Cellular Networking Perspectives

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Pending FCC Ruling on Hearing Aid Compatibility

On November 14, 2001 the FCC (US Federal Communications Commission)

www.fcc.gov

released a Notice of Proposed Rule Making (NPRM) on Hearing-Aid compatibility for wireless phones. Comments against WT Docket No. 01-309 must be filed by January 11, 2002, and reply comments are due by February 11, 2002.

Many digital cellular, PCS and ESMR phones cause unacceptable interference when used with hearing aids. These phones have had an exemption from FCC interference rules, but there is pressure from the deaf and hard-of-hearing community to end this.

They are concerned that not only are they denied the benefits of digital wireless communications, but that when analog is phased out, they will be left with no means of wireless communications. Some of the benefits of digital wireless, such as SMS, are particularly applicable to people with hearing disabilities.

The basic question is whether hearing aids should be made compatible with digital phones, or digital phones with hearing aids (or a bit of both). The FCC notes that compatibility is only required for hearing aids that are "designed to be compatible" with hearing-aid compatible phones, which seems to put some of the onus on hearing aid manufacturers to achieve compatibility. Shielding the hearing aid is often an effective solution for external (behind the ear) aids, but 11.2nternal means" to provide compatibility. This seems to put the entire onus on wireless devices. Furthermore, the FCC is currently interpreting this to mean that a special device, such as a cable, used to achieve compatibility would be considered 'external', and therefore they would not consider this legally acceptable, even if it is the technically best solution.

> **Huh?**
>
> If there are any acronyms or terms that you are unfamiliar with, check our website glossary. You will probably find them there:
>
> www.cnp-wireless.com/glossary.html

ESIF: Emergency Services Interconnection Forum

ATIS (www.atis.org) and NENA (www.nena.org) are trying to establish a forum (the ESIF) to resolve problems with interconnection of telephony and emergency services systems to meet the US FCC Emergency Services mandate. This effort is most enthusiastically supported by companies providing wireless emergency services support capabilities.

One of the big problems with the implementation of wireless 9-1-1 is that Local Exchange Carriers (LECs) are outside the FCC mandate. Yet, because they generally provide Selective Routers, they are essential to

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achieving interconnection between wireless carriers and the Public Service Answering Points (PSAPs).

ESIF could perform a valuable service by involving the LECs in interconnect discussions. The major concerns with this forum, as expressed by wireless industry companies, are the cost of membership and whether yet another forum is needed.

9-1-1: No Shortcuts

In an open letter to the wireless industry on December 12, 2001, NENA requested that wireless manufacturers and carriers disable emergency dialing shortcuts (such as pressing and holding the ‘1’ or ‘9’ key).

NENA claims that between 25% and 70% of emergency calls from wireless phones are due to accidental invocation of this capability (e.g. putting a phone in a briefcase, pocket or purse where something presses against the keys). Emergency personnel waste a lot of time ensuring that these calls are not from someone who is unable to speak (e.g. a choking or heart attack victim).

The NENA letter is at:

> www.nena.org/UnintCallLetter12-01.PDF

Goodbye UWCC

The UWCC (Universal WIreless Communications Consortium) was dissolved on December 25, 2001. It was once the leading proponent of ANSI-136 TDMA digital cellular and PCS. Ever since the announcement by AT&T Wireless that it would be jumping to GSM directly, rather than through a GPRS/ANSI-136 overlay, the UWCC’s *raison d’être* has been called into question.

It now appears clear that ANSI-136 is a technological dead-end, and that carriers must either jump to GSM (including GPRS, EDGE and, eventually, W-CDMA) or to cdma2000.

At about the same time, many of the players in the UWCC announced the formation of a new organization (as yet unnamed) that will promote the GSM/GPRS/EDGE/W-CDMA path from ANSI-136. Founding members include AT&T Wireless, Cingular, Rogers, Compaq, Lucent, Motorola, Nokia, Openwave, and Siemens. Latin American carriers have been invited to join, since ANSI-136 was widely implemented in that region.

