

EXH. SET-3
Docket UT-181051
Witness: Steven E. Turner

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EXHIBIT: SET-3
ADMIT W/D REJECT

BEFORE THE WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION

**WASHINGTON UTILITIES AND
TRANSPORTATION COMMISSION,**

Complainant,

v.

**CENTURYLINK COMMUNICATIONS,
LLC,**

Respondent.

DOCKET UT- 181051

**EXHIBIT TO
TESTIMONY OF**

STEVEN E. TURNER

**ON BEHALF OF
CENTURYLINK COMMUNICATIONS, LLC**

RUTGERS UNIVERSITY, ILLUMENET SIGNALING SYSTEM 7 (SS7)

March 31, 2022



Signaling System 7 (SS7)

Definition

Signaling System 7 (SS7) is an architecture for performing out-of-band signaling in support of the call-establishment, billing, routing, and information-exchange functions of the public switched telephone network (PSTN). It identifies functions to be performed by a signaling-system network and a protocol to enable their performance.

Topics

1. What Is Signaling?
2. What Is Out-of-Band Signaling?
3. Signaling Network Architecture
4. The North American Signaling Architecture
5. Basic Signaling Architecture
6. SS7 Link Types
7. Basic Call Setup Example
8. Database Query Example
9. Layers of the SS7 Protocol
10. What Goes Over the Signaling Link
11. Addressing in the SS7 Network
12. Signal Unit Structure
13. What Are the Functions of the Different Signaling Units?
14. Message Signal Unit Structure

Self-Test

Correct Answers

Glossary

1. What Is Signaling?

Signaling refers to the exchange of information between call components required to provide and maintain service.

As users of the PSTN, we exchange signaling with network elements all the time. Examples of signaling between a telephone user and the telephone network include: dialing digits, providing dial tone, accessing a voice mailbox, sending a call-waiting tone, dialing *66 (to retry a busy number), etc.

SS7 is a means by which elements of the telephone network exchange information. Information is conveyed in the form of messages. SS7 messages can convey information such as:

- I'm forwarding to you a call placed from 212-555-1234 to 718-555-5678. Look for it on trunk 067.
- Someone just dialed 800-555-1212. Where do I route the call?
- The called subscriber for the call on trunk 11 is busy. Release the call and play a busy tone.
- The route to XXX is congested. Please don't send any messages to XXX unless they are of priority 2 or higher.
- I'm taking trunk 143 out of service for maintenance.

SS7 is characterized by *high-speed packet data* and *out-of-band signaling*.

2. What Is Out-of-Band Signaling?

Out-of-band signaling is signaling that does not take place over the same path as the conversation.

We are used to thinking of signaling as being in-band. We hear dial tone, dial digits, and hear ringing over the same channel on the same pair of wires. When the call completes, we talk over the same path that was used for the signaling. Traditional telephony used to work in this way as well. The signals to set up a call between one switch and another always took place over the same trunk that would eventually carry the call. Signaling took the form of a series of multifrequency (MF) tones, much like touch tone dialing between switches.

Out-of-band signaling establishes a separate digital channel for the exchange of signaling information. This channel is called a signaling link. Signaling links are used to carry all the necessary signaling messages between nodes. Thus, when a

call is placed, the dialed digits, trunk selected, and other pertinent information are sent between switches using their signaling links, rather than the trunks which will ultimately carry the conversation. Today, signaling links carry information at a rate of 56 or 64 kbps. It is interesting to note that while SS7 is used only for signaling between network elements, the ISDN D channel extends the concept of out-of-band signaling to the interface between the subscriber and the switch. With ISDN service, signaling that must be conveyed between the user station and the local switch is carried on a separate digital channel called the D channel. The voice or data which comprise the call is carried on one or more B channels.

Why Out-of-Band Signaling?

Out-of-band signaling has several advantages that make it more desirable than traditional in-band signaling.

- It allows for the transport of more data at higher speeds (56 kbps can carry data much faster than MF outpulsing).
- It allows for signaling at any time in the entire duration of the call, not only at the beginning.
- It enables signaling to network elements to which there is no direct trunk connection.

3. Signaling Network Architecture

If signaling is to be carried on a different path from the voice and data traffic it supports, then what should that path look like? The simplest design would be to allocate one of the paths between each interconnected pair of switches as the signaling link. Subject to capacity constraints, all signaling traffic between the two switches could traverse this link. This type of signaling is known as associated signaling, and is shown below in *Figure 1*.

Figure 1. Associated Signaling



Associated signaling works well as long as a switch's only signaling requirements are between itself and other switches to which it has trunks. If call setup and

management was the only application of SS7, associated signaling would meet that need simply and efficiently. In fact, much of the out-of-band signaling deployed in Europe today uses associated mode.

The North American implementers of SS7, however, wanted to design a signaling network that would enable any node to exchange signaling with any other SS7-capable node. Clearly, associated signaling becomes much more complicated when it is used to exchange signaling between nodes which do not have a direct connection. From this need, the North American SS7 architecture was born.

