber is mobile.
- SS7/C7 is possibly the most important element from a quality of service (QoS) perspective, as perceived by the subscriber.

Impact of SS7 Network Failure

- The critical nature of the SS7 network and the potential impact of failures was demonstrated in January 1990 when a failure in the SS7 software of an AT&T switching node rippled through over 100 switching nodes. The failure caused a nine-hour outage, affecting an estimated 60,000 people and costing in excess of 60 million dollars in lost revenue as estimated by AT&T.

Signaling System No. 7-Based Services

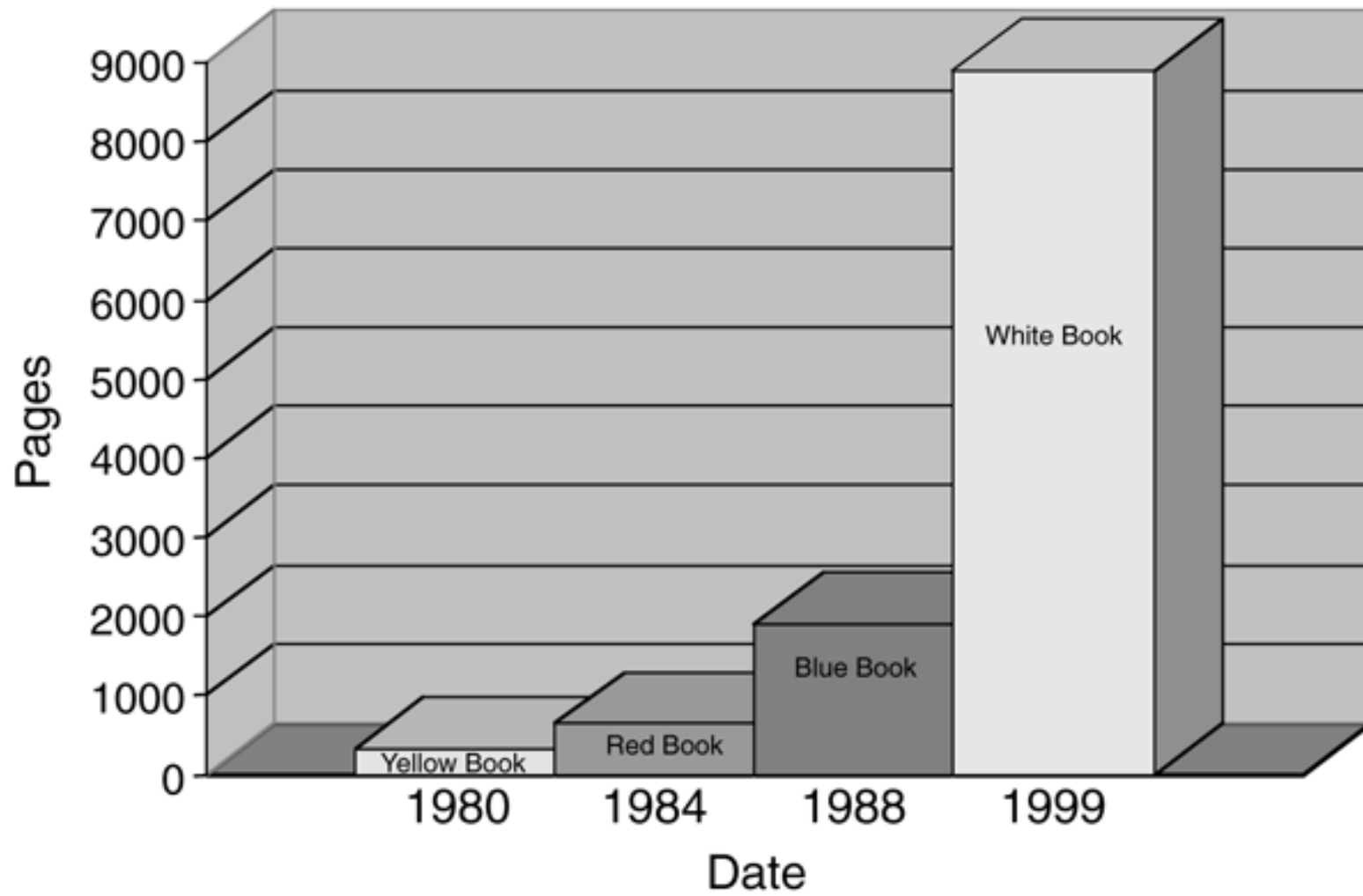
- Telephone-marketing numbers such as toll-free and freephone
- Televoting (mass calling)
- Single Directory Number
- Supplementary services
- Calling name (CNAM)
- Local number portability (LNP)
- Cellular network mobility management and roaming
 - - Short Message Service (SMS)
 - - Enhanced Messaging Service (EMS)— Ringtone, logo, and cellular game delivery

