CHAPTER 3

The Role of SS7

The purpose of this chapter is to introduce Signaling System No. 7 (SS7/C7) and give the reader an indication of how it affects the lives of nearly two billion people globally. The chapter begins by providing a brief introduction to the major services that SS7/C7 provides and explains how the protocol has been and will continue to be a key enabler of new telecommunication services. It concludes with an explanation of why SS7/C7 is a cornerstone of convergence.

SS7/C7 is the protocol suite that is employed globally, across telecommunications networks, to provide signaling; it is also a private, "behind the scenes," 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.

AT&T developed SS7/C7 in 1975, and the *International Telegraph and Telephone Consultative Committee* (CCITT) [109] adopted it in 1980 as a worldwide standard. For more information on the standards bodies, see Chapter 2, "Standards." Over the past quarter of a century, SS7 has undergone a number of revisions and has been continually enhanced to support services that are taken for granted on a daily basis.

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).

Each time you place and release a telephone call that extends beyond the local exchange, SS7/C7 signaling takes place to set up and reserve the dedicated network resources (trunk) for the call. At the end of the call, SS7/C7 takes action to return the resources to the network for future allocation.

TIP Calls placed between subscribers who are connected to the same switch do not require the use of SS7/C7. These are known as intraoffice, intraexchange, or line-to-line calls.

Each time a cellular phone is powered up, SS7/C7-based transactions identify, authenticate, and register the subscriber. Before a cellular call can be made, further transactions check

that the cellular phone is not stolen (network dependent option) and qualify permission to place the call (for example, the subscriber may be barred from International usage). In addition, the 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.

Although the average person typically uses SS7/C7 several times a day, it is largely unheard of by the general public because it is a "behind the scenes" private network—in stark contrast to IP. Another reason for its great transparency is its extreme reliability and resilience. For example, SS7/C7 equipment must make carrier grade quality standards—that is, 99.999 percent availability. The three prime ways it achieves an industry renowned robustness is by having a protocol that ensures reliable message delivery, self-healing capabilities, and an over-engineered physical network.

Typically, the links that comprise the network operate with a 20–40 percent loading and have full redundancy of network elements. SS7/C7 might well be the most robust and reliable network in existence.

SS7/C7 is possibly the most important element from a *quality of service* (QoS) perspective, as perceived by the subscriber.

NOTE Here QoS refers to the quality of services as perceived by the subscriber. It should not be confused with QoS as it relates specifically to packet networks.

QoS is quickly becoming a key in differentiating between service providers. Customers are changing service providers at an increasing pace for QoS reasons, such as poor coverage, delays, dropped calls, incorrect billing, and other service-related impairments and faults. SS7/C7 impairments nearly always impact a subscriber's QoS directly. A complete loss of signaling means a complete network outage, be it a cellular or fixed-line network. Even a wrongly-provisioned screening rule at a SS7/C7 node in a cellular network can prohibit subscribers from roaming internationally or sending text messages. A loss of one signaling link could potentially bring down thousands of calls. For this reason, the SS7/C7 network has been designed to be extremely robust and resilient.

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

In addition to setting up and releasing calls, SS7/C7 is the workhorse behind a number of telecommunication services, including:

- Telephone-marketing numbers such as toll-free and freephone
- Televoting (mass calling)
- Single Directory Number
- *Enhanced 911* (E911)—used in the United States
- Supplementary services
- Custom local area signaling services (CLASS)
- Calling name (CNAM)
- Line information database (LIDB)
- Local number portability (LNP)
- Cellular network mobility management and roaming
  - Short Message Service (SMS)
  - *Enhanced Messaging Service* (EMS)—Ringtone, logo, and cellular game delivery
- Local exchange carrier (LEC) provisioned private virtual networks (PVNs)
- Do-not-call enforcement

The following sections describe these telecommunications services.

Telephone-Marketing Numbers

The most commonly used telephone-marketing numbers are *toll-free* calling numbers (800 calling), known as *freephone* (0800) in the United Kingdom. Because the call is free for the caller, these numbers can be used to win more business by increasing customer response. Telephone-marketing numbers also provide premium rate lines in which the subscriber is charged at a premium in exchange for desired content. Examples of such services include adult services and accurate road reports.

Another popular telephone-marketing number is *local call*, with which a call is charged as a local call even though the distance might be national. In recent years in the United Kingdom, marketing numbers that scarcely alter the call cost have been a popular means of masking geographical location. These numbers allow for a separation between the actual number and the advertised number.

