

MOBILE COMMUNICATIONS SERIES

GSM AND PERSONAL COMMUNICATIONS HANDBOOK



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CHAPTER

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Short message service

The GSM *short message service* (SMS) provides a unique means of bringing short alphanumeric (letters and numbers) messages or other kinds of information to the user of a mobile telephone. The messages appear on the phone's display, which is usually an LCD. GSM distinguishes two different types of short messaging:

1. A dedicated service, between two parties, which requires the establishment of a (dedicated) point-to-point bearer link, thus the name *point-to-point SMS*;
2. Broadcast service between the network (through one or more base stations) and all users within a cell or service area. This is called *point-to-omnipoint* or *cell broadcast SMS*.

6.1 Short message service: point-to-point

The point-to-point service may be compared to the familiar paging service, but it is much more comprehensive. Traditional paging services deliver messages through an operator or computer, whereas GSM additionally allows direct (bidirectional) messaging without operator interaction. Sophisticated two-way paging (Motorola's FLEX family of protocols is an example) has recently appeared in the paging and messaging industry that closely mimics GSM's SMS, thus assuring us the tiny pagers we know so well are not likely to disappear, even though they do not have GSM's voice services. Nevertheless, GSM's SMS allows anyone to send alphanumeric messages to a mobile user at any time. Short messages might be sent because the recipient did not respond to a call, or has not switched on his mobile phone, or is busy on another phone, or cannot be reached for some other private reason. The "store-and-forward" mechanism behind SMS makes sure that when the recipient's phone cannot be immediately reached, the message is eventually delivered when the receiving subscriber's terminal is back in service or otherwise ready to receive messages.

Another difference between SMS and the common one-way pager is that with traditional paging services one never knows exactly if or when messages really arrive at the addressee, whereas with GSM, one can receive confirmation of the arrival of each message. In the unfortunate case where a message does not arrive within a specified time, the sender will be notified. There is an optional service for notification of when a message actually does arrive at the mobile phone.

Point-to-point short messages use a dedicated link, as in a voice call, on a duplex radio channel. This has the advantage that the network and the mobile station actually talk to each other, thus error handling mechanisms make sure that a message arrives properly at the recipient's mobile station and is stored properly therein. If this is not the case or if the mechanism fails for any reason, an error message will be created by the mobile station notifying the network of the problem together with the reason why a message was not received correctly. Since this message link uses a different *service access point identifier* (SAPI) than speech, it is even possible to send a message to a phone that is already carrying normal voice traffic for the recipient.

Short message service

Another advantage over, for cost: when compared to a voice stored during a charged voice call, direct short message way of getting quick and short in

The term *short message* comes individual message, which is limited to 140 bytes) for each single message. Point-to-point SMS can be found in [1]

6.1.1 Implementation of point-to-point SMS in the network

To clearly describe the message flow depicted in Figure 6.1 and is described (SME) is, in general, the device that initiates the message flow:

- ▶ A mobile station. In this case the message is sent between two mobile stations. The message flow does not necessarily have to go through the network. SMS is transparent to user equipment.
- ▶ A computer directly connected to the network. This is provided by the operator, who can initiate a message flow and requesting a message to be sent to a specific user.
- ▶ A device or computer located in the network. This allows someone to dial directly to a specific user and send a message.
- ▶ A computer that delivers updates to the network. This service the user subscribes to and can request. This should not be confused with the always without request.

The SC handles all functions related to the message flow. It receives a message from a SME and if the message cannot reach the addressee, it stores the message in the specified by the user or the operator.

Another advantage over, for example, leaving voice mail messages is **cost**: when compared to a voice mail service, for which the message is stored during a charged voice call and has to be retrieved by yet another charged voice call, direct short messaging is by far the most economical way of getting quick and short information to the right destination.

The term *short message* comes from the relatively short length of each individual message, which is limited to 160 characters (mapped onto 140 bytes) for each single message. The technical specification for point-to-point SMS can be found in [1].