Signaling System No. 7: The Key to Convergence

- SS7/C7 is invested with Internet and other data-centric technologies to:
 - Internet Call Waiting
 - Internet Calling Name Services
 - Click-to-Dial Applications
 - Web-Browser-Based Telecommunication Services
 - WLAN "Hotspot" Billing
 - Location-Based Games

Pre-SS7 Systems

- CCITT R1 (regional 1)
- C6 (CCITT Signaling System No. 6), also called SS6, was the first system to employ Common Channel Signaling (CCS).
- AT&T developed SS7/C7 in 1975, and the International Telegraph and Telephone Consultative Committee (CCITT) adopted it in 1980 as a worldwide standard.

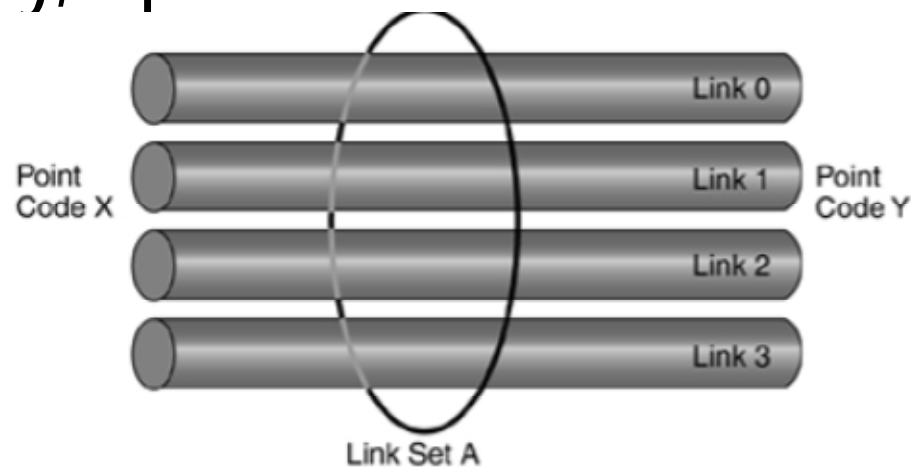


SS7 Network Architecture

- The worldwide signaling network has two functionally independent levels:
 - International
 - National
- SS7 network nodes are called signaling points (SPs).
- Each SP is addressed by an integer called a point code (PC).
 - The international network uses a 14-bit PC.
 - The national networks also use a 14-bit PC except North America and China, which use an incompatible 24-bit PC.

Signaling Links and Linksets

- SPs are connected to each other by signaling links over which signaling takes place.
- The bandwidth of a signaling link is normally 64 kilobits per second (kbps).
- To provide more bandwidth and/or for redundancy, up to 16 links between two SPs can be used. This collection of links is called a linkset.



two SP

Routes and Routesets

- SS7 routes are statically provisioned at each SP. There are no mechanisms for route discovery.
- A ***route*** is defined as a preprovisioned path between source and destination for a particular relation.
- All the preprovisioned routes to a particular SP destination are called the ***routeset***.

Node Types

- There are three different types of SP:
 - Signal Transfer Point
 - Service Switching Point
 - Service Control Point



Signal Transfer Point

- A Signal Transfer Point (STP) is responsible for the transfer of SS7 messages between other SS7 nodes, acting somewhat like a router in an IP network.
- An STP is neither the ultimate source nor the destination for most signaling messages.
- An STP can exist in one of two forms:
 - Standalone STP: deployed in "mated" pairs for the purposes of redundancy. Under normal operation, the mated pair shares the load. If one of the STPs fails or isolation occurs because of signaling link failure, the other STP takes the full load until the problem with its mate has been rectified.
 - Integrated STP (SP with STP): combine the functionality of an SSP and an STP. They are both the source and destination for MTP user traffic. They also can transfer incoming messages to other nodes.