Televoting

Televoting is a mass calling service that provides an easy method of surveying the public on any imaginable subject. The host (for example, a deejay at a radio station) presents specific questions and the caller uses a telephone keypad to select a choice; the caller's action adds to the vote for that particular choice. The conversation phase is usually limited to a simple, automated "thank you for…" phrase. Televoting can also be used in many other areas, such as responding to fundraising pleas and telephone-based competitions. A single night of televoting might result in 15 million calls [110]. Televoting services represent some of the most demanding—as well as lucrative—call scenarios in today's telephone networks. Revenue generation in this area is likely to grow as customers shift more toward an "interactive" experience, on par with convergence.

Single Directory Number

Another service that uses SS7/C7 and has been deployed in recent years is the single directory number, which allows a company with multiple offices or store locations to have a single directory number. After analyzing the calling party's number, the switch directs the call to a local branch or store.

Enhanced 911

E911, which is being deployed across some states in the United States, utilizes SS7 to transmit the number of the calling party, look up the corresponding address of the subscriber in a database, and transmit the information to the emergency dispatch operator to enable a faster response to emergencies. E911 might also provide other significant location information, such as the location of the nearest fire hydrant, and potentially the caller's key medical details. The *Federal Communications Commission* (FCC) also has a cellular 911 program in progress; in addition to providing the caller's telephone number, this program sends the geographical location of the antenna to which the caller is connected. Enhancement proposals are already underway to obtain more precise location information.

Supplementary Services

Supplementary services provide the subscribers with more than *plain old telephony service* (POTS), without requiring them to change their telephone handsets or access technology. Well-known supplementary services include three-way calling, *calling number display* (CND), call-waiting, and call forwarding. Note that the exact names of these services might differ, depending on the country and the operator.

Recently, supplementary services have been helpful in increasing operators' revenues since revenues against call minutes have been on the decline. Usually the subscriber must pay a fixed monthly or quarterly fee for a supplementary service.

Custom Local Area Signaling Services (CLASS)

Custom local area signaling services (CLASS) are an extension of supplementary services that employ the use of SS7 signaling between exchanges within a local geographical area. Information provided over SS7 links, such as the calling party number or the state of a subscriber line, enable more advanced services to be offered by service providers. A few examples of CLASS services include:

- **Call block**—Stops pre-specified calling party numbers from calling.
- **Distinctive ringing**—Provides a distinct ringing signal when an incoming call originates from a number on a predefined list. This feature is particularly beneficial to households with teenagers.
- **Priority ringing**—Provides a distinct ring when a call originates from a pre-specified numbers. If the called subscriber is busy and has *call waiting,* the subscriber receives a special tone indicating that a number on the priority list is calling.
- **Call completion to busy subscriber (CCBS)**—If a subscriber who has CCBS calls a party who is engaged in another call, the subscriber can activate CCBS with a single key or sequence. When activated, CCBS causes the calling party's phone to ring when the called party becomes available; when the calling party answers, the called party's phone automatically rings again. This feature saves the calling party from continuously attempting to place a call to a party is still unavailable.

Note that the exact names of these services might differ, depending on the country and the operator. In addition, the term "CLASS" is not used outside of North America.

Calling Name (CNAM)

Calling name (CNAM) is an increasingly popular database-driven service that is only available in the United States at this time. With this service, the called party receives the name of the person calling in addition to their number. The called party must have a compatible display box or telephone handset to use this service. The CNAM information is typically stored in regional telecommunications databases. SS7/C7 queries the database for the name based on the number and delivers the information to the called party's local switch.

Line Information Database (LIDB)

Line information database (LIDB) is a multipurpose database that stores valuable information about individual subscribers to provide feature-based services (it is only available in the United States at this time). Such information might include the subscriber's profile, name and address, and billing validation data. The name and address information can be used to power CNAM, for example. The billing validation data is used to support alternate billing services such as calling card, collect, and third number billing. Alternate billing services allow subscribers to bill calls to an account that is not necessarily associated with the originating line. For example, it can be used to validate a subscriber's calling card number that is stored in the LIDB, designating this as the means of payment. SS7/C7 is responsible for the real-time database query/response that is necessary to validate the calling card before progressing to the call setup phase.

Local Number Portability (LNP)

Local number portability (LNP) provides the option for subscribers to retain their telephone number when changing their telephone service. There are three phases of number portability:

- Service Provider Portability
- Service Portability
- Location Portability

The various phases of LNP are discussed in more detail in Chapter 11, "Intelligent Networks."