4. The North American Signaling Architecture

The North American signaling architecture defines a completely new and separate signaling network. The network is built out of the following three essential components, interconnected by signaling link:

- **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.

Once deployed, the availability of SS7 network is critical to call processing. Unless SSPs can exchange signaling, they cannot complete any interswitch calls. For this reason, the SS7 network is built using a highly redundant architecture. Each individual element also must meet exacting requirements for availability. Finally, protocol has been defined between interconnected elements to facilitate the routing of signaling traffic around any difficulties that may arise in the signaling network.

To enable signaling network architectures to be easily communicated and understood, a standard set of symbols was adopted for depicting SS7 networks. *Figure 2* shows the symbols that are used to depict these three key elements of any SS7 network.

Figure 2. Signaling Network Elements



STPs and SCPs are customarily deployed in pairs. While elements of a pair are not generally co-located, they work redundantly to perform the same logical function. When drawing complex network diagrams, these pairs may be depicted as a single element for simplicity, as shown in *Figure 3*.

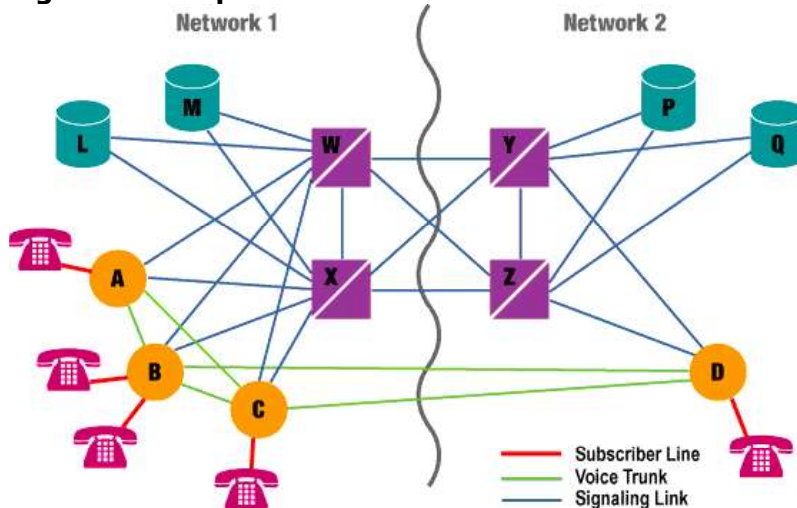
Figure 3. STP and SCP Pairs



5. Basic Signaling Architecture

Figure 4 shows a small example of how the basic elements of an SS7 network are deployed to form two interconnected networks.

Figure 4. Sample Network



The following points should be noted:

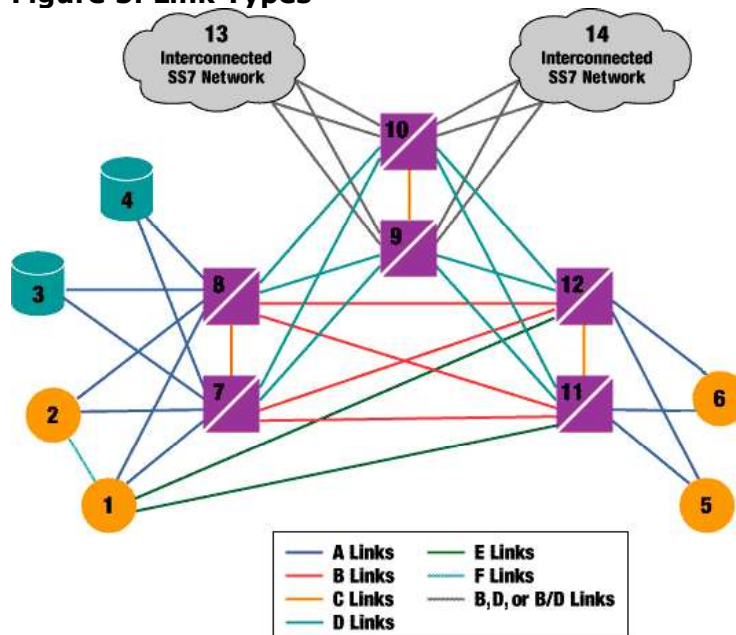
1. STPs W and X perform identical functions. They are redundant. Together, they are referred to as a mated pair of STPs. Similarly, STPs Y and Z form a mated pair.

2. Each SSP has two links (or sets of links), one to each STP of a mated pair. All SS7 signaling to the rest of the world is sent out over these links. Because the STPs of a mated pair are redundant, messages sent over either link (to either STP) will be treated equivalently.
3. The STPs of a mated pair are joined by a link (or set of links).
4. Two mated pairs of STPs are interconnected by four links (or sets of links). These links are referred to as a quad.
5. SCPs are usually (though not always) deployed in pairs. As with STPs, the SCPs of a pair are intended to function identically. Pairs of SCPs are also referred to as mated pairs of SCPs. Note that they are not directly joined by a pair of links.
6. Signaling architectures such as this, which provide indirect signaling paths between network elements, are referred to as providing quasi-associated signaling.