6.1.1 Implementation of point-to-point SMS in the network

To clearly describe the message flow, the relevant network structure is depicted in Figure 6.1 and is described as follows. The *short message entity* (SME) is, in general, the device that originates a short message. It might be:

- ▶ *A mobile station.* In this case we observe the transmission of a message between two mobile stations. By the way, the two mobile stations do not necessarily have to be roaming in the same network; SMS is transparent to user locations.
- ▶ *A computer directly connected to the service center (SC).* This is a service provided by the operator, which can be used simply by dialing in and requesting a message to be sent to a specific subscriber.
- ▶ *A device or computer located in the fixed network.* The special computer allows someone to dial directly into the SC in order to dispatch a message.
- ▶ *A computer that delivers updated news services.* This is an example of a service the user subscribes to and to which she makes some kind of request. This should not be confused with cell broadcast, which is always without request.

The SC handles all functions related to point-to-point SMS. The SC receives a message from a SME and forwards it to the addressee. If it cannot reach the addressee, it stores the message up to some maximum time specified by the user or the operator. If necessary, or if requested, the SC

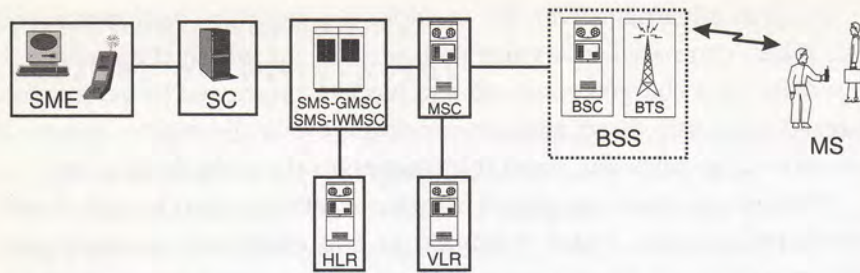


Figure 6.1 Network entities involved in the provision of short messages.

notifies the sender about the successful or unsuccessful delivery of a message. The SC, by definition, is not part of the GSM PLMN. In actual practice it is integrated into or connected to the MSC.

When SMS services first started it was common for there to be only one service center per operator. However, with the increasing number of applications for short messages, an operator would need several service centers to handle all of the messages. This is, for example, the case if one center were to handle the SMS for standard text messages between two subscribers, and another center handles a kind of service where the user sends a message to the SC requesting the latest result of a Formula 1 car race or the latest stock exchange information. This second set of examples is similar to faxback services.

It is also possible, on the other hand, for one SC to serve several PLMNs. This would be the case, for example, when two operators in one country share an SC, or two operators in different countries share an SC. One service center might be connected to several MSCs.

The *short message service-gateway mobile services switching center* (SMS-GMSC) is a dedicated function within a MSC that allows it to receive a short message from the SC, investigate the attached *home location register* (HLR) in order to find out where the recipient mobile station is currently located, and then deliver the short message to the visiting MSC and, eventually, to the mobile station. The SMS-GMSC function is used when a mobile station is the recipient of the message. This is represented in Figure 6.1 by a mobile-terminated short message, which would flow from left to right in the figure.

The *short message service-interworking mobile services switching center* (SMS-IWMSC) is another dedicated function within a MSC that allows

Short message service

the SC to receive short messages. The mobile station is the originator of the message to the recipient's mobile station. This is a mobile-originated SMS.

SMS-GMSC and SMS-IWMSC are responsible for the forwarding of short messages. They handle the exchange of information between the network and the mobile station. For example, the exchange of status reports and delivery receipts.

The *home location register* (HLR) is a database that contains the relevant data in the HLR is (1) the identity of the mobile station, and (2) whether the mobile station is currently in the network. This information is needed for the forwarding of short messages.

The *mobile services switching center* (MSC) is the central element in the network. With all of its registers, it handles the forwarding of short messages via the mobile network, to the mobile station. It has connections to other entities in the network, such as the HLR, VLR, and BSS. It also handles information about the current location of the mobile station, which is needed in order to forward short messages.