SSP and SCP

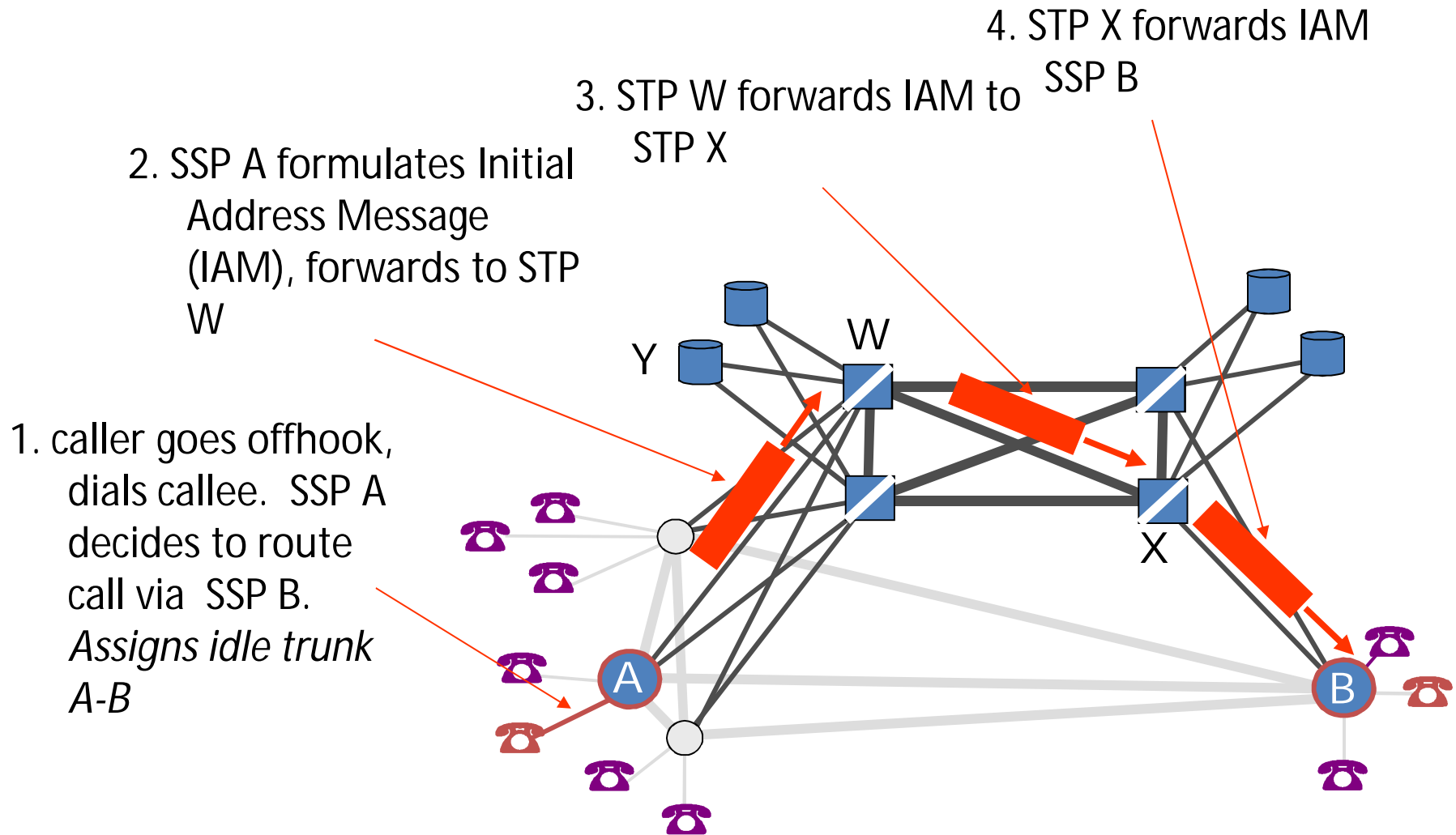
- **Service Switching Point**

- A Service Switching Point (SSP) is a voice switch that incorporates SS7 functionality.
- An SSP can originate and terminate messages, but it cannot transfer them. If a message is received with a point code that does not match the point code of the receiving SSP, the message is discarded.

- **Service Control Point**

- A Service Control Point (SCP) acts as an interface between telecommunications databases and the SS7 network.
- Telephone companies and other telecommunication service providers employ a number of databases that can be queried for service data for the provision of services.