6. SS7 Link Types

SS7 signaling links are characterized according to their use in the signaling network. Virtually all links are identical in that they are 56-kbps or 64-kbps bidirectional data links that support the same lower layers of the protocol; what is different is their use within a signaling network. The defined link types are shown in *Figure 5* and defined as follows:

Figure 5. Link Types



A Links

A links interconnect an STP and either an SSP or an SCP, which are collectively referred to as signaling end points ("A" stands for access). A links are used for the sole purpose of delivering signaling to or from the signaling end points (they could just as well be referred to as signaling beginning points). Examples of A links are 2–8, 3–7, and 5–12 in *Figure 5*.

Signaling that an SSP or SCP wishes to send to any other node is sent on either of its A links to its home STP, which, in turn, processes or routes the messages. Similarly, messages intended for an SSP or SCP will be routed to one of its home STPs, which will forward them to the addressed node over its A links.

C Links

C links are links that interconnect mated STPs. As will be seen later, they are used to enhance the reliability of the signaling network in instances where one or several links are unavailable. "C" stands for cross (7–8, 9–10, and 11–12 are C links). B links, D links, and B/D links interconnecting two mated pairs of STPs are referred to as either B links, D links, or B/D links. Regardless of their name, their function is to carry signaling messages beyond their initial point of entry to the signaling network towards their destination. The "B" stands for bridge and describes the quad of links interconnecting peer pairs of STPs. The "D" denotes diagonal and describes the quad of links interconnecting mated pairs of STPs at different hierarchical levels. Because there is no clear hierarchy associated with a connection between networks, interconnecting links are referred to as either B, D, or B/D links (7–11 and 7–12 are examples of B links; 8–9 and 7–10 are examples of D links; 10–13 and 9–14 are examples of interconnecting links and can be referred to as B, D, or B/D links).

E Links

While an SSP is connected to its home STP pair by a set of A links, enhanced reliability can be provided by deploying an additional set of links to a second STP pair. These links, called E (extended) links provide backup connectivity to the SS7 network in the event that the home STPs cannot be reached via the A links. While all SS7 networks include A, B/D, and C links, E links may or may not be deployed at the discretion of the network provider. The decision of whether or not to deploy E links can be made by comparing the cost of deployment with the improvement in reliability. (1–11 and 1–12 are E links.)

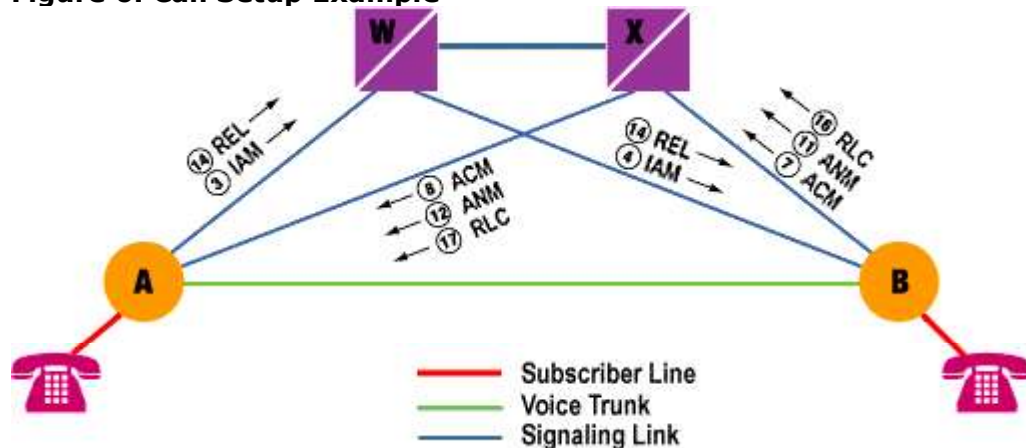
F Links

F (fully associated) links are links which directly connect two signaling end points. F links allow associated signaling only. Because they bypass the security features provided by an STP, F links are not generally deployed between networks. Their use within an individual network is at the discretion of the network provider. (1-2 is an F link.)

7. Basic Call Setup Example

Before going into much more detail, it might be helpful to look at several basic calls and the way in which they use SS7 signaling (see *Figure 6*).

Figure 6. Call Setup Example



In this example, a subscriber on switch A places a call to a subscriber on switch B.

1. Switch A analyzes the dialed digits and determines that it needs to send the call to switch B.
2. Switch A selects an idle trunk between itself and switch B and formulates an initial address message (IAM), the basic message necessary to initiate a call. The IAM is addressed to switch B. It identifies the initiating switch (switch A), the destination switch (switch B), the trunk selected, the calling and called numbers, as well as other information beyond the scope of this example.
3. Switch A picks one of its A links (e.g., AW) and transmits the message over the link for routing to switch B.
4. STP W receives a message, inspects its routing label, and determines that it is to be routed to switch B. It transmits the message on link BW.