The *visitor location register* (VLR) is a database that contains the relevant data in the VLR is the more precise location of the mobile station. This information is needed for the forwarding of short messages.

The *base station subsystem* (BSS) is the part of the network that handles the radio interface (U_m) between the mobile station and the network.

The *mobile station* (MS) is the mobile station, which is the originator or a recipient of a short message. It is responsible for the forwarding of short messages to the network about abnormal conditions, such as network congestion or overflow.

6.1.1.1 Functions and

Short message service is based on the exchange of information between the service center, the HLR, the VLR, and the BSS. Depending on the direction of the message, the forwarding of the message involves the exchange of information between the service center, the HLR, the VLR, and the BSS. In addition, other message forwarding mechanisms, such as a status report and delivery receipt, are used for carrying the actual user data.

the SC to receive short messages from the MSC. This would be the case if the mobile station is the originator of a short message. It then submits the message to the recipient's service center. The SMS-IW MSC is used for mobile-originated SMS.

SMS-GMSC and SMS-IW MSC are not only responsible for the forwarding of short messages, but in general for the complete exchange of information between the network and the SMSC, which includes, for example, the exchange of status messages, as described later.

The *home location register* (HLR) stores the identity and user data of all the subscribers belonging to the area of the related MSC. For SMS, the relevant data in the HLR is (1) the current location (MSC) of the recipient mobile station, and (2) whether it is switched on and available to receive messages.

The *mobile services switching center* (MSC) is a complete exchange system. With all of its registers, it is able to route calls from the fixed network, via the mobile network, to an individual mobile station. The MSC has connections to other entities of the PLMN, which allow it to gather information about the current whereabouts of a mobile station; the location is needed in order to forward messages.

The *visitor location register* (VLR) contains all relevant data on visiting mobile stations of the serving MSC. In the case of SMS, the relevant datum is the more precise paging area where the recipient mobile station is located.

The *base station subsystem* (BSS) is used as a transport vehicle for SMS over the radio (U_m) interface.

The *mobile station* (MS), in the particular case of SMS, is either a sender or a recipient of a short message. The mobile station would also inform the network about abnormal (erroneous) situations, such as memory overflow.

6.1.1.1 Functions and parameters of point-to-point SMS

Short message service is based on functionality that is distributed over the service center, the HLR, the VLR, and the MSC with a number of parameters. Depending on the direction of transmission, the data frame containing the message accommodates different parameters. There are, of course, other message frames supporting different functions of the SMS, such as a status report and a command. Here we discuss only the frames carrying the actual user data, which will appear on the display of a mobile

station when a mobile terminated SMS transaction is completed successfully. In the other direction we have mobile originated message services, which are initiated by messages generated in the mobile phone.

The messages described here are higher layer messages. Additional information must be added to the messages before they can be transported on the air interface. Further details are found in [2].

SMS-MT message frame Figure 6.2 shows the structure and format of a *short message-mobile terminated* (SM-MT) message frame with the different fields and parameters. The *reply path* (RP) flag indicates that an answer for this specific message is paid by the originator of the message, and the recipient can answer free of charge. Sometimes it is sufficient to get a simple *yes* or *no* reply to a short message, such as, "Should we meet today at 12:00?" The reply path option has been defined for this purpose. This gives the recipient the ability to send a short answer without having to pay anything for this service. In GSM SMS, this option is invoked by the sender of the short message.

The *status report indication* (SRI) shows that a status report will be sent back to the originator (SME) of this short message. This means that the report of proper delivery from the mobile station will be passed on to the originator as confirmation of delivery of the short message.