Circumnavigating SS7, Part IV: SCCP

SCCP, the Signaling Connection Control Part, provides advanced routing and message handling capabilities within the SS7 suite of standards. It is only possible, for example, to route messages through international SS7 gateways by using the SCCP global title capabilities, and it is only possible to transport messages larger than a single MTP frame using SCCP segmentation. The biggest limitation of SCCP is that it was not originally designed with adequate consideration given to forward compatibility, making it difficult to use some of its newer capabilities.

The SCCP layer will be present in SS7 transmissions, unless MTP management messages or ISUP (call setup) information is being transmitted. This layer is mandatory for TCAP-based protocols, such as GSM MAP and ANSI-41.

We will use ANSI SCCP (T1.112) for our discussion, pointing out major differences with ITU SCCP (and, by implication, with many national SCCP variants).

Comparison with MTP

MTP is the basic transport mechanism of SS7, and it resides below all other SS7-related protocols. SCCP is not universal. ISUP is one example of an SS7 protocol that uses MTP, but not SCCP. All TCAP-based protocols, such as GSM MAP and ANSI-41, use SCCP, however, even if none of the capabilities of SCCP are used.

SCCP is best viewed as an extension of MTP, rather than a separate protocol layer. It extends MTP’s routing capabilities, allowing international SS7 interworking, and it can even transmit messages larger than a single MTP message can hold. SCCP is, however, beholden to MTP for many capabilities. Large SCCP messages can only be transmitted as a single unit, for example, on high speed MTP links. Consequently, SCCP cannot be regarded as an independent protocol layer.

Message Size Limitations

Standard SCCP messages are limited in size to 252 octets, including the SCCP overhead (which varies depending on the complexity of information included). This limitation can be bypassed by segmenting larger messages into pieces (requiring support of the 1996 XUDT message) or by using higher speed links (requiring support of the 2000 LUDT message).

Protocol Classes

SCCP is divided into four different sub-protocols by the two-bit protocol class parameter:

- 00 - Connectionless (most important)
- 01 - Connectionless, Sequenced
- 10 - Connection-oriented
- 11 - Connection-oriented with flow control.

Sequencing

SCCP, when used in its basic configuration (protocol class 00 - connectionless), does not guarantee that messages are received in the same order in which they were transmitted. This is not a problem for most transaction oriented protocols where there is never more than one message outstanding for a single transaction at any one time. In situations where it is important to ensure that messages arrive in sequence, SCCP provides a sequencing capability. This can be accomplished with connectionless transport by using protocol class 01 or through either of the connection-oriented classes (10 or 11).

Connectionless Message Transport

SCCP is most commonly used in a connectionless mode (protocol class 00 or 01). Each message is self-contained, containing the full address of the destination. Communications can be initiated without the overhead of setting up a relationship with the destination (or of tearing this down, later).

Three messages are provided for the connectionless transport of signaling data in SCCP - UDT, XUDT and LUDT.

UDT - Unit Data

The basic UDT transport message allows up to 252 octets of data to be conveyed in one SCCP message (including the SCCP overhead, which varies in size). The most obvious manifestation of this limitation is that wireless short messages cannot be more than about 150 octets (252 octets less SCCP and ANSI-41 or GSM MAP overhead).

XUDT - Extended Unit Data

More recent versions of SCCP also provide the XUDT message, which allows application messages that are more than 252 octets in length to be segmented into multiple SCCP messages (see below). The problem with implementing this capability is that the entire network has to support this capability. Otherwise, older STP's (pre-1996 ANSI SS7, for example) may discard the XUDT messages they do not understand.