5. Switch B receives the message. On analyzing the message, it determines that it serves the called number and that the called number is idle.
6. Switch B formulates an address complete message (ACM), which indicates that the IAM has reached its proper destination. The message identifies the recipient switch (A), the sending switch (B), and the selected trunk.
7. Switch B picks one of its A links (e.g., BX) and transmits the ACM over the link for routing to switch A. At the same time, it completes the call path in the backwards direction (towards switch A), sends a ringing tone over that trunk towards switch A, and rings the line of the called subscriber.
8. STP X receives the message, inspects its routing label, and determines that it is to be routed to switch A. It transmits the message on link AX.
9. On receiving the ACM, switch A connects the calling subscriber line to the selected trunk in the backwards direction (so that the caller can hear the ringing sent by switch B).
10. When the called subscriber picks up the phone, switch B formulates an answer message (ANM), identifying the intended recipient switch (A), the sending switch (B), and the selected trunk.
11. Switch B selects the same A link it used to transmit the ACM (link BX) and sends the ANM. By this time, the trunk also must be connected to the called line in both directions (to allow conversation).
12. STP X recognizes that the ANM is addressed to switch A and forwards it over link AX.
13. Switch A ensures that the calling subscriber is connected to the outgoing trunk (in both directions) and that conversation can take place.
14. If the calling subscriber hangs up first (following the conversation), switch A will generate a release message (REL) addressed to switch B, identifying the trunk associated with the call. It sends the message on link AW.
15. STP W receives the REL, determines that it is addressed to switch B, and forwards it using link WB.
16. Switch B receives the REL, disconnects the trunk from the subscriber line, returns the trunk to idle status, generates a release complete

message (RLC) addressed back to switch A, and transmits it on link BX. The RLC identifies the trunk used to carry the call.

17. STP X receives the RLC, determines that it is addressed to switch A, and forwards it over link AX.
18. On receiving the RLC, switch A idles the identified trunk.

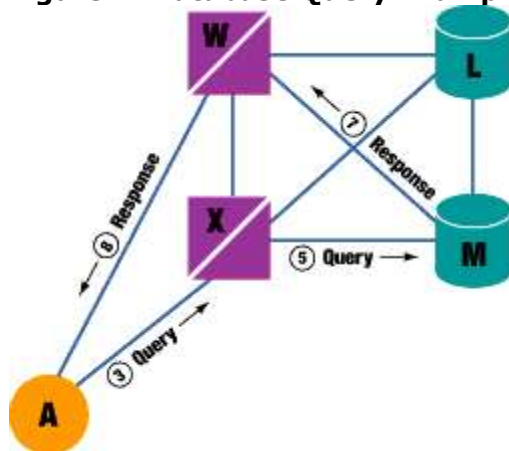
8. Database Query Example

People generally are familiar with the toll-free aspect of 800 (or 888) numbers, but these numbers have significant additional capabilities made possible by the SS7 network. 800 numbers are virtual telephone numbers. Although they are used to point to real telephone numbers, they are not assigned to the subscriber line itself.

When a subscriber dials an 800 number, it is a signal to the switch to suspend the call and seek further instructions from a database. The database will provide either a real phone number to which the call should be directed, or it will identify another network (e.g., a long-distance carrier) to which the call should be routed for further processing. While the response from the database could be the same for every call (as, for example, if you have a personal 800 number), it can be made to vary based on the calling number, the time of day, the day of the week, or a number of other factors.

The following example shows how an 800 call is routed (see *Figure 7*).

Figure 7. Database Query Example



1. A subscriber served by switch A wants to reserve a rental car at a company's nearest location. She dials the company's advertised 800 number.

2. When the subscriber has finished dialing, switch A recognizes that this is an 800 call and that it requires assistance to handle it properly.
3. Switch A formulates an 800 query message including the calling and called number and forwards it to either of its STPs (e.g., X) over its A link to that STP (AX).
4. STP X determines that the received query is an 800 query and selects a database suitable to respond to the query (e.g., M).
5. STP X forwards the query to SCP M over the appropriate A link (MX). SCP M receives the query, extracts the passed information, and (based on its stored records) selects either a real telephone number or a network (or both) to which the call should be routed.
6. SCP M formulates a response message with the information necessary to properly process the call, addresses it to switch A, picks an STP and an A link to use (e.g., MW), and routes the response.
7. STP W receives the response message, recognizes that it is addressed to switch A, and routes it to A over AW.
8. Switch A receives the response and uses the information to determine where the call should be routed. It then picks a trunk to that destination, generates an IAM, and proceeds (as it did in the previous example) to set up the call.

9. Layers of the SS7 Protocol

As the call-flow examples show, the SS7 network is an interconnected set of network elements that is used to exchange messages in support of telecommunications functions. The SS7 protocol is designed to both facilitate these functions and to maintain the network over which they are provided. Like most modern protocols, the SS7 protocol is layered.

Physical Layer

This defines the physical and electrical characteristics of the signaling links of the SS7 network. Signaling links utilize DS-0 channels and carry raw signaling data at a rate of 56 kbps or 64 kbps (56 kbps is the more common implementation).