Example: signaling a POTS call

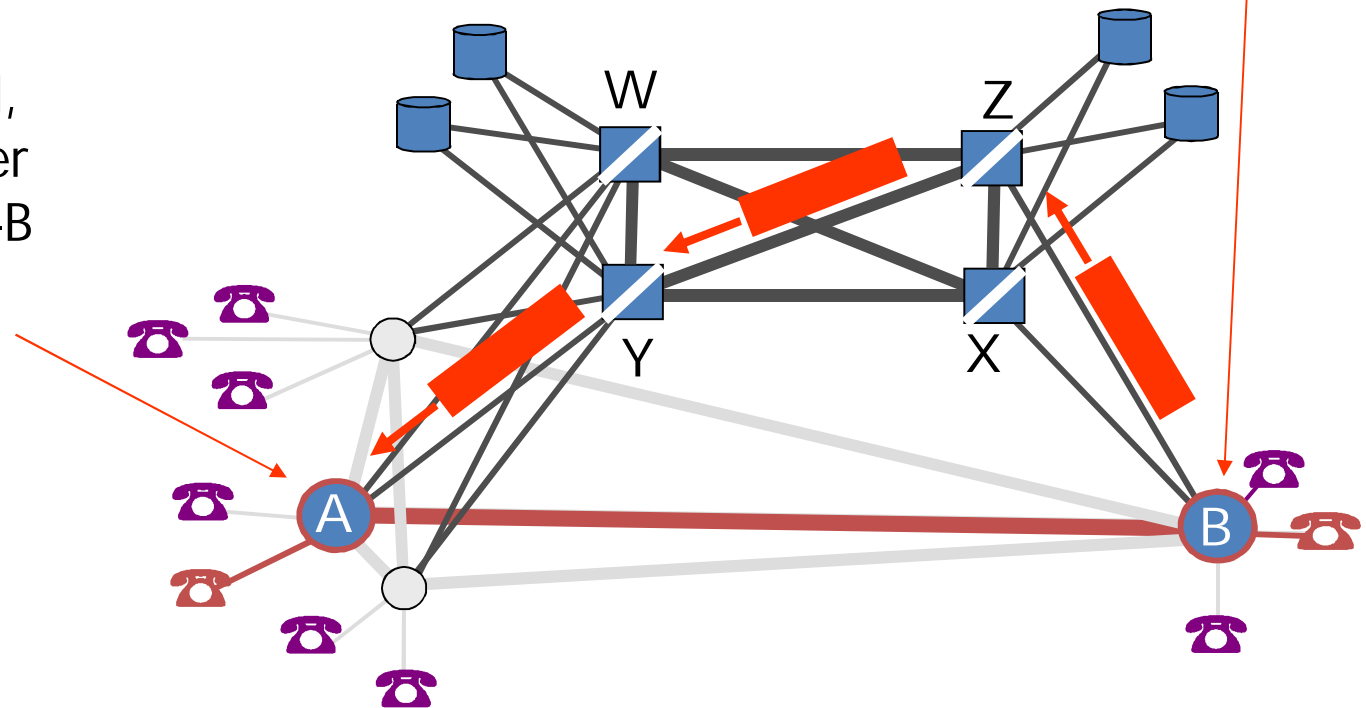


Example: signaling a POTS call

5. B determines it serves callee, creates address completion message (ACM[A,B,trunk]), rings callee phone, sends ringing sound on trunk to A