LUDT - Long Unit Data

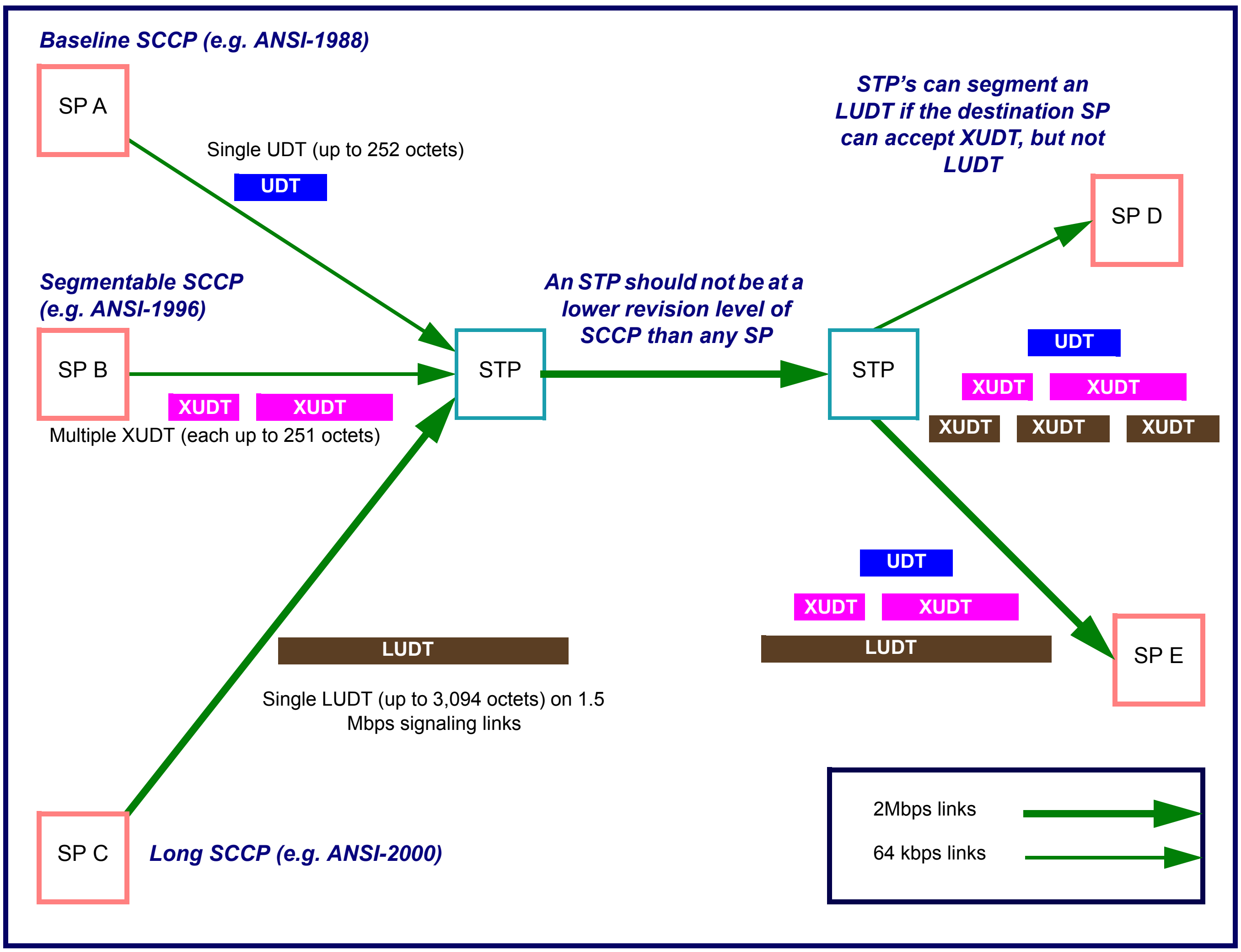
The 2000 version of ANSI SS7 supports 1.5Mbps signaling links (T1). These are not only much faster than the traditional 64kbps links (DS0), but can also carry messages up to 3,904 octets in length. The drawback of this capability is that it also requires network-wide support of either the XUDT or LUDT.