The FCC mandated this feature for fixed-line carriers in the United States as part of the Telecommunications Act of 1996; later that same year, the act was also clarified to cover cellular carriers.

LNP is primarily aimed at stimulating competition among providers by removing the personal inconvenience of changing phone numbers when changing service providers. For example, many businesses and individuals spend relatively large sums of money to print their phone numbers on business cards, letterheads, and other correspondence items. Without LNP, people would have to reprint and redistribute these materials more often. This contributes to the inconvenience and detracts from the profitability of changing the telephone number, thereby making changing providers far more prohibitive.

Since telephone networks route calls based on service provider and geographic numbering plan information, SS7/C7 must figure out where the ported number's new terminating switch is by performing additional signaling before setting the call up. This step should add only a second to the call overhead setup; however, it is a technically challenging network change because it complicates the process by which SS7/C7 establishes a call behind the scenes. This process is further discussed in Chapter 8, "ISDN User Part (ISUP)."

2nd and 3rd Generation Cellular Networks

Cellular networks use SS7/C7 for the same reasons they use fixed line networks, but they place much higher signaling demands on the network because of subscriber mobility. All cellular networks, from 2G (GSM, ANSI-41, and even PDC, which is used in Japan) to 3G (UMTS and cdma2000), use SS7/C7 for call delivery, supplementary services, roaming, mobility management, prepaid, and subscriber authentication. For more information, see Chapter 13, "GSM and ANSI-41 Mobile Application Part (MAP)."

Short Message Service (SMS)

Short Message Service (SMS) forms part of the GSM specifications and allows two-way transmission of alphanumeric text between GSM subscribers. Although it is just now catching on in North America, SMS has been an unexpected and huge revenue source for operators around the world. Originally, SMS messages could be no longer than 160 alphanumeric characters. Many handsets now offer concatenated SMS, which allows users to send and receive messages up to 459 characters (this uses EMS described below). Cellular operators usually use SMS to alert the subscribers that they have voice mail, or to educate them on how to use network services when they have roamed onto another network. Third party companies offer the additional delivery services of sending SMS-to-fax, fax-to-SMS, SMS-to-e-mail, e-mail-to-SMS, SMS-to-web, web-to-SMS, and SMS notifications of the arrival of new e-mail.

Some European (Spain, Ireland, and Germany, for example) and Asian countries (the Philippines, for example) are rolling out fixed-line SMS, which allows users to send SMS through their fixed phone line to cell phones and vice versa, as well as to other fixed-line SMS-enabled phones, fax machines, e-mail, and specialized web pages. Thus far, each European rollout has also offered SMS-to-voice mail. If a caller sends a text message to a subscriber without fixed-line SMS facility, the SMS is speech-synthesized to the subscriber's and their voice mailbox. Fixed-line SMS requires compatible phones, which are becoming readily available.

SMS is carried on the SS7/C7 network, and it makes use of SS7/C7 for the required signaling procedures. For more information, see Chapter 13, "GSM and ANSI-41 Mobile Application Part (MAP)."

Enhanced Messaging Service (EMS)

Enhanced Messaging Service (*EMS*) adds new functionality to the SMS service in the form of pictures, animations, sound, and formatted text. EMS uses existing SMS infrastructure and consists largely of header changes made to a standard SMS message. Since EMS is simply an enhanced SMS service, it uses the SS7/C7 network in the same way; the SS7/C7 network carries it, and it uses SS7/C7 for the required signaling procedures.

EMS allows users to obtain new ring tones, screensavers, pictures, and animations for their cell phones either by swapping with friends or purchasing them online.

Operators have recently begun using EMS for downloading games (from classics like Asteroids, to newer games like Prince of Persia), which can be purchased from operator web sites.

Private Virtual Networks

Although the *private virtual networks* concept is not new, SS7/C7 makes it possible for a *Local exchange carrier* (LEC) to offer the service. The customer receives PVNs, which are exactly like leased (private) lines except that the network does not allocate dedicated physical resources. Instead, SS7/C7 signaling (and a connected database) monitors the "private customer" line. The customer has all the features of a leased-line service as well as additional features, such as the ability to request extra services ad hoc and to tailor the service to choose the cheapest *inter-exchange carrier* (IC), depending on the time of day, day or week, or distance between the two parties.

Do-Not-Call Enforcement

In the United States, federal and state laws have already mandated do-not-call lists [108] in over half the states, and all states are expected to follow suit. These laws restrict organizations (typically telemarketers) from cold-calling individuals. To comply with these laws, SS7 can be used to query state and federal do-not-call lists (which are stored on a database) each time a telemarketer makes an outbound call. If the number is on a do-not-call list, the call is automatically blocked and an appropriate announcement is played to the marketer.