Message Transfer Part—Level 2

The level 2 portion of the message transfer part (MTP Level 2) provides link-layer functionality. It ensures that the two end points of a signaling link can reliably exchange signaling messages. It incorporates such capabilities as error checking, flow control, and sequence checking.

Message Transfer Part—Level 3

The level 3 portion of the message transfer part (MTP Level 3) extends the functionality provided by MTP level 2 to provide network layer functionality. It ensures that messages can be delivered between signaling points across the SS7 network regardless of whether they are directly connected. It includes such capabilities as node addressing, routing, alternate routing, and congestion control.

Collectively, MTP levels 2 and 3 are referred to as the message transfer part (MTP).

Signaling Connection Control Part

The signaling connection control part (SCCP) provides two major functions that are lacking in the MTP. The first of these is the capability to address applications within a signaling point. The MTP can only receive and deliver messages from a node as a whole; it does not deal with software applications within a node.

While MTP network-management messages and basic call-setup messages are addressed to a node as a whole, other messages are used by separate applications (referred to as subsystems) within a node. Examples of subsystems are 800 call processing, calling-card processing, advanced intelligent network (AIN), and custom local-area signaling service (CLASS) services (e.g., repeat dialing and call return). The SCCP allows these subsystems to be addressed explicitly.

Global Title Translation

The second function provided by the SCCP is the ability to perform incremental routing using a capability called global title translation (GTT). GTT frees originating signaling points from the burden of having to know every potential destination to which they might have to route a message. A switch can originate a query, for example, and address it to an STP along with a request for GTT. The receiving STP can then examine a portion of the message, make a determination as to where the message should be routed, and then route it.

For example, calling-card queries (used to verify that a call can be properly billed to a calling card) must be routed to an SCP designated by the company that issued the calling card. Rather than maintaining a nationwide database of where such queries should be routed (based on the calling-card number), switches generate queries addressed to their local STPs, which, using GTT, select the correct destination to which the message should be routed. Note that there is no magic here; STPs must maintain a database that enables them to determine where a query should be routed. GTT effectively centralizes the problem and places it in a node (the STP) that has been designed to perform this function.

In performing GTT, an STP does not need to know the exact final destination of a message. It can, instead, perform intermediate GTT, in which it uses its tables to find another STP further along the route to the destination. That STP, in turn, can perform final GTT, routing the message to its actual destination.

Intermediate GTT minimizes the need for STPs to maintain extensive information about nodes that are far removed from them. GTT also is used at the STP to share load among mated SCPs in both normal and failure scenarios. In these instances, when messages arrive at an STP for final GTT and routing to a database, the STP can select from among available redundant SCPs. It can select an SCP on either a priority basis (referred to as primary backup) or so as to equalize the load across all available SCPs (referred to as load sharing).

ISDN User Part (ISUP)

The ISUP user part defines the messages and protocol used in the establishment and tear down of voice and data calls over the public switched network (PSN), and to manage the trunk network on which they rely. Despite its name, ISUP is used for both ISDN and non-ISDN calls. In the North American version of SS7, ISUP messages rely exclusively on MTP to transport messages between concerned nodes.

Transaction Capabilities Application Part (TCAP)

TCAP defines the messages and protocol used to communicate between applications (deployed as subsystems) in nodes. It is used for database services such as calling card, 800, and AIN as well as switch-to-switch services including repeat dialing and call return. Because TCAP messages must be delivered to individual applications within the nodes they address, they use the SCCP for transport.

Operations, Maintenance, and Administration Part (OMAP)

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. OMAP includes messages that use both the MTP and SCCP for routing.

10. What Goes Over the Signaling Link

Signaling information is passed over the signaling link in messages, which are called signal units (SUs).

Three types of SUs are defined in the SS7 protocol.

- message signal units (MSUs)
- link status signal units (LSSUs)
- fill-in signal units (FISUs)

SUs are transmitted continuously in both directions on any link that is in service. A signaling point that does not have MSUs or LSSUs to send will send FISUs over the link. The FISUs perform the function suggested by their name; they fill up the signaling link until there is a need to send purposeful signaling. They also facilitate link transmission monitoring and the acknowledgment of other SUs.

All transmission on the signaling link is broken up into 8-bit bytes, referred to as octets. SUs on a link are delimited by a unique 8-bit pattern known as a flag. The flag is defined as the 8-bit pattern "01111110". Because of the possibility that data within an SU would contain this pattern, bit manipulation techniques are used to ensure that the pattern does not occur within the message as it is transmitted over the link. (The SU is reconstructed once it has been taken off the link, and any bit manipulation is reversed.) Thus, any occurrence of the flag on the link indicates the end of one SU and the beginning of another. While in theory two flags could be placed between SUs (one to mark the end of the current message and one to mark the start of the next message), in practice a single flag is used for both purposes.