The *more-messages-to-send* (MMS) flag indicates that, for this particular recipient, several messages are waiting to be delivered in the SMSC. This

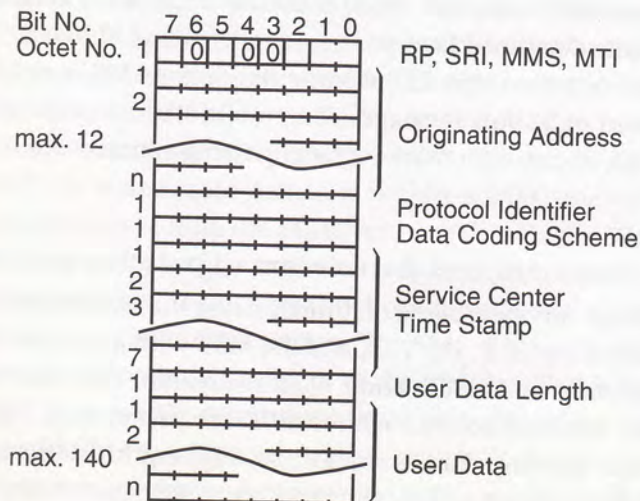


Figure 6.2 Format of an SM-MT.

Short message service

can be the case when a mobile... The basic principle behind this... should be delivered in one go... established. This not only reduces... the radio interface, but also in... tion and ciphering procedures.

The *message type indicator* (MTI) message contained in the frame...

- ▶ Delivering a short message and the corresponding confirmation
- ▶ Submitting a short message and confirmation of the message
- ▶ Status report from the network whereabouts of a previous message
- ▶ Issuing a command from the network

This last command issued... invoke an operation or inquiry... previously sent short message... status report request.

Table 6.1 lists the different values and their meanings.

Value	Direction
00	Network-MS
00	MS-network
01	Network-MS
01	MS-network
10	Network-MS
10	MS-network
11	Any

can be the case when a mobile station was switched off for a long time. The basic principle behind this is that all messages awaiting delivery should be delivered in one go once the signaling channel link has been established. This not only reduces signaling effort and traffic (air time) on the radio interface, but also in the network itself since all the authentication and ciphering procedures are only performed once.

The *message type indicator* (MTI) is a 2-bit value describing the kind of message contained in the frame. The message type is related to:

- ▮ Delivering a short message from the network to the mobile station, and the corresponding confirmation from the mobile station;
- ▮ Submitting a short message from the mobile station to the network, and confirmation of the network;
- ▮ Status report from the network to the mobile station about the whereabouts of a previously sent message;
- ▮ Issuing a command from the mobile station to the network.

This last command issued by the "subscriber" enables the MS to invoke an operation or inquiry at the SC, which could be the deletion of a previously sent short message or the cancellation or initialization of a status report request.

Table 6.1 lists the different values for the message type, the direction, and their meanings.

Table 6.1
List of Values for the Message Type

Value	Direction	Message Type
00	Network-MS	Delivery of a short message from the network
00	MS-network	Report on delivery of short message from the mobile station
01	Network-MS	Sending of a status report from the network
01	MS-network	Sending of a command from the mobile station
10	Network-MS	Submission of a short message from the mobile station
10	MS-network	Report on delivery of short message from the network
11	Any	Reserved value

The *originating address* (OA) contains the address of the sender of a specific message. If the sender was another mobile station, then the originating address is the actual phone number of a specific mobile station. Many mobile phones nowadays realize that this address is a phone number, and allow the user to select this number in order to call the number directly, or respond with another short message. The first option is especially helpful if the user wants to talk to the person who sent the message rather than respond with another short message.

The *protocol identifier* (PID) instructs the service center in which format or protocol the short message should be delivered. There are two major distinctions. One is the transfer of a short message between two mobile phones within the GSM infrastructure, which requires no special treatment because it uses only the higher layers. The other is the use of telematic interworking when a short message has to be "translated" into another format. The user of a mobile telephone is entitled to set up the protocol identifier. Note, however, that not all networks support the different protocols since these always require additional hardware in the network. See Table 6.2 for the different values for the protocol identifiers in telematic interworking. As should be obvious from the list, it is, in principle, possible to transfer a short message into a message for any kind of device.