Figure 1 illustrates how the UDT, XUDT and LUDT can be used within an SS7 network

Responses

SCCP runs over a highly reliable protocol (MTP), so explicit acknowledgments are not necessary. They can be obtained for connectionless messages by specifying 'return message on error' in the Protocol Class octet. Use of this capability is not highly desirable in commercial systems because the entire message will be returned, which could result in significant congestion if an error results in a large number of messages being rejected.

Figure 1: SCCP Data Transmission Options



Hop Counting

Hop counting is a mechanism for ensuring messages do not get transmitted in circles (e.g. when routing tables are in error). The hop counter is initially set to a value (e.g. 16) and decremented every time the SCCP message is re-transmitted. If the value reaches zero it is assumed that the message is looping and the message is discarded or return. This technique does restrict the number of times an SCCP message can be re-transmitted, so the maximum hop count must not be set too low.

Hop counting is not supported by UDT or connection-oriented message, but it is supported by XUDT and LUDT.

ISNI - Intermediate Signaling Network Identification

When AT&T was broken up by the US government in 1984, only long distance carriers were allowed to transport calls across local calling (LATA) boundaries. Some long distance carriers felt that SS7 signaling data should be treated in the same way. Rather than allowing this data to flow naturally through the SS7 network, they wanted to exert tighter control.

For example, they wanted to ensure that if a message traversed their network in one direction, it would also traverse it in the reverse direction.

ISNI is a mechanism for controlling the intermediate signaling (i.e. SS7) networks that are traversed by a message. Because it is not supported by the basic transport message of SCCP (UDT), and because it has no technical value and it consumes valuable space within SCCP messages (up to 18 octets), it is only sparsely implemented. It is only supported by ANSI SS7.

Formats

The formats of the major connectionless SCCP messages – UDT, XUDT and LUDT – are compared in Table 1.

Table 1: Comparison of UDT, XUDT and LUDT Messages

Parameter	Octets	UDT (Unitdata)	XUDT (Extended UDT)	LUDT (Long UDT)
Message Type	1	9	17	19
Protocol Class (bits 1 - 4)	4 bits	0 (connectionless, unsequenced) or 1 (connectionless, sequenced)		
Protocol Class (bits 5-8)	4 bits	0 (discard message on error) or 8 (return message on error)		
SCCP Hop Counter	1	Not included.	Initially set to an arbitrary value (not usually more than 16), and decremented whenever the message is re-transmitted. An error is declared if it reaches 0.	
Called Party Address	Š3	See descriptions of global titles. Identifies the final message destination.		
Calling Party Address	Š2	See descriptions of global titles. Identifies the message originator. Used for validation and for routing replies.		
Data	varies	2 to 252 octets may be included.	2 to 251 octets may be included.	3 to 3,904 octets may be included.
Segmentation	4	Not included.	Contains the number of remaining segments, a special indicator for the first segment, the original Protocol Class (0 or 1) and a 24 bit local reference (3 octet number assigned by the originator to all segments of a message). Required in LUDT because segmentation may occur if a 64kbps link is encountered before the destination is reached.	
ISNI	3-18	Not included	Intermediate network information. Required only if the ISNI feature is implemented.	
INS	5-7	Not included		
Message Type Interworking	3	Not included	Used to preserve the original message type (e.g. UDT) if it is changed at an intermediate node.	
End of Optional Parameters	1	Not included	Zero. Identifies the end of the list of optional parameters.	

Connection-Oriented Transport

SS7 has its greatest advantages as a connectionless communications protocol. However, for applications when these capabilities are not enough, SCCP provides connection-oriented capabilities. While this improves the efficiency of communications when large numbers of messages are being exchanged between two points, it requires establishing and then tearing down connections. This results in far more overhead in situations where a great deal of *ad hoc* communications is required. A perfect example of this is in wireless networks where one MSC may have to communicate with hundreds or even thousands of HLR's (and vice-versa).