11. Addressing in the SS7 Network

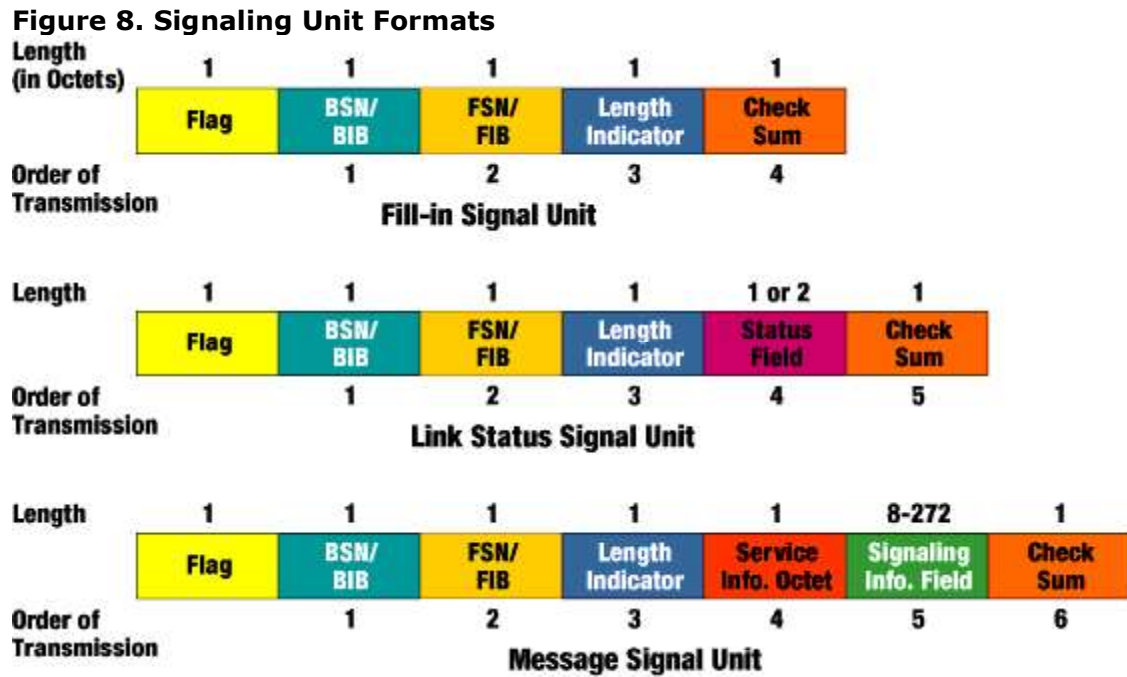
Every network must have an addressing scheme, and the SS7 network is no different. Network addresses are required so that a node can exchange signaling nodes to which it does not have a physical signaling link. In SS7, addresses are

assigned using a three-level hierarchy. Individual signaling points are identified as belonging to a cluster of signaling points. Within that cluster, each signaling point is assigned a member number. Similarly, a cluster is defined as being part of a network. Any node in the American SS7 network can be addressed by a three-level number defined by its network, cluster, and member numbers. Each of these numbers is an 8-bit number and can assume values from 0 to 255. This three-level address is known as the point code of the signaling point. A point code uniquely identifies a signaling point within the American SS7 network and is used whenever it is necessary to address that signaling point.

Network numbers are assigned on a nationwide basis by a neutral party. Regional Bell operating companies (RBOCs), major independent telephone companies, and interexchange carriers (IXCs) already have network numbers assigned. Because network numbers are a relatively scarce resource, companies' networks are expected to meet certain size requirements in order to be assigned a network number. Smaller networks can be assigned one or more cluster numbers within network numbers 1, 2, 3, and 4. The smallest networks are assigned point codes within network number 5. The cluster to which they are assigned is determined by the state in which they are located. The network number 0 is not available for assignment and network number 255 is reserved for future use.

12. Signal Unit Structure

SUs of each type follow a format unique to that type. A high-level view of those formats is shown in *Figure 8*.



All three SU types have a set of common fields that are used by MTP Level 2. They are as follows:

Flag

Flags delimit SUs. A flag marks the end of one SU and the start of the next.

Checksum

The checksum is an 8-bit sum intended to verify that the SU has passed across the link error-free. The checksum is calculated from the transmitted message by the transmitting signaling point and inserted in the message. On receipt, it is recalculated by the receiving signaling point. If the calculated result differs from the received checksum, the received SU has been corrupted. A retransmission is requested.

Length Indicator

The length indicator indicates the number of octets between itself and the checksum. It serves both as a check on the integrity of the SU and as a means of discriminating between different types of SUs at level 2. As can be inferred from *Figure 8*, FISUs have a length indicator of 0; LSSUs have a length indicator of 1 or 2 (currently all LSSUs have a length indicator of 1), and MSUs have a length-indicator greater than 2. According to the protocol, only 6 of the 8 bits in the length indicator field are actually used to store this length; thus the largest value that can be accommodated in the length indicator is 63. For MSUs with more than 63 octets following the length indicator, the value of 63 is used.