6. ACM routed to Z to Y to A

7. SSP A receives ACM, connects subscriber line to allocated A-B trunk (caller hears ringing)

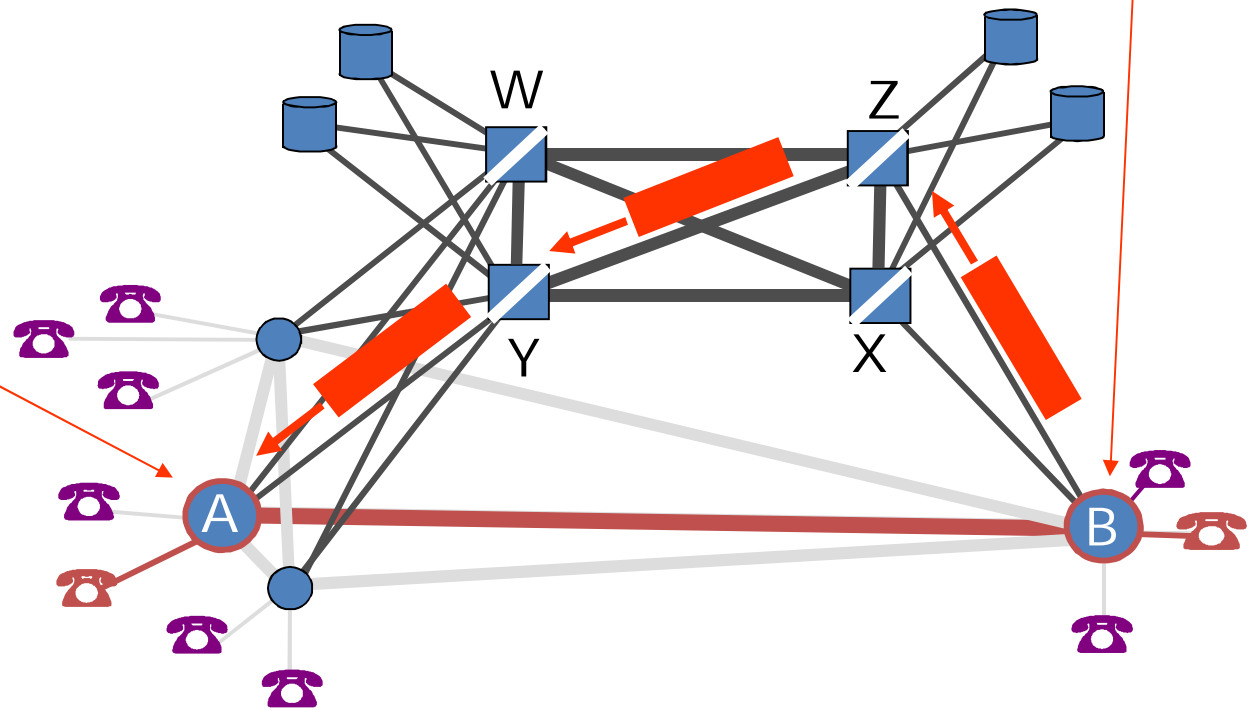


Example: signaling a POTS call

8. Callee goes off hook, B creates, sends answer message to A (ANM[A,B,trunk])

9. ANM routed to A

10. SSP A receives ANM, checks caller is connected in both directions to trunk. *Call is connected!*