Routing

SCCP provides another layer of addressing information for more advanced routing. This routing information can be in the form of a point code (to supplement the point codes transported by MTP) or in the form of a global title. Both a Called Party Address (destination) and Calling Party Address (originating node) are included. The Called Party Address is used for routing. The Calling Party Address may be used for routing responses and for validation of the message sender.

Global Titles

A global title is simply a telephony address that can be used for routing. Examples are phone numbers, calling card numbers, Mobile Identification Numbers (MIN) or International Mobile Subscription Identities (IMSI).

If a global title is included in the SCCP layer, the MTP point code address is used to route to a signaling point (e.g. an STP closer to the destination or an international gateway) where a translation of the global title occurs. This provides another point code, which may be for the final destination or for another intermediate point.

Global titles can be used for both the Called Party and Calling Party (originating point) Addresses. The global title of the originating point is useful to allow replies to be addressed using a global title, something that is essential for true international routing of SS7 messages.

Table 2 lists all the global titles types supported by the 2000 version of ANSI SCCP.

Table 2: ANSI SS7 Global Title Types

Translation Type	Name	Address Type	Usage
1	Identification Cards	IOS/7812	Validating charge card numbers in the ISO/7812 format.
2	14 Digit Telecommunications Calling Cards	ITU-T E.113	Validation of telecommunications call card numbers in the ITU-T E.113 (14 digit) format
3	Cellular Nationwide Roaming	MIN (10 digits)	Routes ANSI-41 messages (e.g. for registration, validation, authentication) between a Serving ANSI-41 MSC and an HLR using the MIN
4	Point Code	Point Code	Used when no global title is specified.
5	Calling Name Delivery	NPA-NXX-XXXX	Routes calling name queries to the database for a North American phone number (NPA-NXX-XXXX).
6	Call Management	NPA-NXX-XXXX	Automatic callback and automatic recall.
7	Message Waiting	NPA-NXX-XXXX	Access to the Message Storage System.
8	SCP Assisted Call Processing	SCP ID	Access to a SCP (Service Control Point) using an extended point-code-like format.
9	National and International Cellular/ PCS Roaming	E.212 IMSI	Routes GSM MAP signaling messages to an HLR based on the IMSI received from a mobile. Should not be used for ANSI-41 messages.
10	Network Entity Address	E.164 MDN	Routes GSM MAP messages based on the address of a network element, in the format of an E.164 phone number. These numbers are never portable, so number portability queries are never required when routing this global title.
11	Internetwork NP Query/Response	NPA-NXX-XXXX	Routes a query to a remote Number Portability database, identifying the database based on the phone number.
12	Wireless MIN-Based Short Message Service	MIN (10 digits)	Routes an ANSI-41 message to a Message Center based on the MIN received from the mobile initiating the short message transmission.
13	Wireless IMSI-Based Short Message Service	E.212 IMSI	Routes an ANSI-41 message to a Message Center based on the IMSI received from the mobile initiating the short message transmission.

Table 2: ANSI SS7 Global Title Types (continued)

Translation Type	Name	Address Type	Usage
14	Mobile Subscriber Addressing	E.164 MDN	Routes a message to a GSM HLR when the MDN (Mobile Directory Number) is available. Unlike translation type 10, a number portability query may be necessary if the MDN is in a portable block.
15	Packet Data Interworking	E.212 IMSI	Routes a message to a GPRS-HLR (GSM packet data system).
16	Cellular/PCS Interworking	E.212 IMSI	Routes an ANSI-41 message to an ANSI-41 HLR or to an ANSI-41/GSM interworking and interoperability function (IIF), at which point the message is converted and translation type 9 is used.
17	Mobile Subscriber Message Center Addressing	E.164 MDN	Routes a message to a Message Center (MC) based on the phone number of a mobile. This may be required when routing mobile-to-mobile short messages between the originating mobile's MC and the terminating mobile's MC.