Table 6.2
Values for the Protocol Identifiers Used for SMS

Value	Telematic Device
0	Implicit, the device type is specific to this service center or can be deduced from the basis of the address
1	Telex (or teletex reduced to telex format)
2	Group 3 telefax
3	Group 4 telefax
4	Voice telephone (i.e., conversion to speech)
5	ERMES (European Radio Messaging System)
6	National Paging System (as it is known to the service center)
7	Videotext (T.100/T.101)
8	Teletex, carrier unspecified
9	Teletex in PSPDN (public-switched packet data network)
10	Teletex in CSPDN (cellular-switched packet data network)
11	Teletex in analog PSTN (public-switched telephone network)

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Value	Telematic Device
12	Teletex in digital ISDN (integrated digital network)
13	Universal computer interface
14-15	Reserved (two combinations)
16	Message handling facility
17	Any public X.400-based message transfer
18-23	Reserved (six combinations)
24-30	Values specific to each service center; agreement between the short message service and the service center are seven combinations available
31	GSM mobile station. The service center received alphabet coding to a mobile station (e.g., the default one)

The *data coding scheme* (DCS) in the short message service (SMS) decoding is used for the alphabet used. Two alphabets are available: (1) the default alphabet and (2) the GSM alphabet. These are specified in Section 6.1.2. The DCS also specifies the class of the short message.

The *service center time stamp* (SC-TS) is the time when the message arrived at the service center. This time stamp is used for each mobile phone user can see, but it does not indicate when the message was actually sent, or, to be received it. From this time stamp, one can determine how long it took the network to deliver the message. The time stamp is in the Year:Month:Day:Hour:Minute:Second format. The value is represented by two digits.

The *user data length* (UDL) indicates the length of the user data in characters. The length is, therefore, the 8-bit coding scheme is used, the length is in octets. If the default (7-bit coding scheme) number of octets is less than the maximum length of 140 octets.

The *user data* (UD) contains the user data. The maximum length of 140 octets. Section 6.1.2 shows the coding of the individual characters. The short message contains up to 160 octets. The maximum of only 140 octets. In Section 6.1.2, the coding of the user data is shown along with the coding of the

Value	Telematic Device
12	Teletex in digital ISDN (integrated services digital network)
13	Universal computer interface (UCI) as specified in ETSI DE/PS 3 01-3
14-15	Reserved (two combinations)
16	Message handling facility that is known to the service center
17	Any public X.400-based message system
18-23	Reserved (six combinations)
24-30	Values specific to each service center; the usage is based on mutual agreement between the short message entity and the service center (there are seven combinations available for each service center)
31	GSM mobile station. The service center converts the short message from the received alphabet coding to any alphabet decoding supported by that mobile station (e.g., the default one)

The *data coding scheme* (DCS) informs the mobile station about which decoding is used for the alphabet used in the actual message. Currently, two alphabets are available: (1) the default alphabet or (2) 8-bit data. These are specified in Section 6.1.2. In addition to the alphabet, the DCS also specifies the class of the short message.

The *service center time stamp* (SCTP) indicates when a specific message arrived at the service center. This time is also delivered to the recipient. Each mobile phone user can see, by this time stamp, when the received message was actually sent, or, to be more precise, when the service center received it. From this time stamp, one could actually evaluate how long it took the network to deliver the message. The format of the time stamp is in the Year:Month:Day:Hour:Minute:Second:Time zone order. Each value is represented by two digits.

The *user data length* (UDL) indicates the length of the following data in characters. The length is, therefore, dependent on the coding scheme. If the 8-bit coding scheme is used, then the UDL is identical to the number of octets. If the default (7-bit coded) GSM alphabet is used, then the number of octets is less than the number of characters.

The *user data* (UD) contains the actual encoded message with a maximum length of 140 octets. Section 6.1.2 describes the GSM alphabet and the coding of the individual characters. This reveals the mystery of why a short message contains up to 160 characters, but can be carried by a maximum of only 140 octets. In Section 6.1.3 a complete message will be shown along with the coding of the user data.