BSN/BIB FSN/FIB

These octets hold the backwards sequence number (BSN), the backwards indicator bit (BIB), the forward sequence number (FSN), and the forward indicator bit (FIB). These fields are used to confirm receipt of SUs and to ensure that they are received in the order in which they were transmitted. They also are used to provide flow control. MSUs and LSSUs, when transmitted, are assigned a sequence number that is placed in the forward sequence number field of the outgoing SU. This SU is stored by the transmitting signaling point until it is acknowledged by the receiving signaling point.

Because the seven bits allocated to the forward sequence number can store 128 distinct values, it follows that a signaling point is restricted to sending 128 unacknowledged SUs before it must await an acknowledgment. By acknowledging an SU, the receiving node frees that SU's sequence number at the

transmitting node, making it available for a new outgoing SU. Signaling points acknowledge receipt of SUs by placing the sequence number of the last correctly received and in-sequence SU in the backwards sequence number of every SU they transmit. In that way, they acknowledge all previously received SUs as well. The forward and backwards indicator bits are used to indicate sequencing or data-corruption errors and to request retransmission.

13. What are the Functions of the Different Signaling Units?

FISUs themselves have no information payload. Their purpose is to occupy the link at those times when there are no LSSUs or MSUs to send. Because they undergo error checking, FISUs facilitate the constant monitoring of link quality in the absence of signaling traffic. FISUs also can be used to acknowledge the receipt of messages using the backwards sequence number and backwards indicator bit.

LSSUs are used to communicate information about the signaling link between the nodes on either end of the link. This information is contained in the status field of the SU (see *Figure 8*). Because the two ends of a link are controlled by independent processors, there is a need to provide a means for them to communicate. LSSUs provide the means for performing this function. LSSUs are used primarily to signal the initiation of link alignment, the quality of received signaling traffic, and the status of the processors at either end of the link. Because they are sent only between the signaling points at either end of the link, LSSUs do not require any addressing information.

MSUs are the workhorses of the SS7 network. All signaling associated with call setup and tear down, database query and response, and SS7 network management takes place using MSUs. MSUs are the basic envelope within which all addressed signaling information is placed. As will be shown below, there are several different types of MSUs. All MSUs have certain fields in common. Other fields differ according to the type of message. The type of MSU is indicated in the service-information octet shown in *Figure 8*; the addressing and informational content of the MSU is contained in the signaling information field.

14. Message Signal Unit Structure

The functionality of the message signal unit lies in the actual content of the service information octet and the signaling information field (see *Figure 8*).

The service information octet is an 8-bit field (as might be inferred from its name) that contains three types of information as follows:

1. four bits are used to indicate the type of information contained in the signaling information field; they are referred to as the service indicator; the values most commonly used in American networks are outlined in *Table 1*

Table 1. Common Signaling Indicator Values

Value	Function
0	signaling network management
1	signaling network testing and maintenance
3	signaling connection control part (SCCP)
5	ISDN user part (ISUP)

2. two bits are used to indicate whether the message is intended (and coded) for use in a national or international network; they are generally coded with a value of 2, national network
3. the remaining 2 bits are used (in American networks) to identify a message priority, from 0 to 3, with 3 being the highest priority; message priorities do not control the order in which messages are transmitted; they are only used in cases of signaling network congestion; in that case, they indicate whether a message has sufficient priority to merit transmission during an instance of congestion or whether it can be discarded en route to a destination

The format of the contents of the signaling information field is determined by the service indicator. (Within user parts, there are further distinctions in message formats, but the service indicator provides the first piece of information necessary for routing or decoding the message.)

The first portion of the signaling information field is identical for all MSUs currently in use. It is referred to as the routing label. Simply stated, the routing label identifies the message originator, the intended destination of the message, and a field referred to as the signaling-link selection field which is used to distribute message traffic over the set of possible links and routes. The routing label consists of 7 octets that are outlined below in *Table 2* (in order of transmission).

Table 2. Routing Label

Octet Group	Function	Number of Octets Involved
destination point code (DPC)	contains the address of the node to which the message is being sent	3 octets
originating point code (OPC)	contains the address of message originator	3 octets
signaling link selection (SLS)	distributes load among redundant routes	1 octet

Point codes consist of the three-part identifier (network number, cluster number, member number), which uniquely identifies a signaling point.

Self-Test

1. The signaling of SS7 features _____ signaling.
 - a. in-band
 - b. out-of-band
2. SS7 _____ multifrequency tones for signaling.
 - a. uses
 - b. does not use
3. Associated signaling _____ for signaling to network elements to which there is no direct trunk connection.
 - a. allows
 - b. does not allow
4. SSPs _____ the packet switches of the SS7 network.
 - a. are
 - b. are not

Questions 5–7: Identify elements of this figure.