Example: signaling a 800 ca11

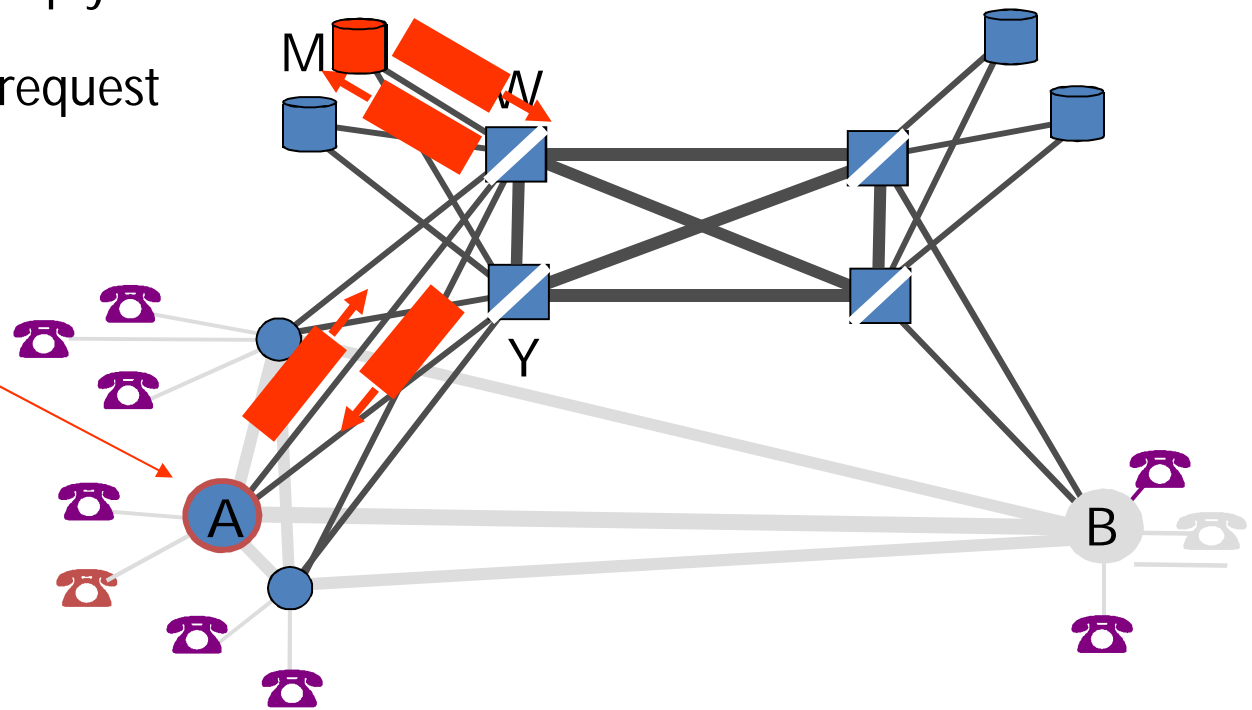
800 number: logical phone number

- translation to physical phone number needed, e.g., 1-800-CALL_ATT translates to 162-962-1943

3. M performs lookup,
sends reply to A

2. STP W forwards request
to M

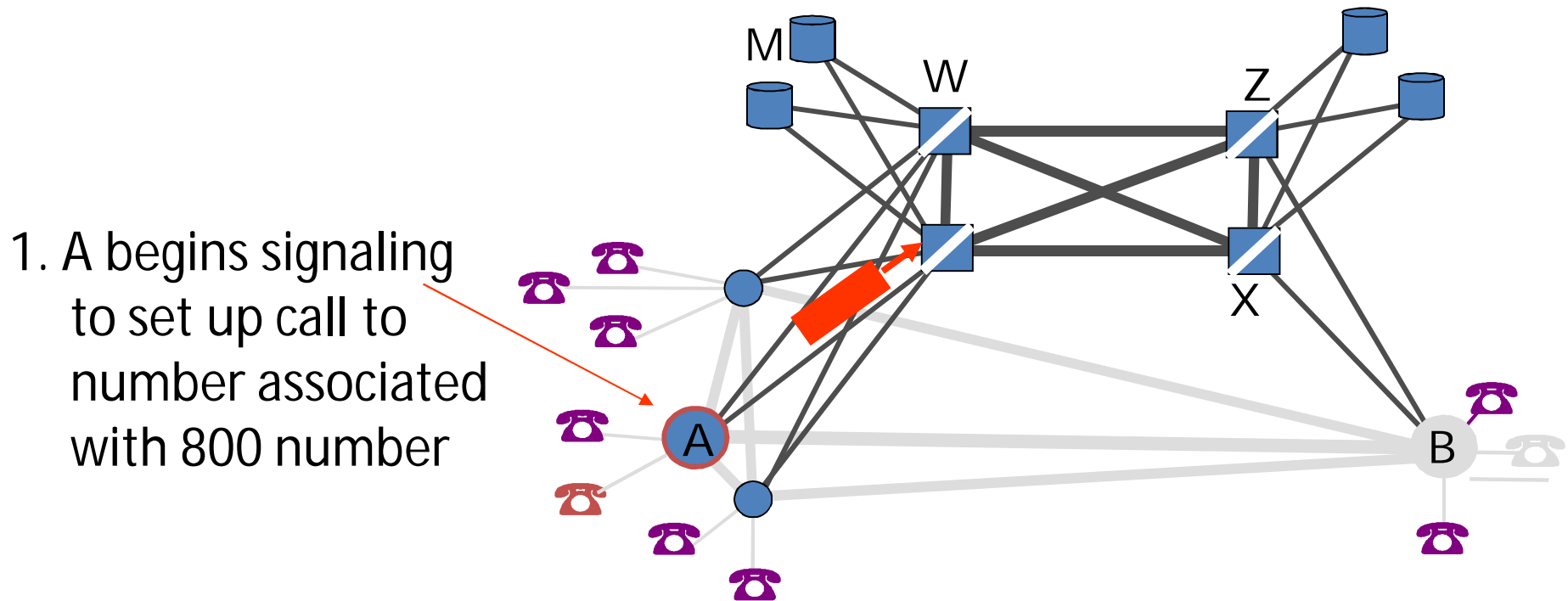
1. Caller dials 800 number,
A recognizes 800
number, formulates
translation query, send
to STP W