SMS-MO message frame Figure 6.3 shows the structure and format of a *short message–mobile originated* (SM-MO) message with the different fields and parameters. The RP indicates that the sender of the message is willing to pay for the response.

The *status report request* (SRR) indicates that the sender of this short message wants to have a confirmation that the message was delivered. If the message was delivered within the validity period, then the sender will get a positive confirmation along with the time when the message was delivered. All of this will appear within a status report explained in the paragraph about the message type. If the message could not be delivered, then the sender would be notified about this fact along with a cause value.

The *validity period format* (VPF) describes whether the validity period is present in this message, and if it is present, whether it is represented as a relative or an absolute value.

The *message type indicator* (MTI) is identical to the one described in the chapter on supplementary services, Chapter 7.

The *message reference* (MR) allows the mobile station to number the short messages that have been sent. This MR is used when a status report is issued to the mobile station by the service center.

The *destination address* (DA) indicates the recipient of this short message. The address is entered as a normal phone number. The PID and the DCS are, again, identical to the mobile-terminated message.

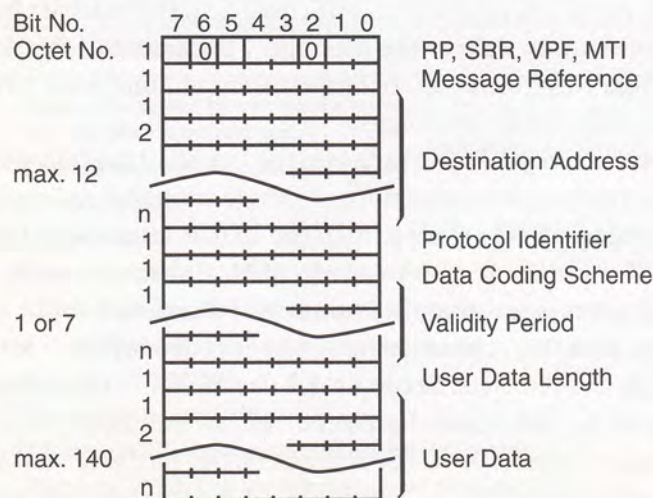


Figure 6.3 Format of an SM-MO.

Short message service

The *validity period* (VP) is valid, and how long the SC sh Let's say we sent an urgent sh this evening. It would not mak this message tomorrow morn different formats: the relative

In the case of the absolute time stamp. The absolute valid sage. In the relative represen frames decreases with increa validity periods up to 12 hou decreases to 30-minute steps 1 week, the resolution decrea 1 week up to 63 weeks (more reality, however, the long vali indications are mostly theoret tend to limit validity times to limits the amount of expensi messages.

The UDL and UD are simi

Additional functionality considered specific messages received from them. We have sages are sent and how the n details become important, switched off or move out of re

Consider a message that is When the *priority indicator* for ter continuously tries to delive as "no memory available," is r station is temporarily absent, condition is cleared. Sending t chances of early delivery; the return of a mobile station to se clear his short message memor

When the SMS could not available in the VLR as the mob as *message-waiting-data* field, w

The *validity period* (VP) indicates how long a specific short message is **valid**, and how long the SC should, therefore, try to deliver the message. Let's say we sent an urgent short message indicating an appointment for this evening. It would not make much sense to try continuously to deliver this message tomorrow morning. The validity can be represented in two different formats: the relative validity and the absolute validity.

In the case of the absolute validity, the format is identical to the SC time stamp. The absolute validity specifies the "expiration date" of a message. In the relative representation of validity, the resolution of time frames decreases with increasing time. The resolution is 5 minutes for validity periods up to 12 hours. From 12 hours to 1 day the resolution decreases to 30-minute steps. For validity periods between 1 day and 1 week, the resolution decreases even further to a whole day; and from 1 week up to 63 weeks (more than a year) it decreases to 1-week steps. In reality, however, the long validity periods with low-resolution expiration indications are mostly theoretical curiosities because network operators tend to limit validity times to a maximum of several days. Doing this limits the amount of expensive network resources required for storing messages.