**Element
Symbol 1**



**Element
Symbol 2**



**Element
Symbol 3**

5. Element symbol one is _____.
 - a. SSP
 - b. STP
 - c. SCP
6. Element symbol two is _____.
 - a. SSP
 - b. STP
 - c. SCP
7. Element symbol three is _____.
 - a. SSP
 - b. STP
 - c. SCP
8. STPs and SCPs are not customarily deployed in pairs.
 - a. true
 - b. false
9. SCPs are always deployed in pairs.
 - a. true
 - b. false
10. A links connect an STP and either an SSP or an SCP.
 - a. true

- b. false
11. An ACM indicates that an IAM has reached the called subscriber's switch and that the subscriber is not busy.
- a. true
 - b. false
12. An IAM indicates that a call has reached its proper destination.
- a. true
 - b. false
13. When a called subscriber picks up the phone, his or her switch sends an ANM to indicate that the trunks should be connected in both directions.
- a. true
 - b. false
14. An REL is a message that indicates that switches at both ends have released the trunk.
- a. true
 - b. false
15. All 800 numbers are assigned to a subscriber line themselves.
- a. true
 - b. false
16. Dialing an 800 number causes the switch to suspend a call and query a database for further instructions.
- a. true
 - b. false
17. Links that connect nonmated STP pairs in different networks may be referred to as _____.
- a. B links
 - b. D links

- c. B/D links
 - d. any of the above
18. MTP management messages and ISUP call setup messages are addressed to _____.
- a. separate applications
 - b. a signal connection control port
 - c. B links
 - d. a node as a whole
19. The SCCP supports _____.
- a. routing to subsystems
 - b. global title translation
 - c. load sharing among SCPs
 - d. all of the above and other functions as well
20. Signaling units are broken up into units of how many bits?
- a. 8
 - b. 16
 - c. 32
 - d. 64

Correct Answers

1. The signaling of SS7 features _____ signaling.
- a. in-band
 - b. out-of-band**
- See Topic 1.

2. SS7 _____ multifrequency tones for signaling.

a. uses

b. does not use

See Topic 2.

3. Associated signaling _____ for signaling to network elements to which there is no direct trunk connection.

a. allows

b. does not allow

See Topic 2.

4. SSPs _____ the packet switches of the SS7 network.

a. are

b. are not

See Topic 4.

Questions 5–7: Identify elements of this figure.



**Element
Symbol 1**



**Element
Symbol 2**



**Element
Symbol 3**

5. Element symbol one is _____.

a. SSP

b. STP

c. SCP

See Topic 4.

6. Element symbol two is _____.

a. SSP

b. STP

- c. SCP
- See Topic 4.
7. Element symbol three is _____.
- a. SSP
 - b. STP
 - c. SCP**
- See Topic 4.
8. STPs and SCPs are not customarily deployed in pairs.
- a. true
 - b. false**
- See Topic 4.
9. SCPs are always deployed in pairs.
- a. true
 - b. false**
- See Topic 4.
10. A links connect an STP and either an SSP or an SCP.
- a. true**
 - b. false
- See Topic 6.
11. An ACM indicates that an IAM has reached the called subscriber's switch and that the subscriber is not busy.
- a. true**
 - b. false
- See Topic 7.

12. An IAM indicates that a call has reached its proper destination.

a. true

b. false

See Topic 7.

13. When a called subscriber picks up the phone, his or her switch sends an ANM to indicate that the trunks should be connected in both directions.

a. true

b. false

See Topic 7.

14. An REL is a message that indicates that switches at both ends have released the trunk.

a. true

b. false

See Topic 7.

15. All 800 numbers are assigned to a subscriber line themselves.

a. true

b. false

See Topic 8.

16. Dialing an 800 number causes the switch to suspend a call and query a database for further instructions.

a. true

b. false

See Topic 8.

17. Links that connect nonmated STP pairs in different networks may be referred to as _____.

a. B links

- b. D links
- c. B/D links

d. any of the above

See Topic 6.

18. MTP management messages and ISUP call setup messages are addressed to _____.

- a. separate applications
- b. a signal connection control port
- c. B links

d. a node as a whole

See Topic 9.

19. The SCCP supports _____.

- a. routing to subsystems
- b. global title translation
- c. load sharing among SCPs

d. all of the above and other functions as well

See Topic 9.

20. Signaling units are broken up into units of how many bits?

- a. 8**
- b. 16
- c. 32
- d. 64

See Topic 10.

Glossary

ACM

address complete message

ANM

answer message

A links

access links

BIB

backward indicator bit

B links

bridge links

BSN

backward sequence number

D links

diagonal links

DPC

destination point code

E link

extended link

F link

fully associated link

FIB

forward indicator bit

FISU

fill in signal unit

FSN

forward sequence number

IAM

initial address message

ISDN

integrated services digital network

ISUP

ISDN user part

kbps

kilobits per second

LSSU

link status signal unit

MF

multifrequency

MSU

message signal unit

MTP

message transfer part

OMAP

operations, maintenance, and administration part

OPC

originating point code

PSTN

public switched telephone network

RBOC

regional Bell operating company

REL

release message

RCL

release complete message

RSP

route set prohibited test message

RSR

restricted test message

SS7

signaling system 7

SCCP

signaling connection control part

SCP

signal control point

SLS

signaling link selection

SSP

signal switching point

STP

signal transfer point

SU

signal unit

TCAP

transaction capabilities application part

TFA

transfer allowed message

TFP

transfer prohibited message

TFR

transfer restricted message