Signaling System No. 7: The Key to Convergence

Telecommunications network operators can realize increased investment returns by marrying existing SS7/C7 and intelligent networking infrastructures with Internet and other data-centric technologies. SS7/C7 is a key protocol for bridging the telecom and datacom worlds.

The following sections describe the exemplar hybrid network services that SS7/C7 enable:

- Internet Call Waiting
- Internet Calling Name Services
- Click-to-Dial Applications
- Web-Browser-Based Telecommunication Services
- WLAN "Hotspot" Billing
- Location-Based Games

Internet Call Waiting and Internet Calling Name Services

Internet call waiting is a software solution that alerts online Internet users with a call-waiting message on their computer screens when a telephone call enters the same phone line they use for their Internet service. The user can then send the call to voice mail, accept the call, or reject it.

Some providers linking it to CNAM, as mentioned in Calling Name (CNAM), have enhanced the Internet call-waiting service. This service is known as Internet calling name service, and it provides the calling party's name and number.

Click-to-Dial Applications

Click-to-dial applications are another SS7-IP growth area. An example of a click-to-dial application is the ability to click a person's telephone number in an email signature to place a call. These types of services are particularly beneficial to subscribers because they do not require them to change their equipment or access technologies; a POTS and a traditional handset are the only requirements.

Web-Browser-Based of Telecommunication Services

Over the coming decade, we are likely to witness an increase in web based telecommunications services. An example is customer self-provisioning via the Internet, a practice that has been in the marketplace for some time and is likely to increase in both complexity and usage. A customer can already assign himself a premium or toll-free "number for life" via the Internet. The customer can subsequently use a Web interface to change the destination number it points to at will, so that during the day it points to the customer's office phone, and in the evening it points to the customer's cell phone, and so forth.

Another example is the "call me" service, which allows a customer to navigate a Web page to arrange a callback from a department, rather than navigating interactive voice response (IVR) systems through the use of voice prompts and a touch-tone phone.

The potential extends far beyond traditional telecommunications services, to the point where the distinction between Web and telecommunications services is blurred. An example of such an enabling technology is Voice Extensible Markup Language (VoiceXML), which extends Web applications to telephones and shields application authors from low-level, platform-specific *interactive voice response* (IVR) and call control details.

The marriage is not only between SS7/C7, the Internet, and fixed-line networks—it also extends to cellular networks. Plans are underway to put the location-based information and signaling found in cellular networks into hybrid use. For example, Web-based messenger services could access cellular network *home location registers* (HLRs) to enable a user to locate a friend or relative in terms of real-time geographic location.

WLAN "Hotspot" Billing

SS7/C7 has recently begun playing a role in the marriage of wireless (WLANs) and cellular networks. A subscriber can use a cellular subscriber identity module (SIM) card for authentication and billing purposes from a WLAN hotspot. For example, if a subscriber is at a café with WLAN facilities (typically wi-fi), the subscriber can request permission to use the service via a laptop screen. This request triggers a short cellular call to authenticate the subscriber (using SS7/C7 signaling). The usage is then conveniently billed to the subscriber's cellular phone bill.

NOTE A SIM is used in 2nd generation cellular networks based on GSM, and on 2.5/3G networks as defined by 3GPP. A SIM contains the subscriber's identity so that the subscriber can change cellular equipment freely by simply changing the SIM card over to the new device. This means that the subscriber can plug the SIM into a new cellular handset and the number "transfers" to that handset, along with the billing.

Location-Based Games

SS7/C7 is not only used to deliver games to cell phones, but it also plays a role in the creation of a new genre of location-based games and entertainment. Cellular games incorporate the player's location using SS7/C7 to provide mobility information a dedicated web site as a central point. Some of the games that are emerging at the time of this writing are using global positioning system (GPS), WLAN support, and built-in instant messaging capabilities (to help tease your opponents) to blend higher location accuracy.

Summary

This chapter has shown that, although it is transparent, SS7/C7 plays a role in the lives of virtually every individual in developed countries. It is also the key to new, revenue-generating services and is crucial to the QoS as perceived by subscribers—both of which lie at the very heart of success in a fiercely competitive telecommunications market. Furthermore SS7/C7 is a common thread that ties fixed-line, cellular, and IP networks together, and it is a key enabler for the convergence of the telecommunications and data communications industries.