Example: signaling a 800 ca11

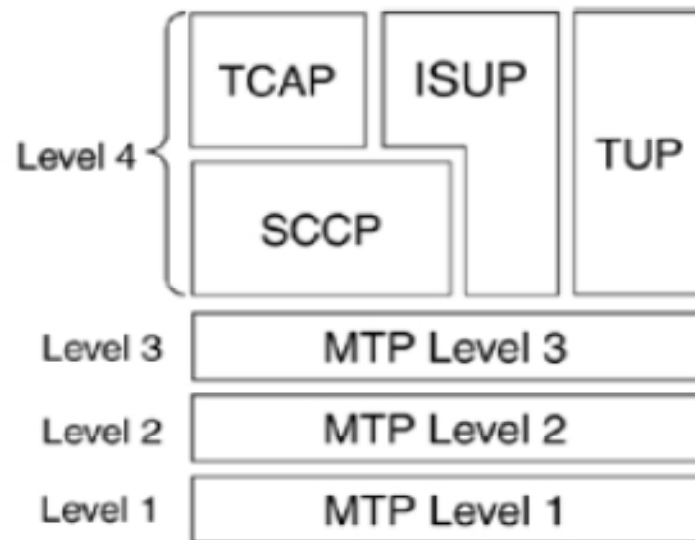
800 number: logical phone number

- translation to physical phone number needed



SS7 Protocol Overview

- The number of possible protocol stack combinations is growing. The main protocols are:
 - Message Transfer Parts (MTP 1, 2, and 3)
 - Signaling Connection Control Part (SCCP)
 - Transaction Capabilities Application Part (TCAP)
 - Telephony User Part (TUP)
 - ISDN User Part (ISUP)



SS7 Protocol Overview

- The SS7 physical layer is called MTP level 1 (MTP1)
- The data link layer is called MTP level 2 (MTP2),
- The network layer is called MTP level 3 (MTP3).

Collectively they are called the Message Transfer Part (MTP).

- The MTP transfers the signaling message, in the correct sequence, without loss or duplication.
- The MTP provides reliable transfer and

MTP2

- MTP2 ensures reliable transfer of signaling messages.
- It encapsulates signaling messages into variable-length SS7 packets.
- SS7 packets are called signal units (SUs).
- MTP2 provides delineation of SUs, alignment of SUs, signaling link error monitoring, error correction by retransmission, and flow control.
- The MTP2 protocol is specific to narrowband links (56 or 64 kbps).

MTP3

- MTP3 performs two functions:
 - **Signaling Message Handling (SMH)** Delivers incoming messages to their intended User Part and routes outgoing messages toward their destination. MTP3 uses the PC to identify the correct node for message delivery. Each message has both an Origination Point Code (OPC) and a DPC. The OPC is inserted into messages at the MTP3 level to identify the SP that originated the message. The DPC is inserted to identify the address of the destination SP. Routing tables within an SS7 node are used to route messages.
 - **Signaling Network Management (SNM):** Monitors linksets and routesets, providing status to network nodes so that traffic can be rerouted when necessary. SNM also provides procedures to take corrective action when failures occur, providing a self-healing mechanism for the SS7 network.

TUP and ISUP

- TUP and ISUP sit on top of MTP to provide circuit-related signaling to set up, maintain, and tear down calls.
- Both TUP and ISUP are used to perform interswitch call signaling.
- ISUP also has inherent support for supplementary services, such as automatic callback, calling line identification.

SCCP

- SCCP provides a more flexible means of routing and provides mechanisms to transfer data over the SS7 network.
- Such additional features are used to support noncircuit-related signaling, which is mostly used to interact with databases (SCPs). It is also used to connect the radiorelated components in cellular networks and for inter-SSP communication supporting CLASS services.
- For example, in cellular networks, SCCP transfers queries and responses between the Visitor Location Register (VLR) and Home

TCAP

- TCAP allows applications (called subsystems) to communicate with each other (over the SS7 network) using agreed-upon data elements.
- These data elements are called components.
- Components can be viewed as instructions sent between applications.
- TCAP also provides transaction management, allowing multiple messages to be associated with a particular communications exchange, known as a transaction.