The UDL and UD are similar to the mobile-terminated case.

Additional functionality in the network So far we have only considered specific messages that were sent out to mobile stations or received from them. We have not yet explored the details of how the messages are sent and how the network ensures their proper delivery. These details become important, for example, when mobile phones are switched off or move out of reach of the network.

Consider a message that is waiting in the service center for delivery. When the *priority* indicator for such a message is set, then the service center continuously tries to deliver the message even though an error, such as "no memory available," is returned from the target mobile, the mobile station is temporarily absent, or the HLR does not confirm that an error condition is cleared. Sending the short message more often increases the chances of early delivery; there are more opportunities to detect the return of a mobile station to service, or that the user has finally decided to clear his short message memory, either in the phone or in the SIM card.

When the SMS could not be delivered, the *messages waiting* element is available in the VLR as the *mobile-station-not-reachable* flag, and in the HLR as *message-waiting-data* field, which is further subdivided into different

conditions. The implementation in the VLR is mandatory, and it is optional in the HLR. If a delivery attempt of a short message was unsuccessful, then the network will return some diagnostic results. If the mobile station is not available, then the *mobile-station-not-reachable* flag is set in the VLR. If the mobile station becomes alive again, or becomes otherwise accessible by the network, the VLR will notify the SC of this happy event through the HLR. Other error cases will generate an entry into the optional *message-waiting-data* field in the HLR. If this is not present, the option to include it in the HLR has not been exercised, and then the SC would simply receive a failure indication. The SC, then, is obliged to cope with failure indications itself. Even though it is optional, the assistance of the HLR is a more effective way to deal with erroneous message deliveries. As soon as the HLR detects that a problem is resolved, it notifies the SC with the *alert-SC* command. In the *message-waiting-data* field, there is sufficient room to enter the addresses of multiple service centers that have to be notified when problems are resolved.

The *mobile-station-not-reachable* flag and the *message-waiting-data* field will only be cleared if all messages have been sent successfully to a mobile station. This data management scheme makes sure that all messages arrive at the mobile properly.

The service center can also send a status report to the originator of a message. The status can be simply that a message was successfully delivered to the SME. The request for this status message can be invoked by the originator with a dedicated request for this status report within the short message. On the other hand, a status report can also be issued when a message could not be delivered to the recipient. The implementation of this status report capability is optional, and is left entirely to the operator.

6.1.1.2 SMS MT

In the case of mobile-terminated SMS, where the message will arrive in the mobile station, the following steps will take place:

1. The short message is generated in the SME. It does not matter whether the SME is another mobile station or an entity within the PLMN.
2. The short message is sent from the SME to the service center. The service center controls further handling of the message. It checks

the validity period, and if a message was received in the protocol, it checks whether the message was sent to the same address as the original message.

3. The SC notifies the SMS-MSC that a mobile station. If the message is not received, then the MSC will pass the message to the recipient.
4. The SMS-GMSC asks the SMS-MSC if the mobile station is currently located in the area. If the mobile station is currently not available, the SMS-MSC will occur (see Section 6.1.1.1). The HLR will set a flag that the message was not successful. This situation is finally successful.
5. With the MSC's knowledge, the recipient mobile station is notified of the message on to the visited MSC.
6. The visited MSC checks the mobile station area the mobile station is currently located in.
7. The BTSs in the location area are alerted, page the mobile station, and establish a radio channel and delivers the message.
8. The mobile terminal receives the message. The notification is a visual signal that may be a vibration or a ring tone.

Figure 6.4 shows the display of a short message. A problem that the size of the display is not big enough for a mobile station, therefore, has to be solved. The messages and provide a means for the user to view the message itself, there is lots of

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