Table 3 describes the format of ANSI global titles. In theory, the numbering plan and encoding scheme can also be included (Global Title Indicator=1), but this is not fully defined in ANSI, and is therefore not used.

ITU SS7, by contrast, sets the Translation Type to zero and *does* include the numbering plan to distinguish between global titles. The subsystem number can be used to distinguish between global titles using the same numbering plan. This unnecessary difference makes interworking between ANSI and international SS7 more difficult.

The National/International bit is usually set to 1, indicating national (as the format is defined nationally, even if the address is international).

The Routing Indicator is set to 0 to allow translation of the global title or 1 to force use of the point code in the MTP layer (e.g. upon transmission to the final destination).

The Point Code Indicator bit is set to 1 if the global title also contains a point code and the SSN Indicator bit is 1 if a subsystem number is included. The order of these bits is reversed in ITU SS7.

Table 3: ANSI SS7 Global Title Format

Octet	Bits							
	8	7	6	5	4	3	2	1
1	National/ International	Routing Indicator	Global Title Indicator (always 2 in ANSI SCCP)				Point Code Indicator	SSN Indicator
2	Translation Type (See Table 2 for currently supported values)							
3 and further	Digits of global title follow, usually stored two to an octet in the BCD format. Binary 0000 through 1001 represent the digits 0 through 9, and binary 0000 is also used as a filler if there are an odd number of digits. Values 1010 through 1111 are not currently used.							

Summary of Messages

Table 4 lists all SCCP messages defined in ANSI T1.112-2000.

Conclusions

SCCP is an essential component of the SS7 network, but it is far from a perfect protocol. Its major limitations are:

- Lack of forward compatibility makes it difficult to implement advanced capabilities, such as high speed signaling links.
- Each global title must be supported by routing tables at every STP through which a message with that global title could be routed. This makes carriers reluctant to implement new global titles. ANSI-41 carriers, for example, do not use any global titles, and GSM carriers use the very kludgy E.214 transformation from E.212 to E.164 to avoid implementation of both E.212 and E.164 global titles.
- Lack of international standardization. Although interworking is possible, this is not as good as true compatibility.

Despite these limitations, SCCP will be around for a considerable time. SCCP provides reliable *and* connectionless communications, whereas internet protocols force a choice between reliable and connection-oriented (e.g. TCP or SCTP) *or* connectionless and unreliable (e.g. IP or UDP) communications. Domain name services are a better model for address resolution, allowing routers to work on only the most basic address (i.e. IP addresses and not domain names), but they do not currently support telephony addresses with any degree of sophistication.

Table 4: SCCP Messages

Invoking Message	Response	Purpose
CR – Connection Request	CC – Connection Confirm or CREF – Connection Refused	Used to set up a signaling connection. Only required for connection-oriented communication (protocol classes 2 and 3)
DT1 – Data Form 1		Transport of data over a connection (protocol class 2)
DT2 – Data Form 2	AK – Data Acknowledgment	Transport of data over a connection with flow control (protocol class 3). Acknowledgment at the SCCP level (via AK) is necessary for the end-to-end flow control mechanism which only allows a fixed number of messages to be in transit on any one connection.
ED – Expedited Data	EA – Expedited Data Acknowledgment	Transmits high priority data over an SCCP connection. Only one ED may be outstanding at a time.
ERR – Protocol Data Unit Error		Reports the detection of a protocol error on a connection (protocol class 2 or 3).
IT – Inactivity Test		Tests a signaling connection (protocol class 2 or 3).
LUDT - Long Unitdata	LUDTS - LUDT Service or UDTS	Similar to the UDT, but allows larger messages (up to 3,904 octets). Can only be used with high speed (1.5Mbps) signaling links.
RLSD – Released	RLC – Release Complete	Releases a signaling connection.
RSR – Reset Request	RSC – Reset Confirmation	Initiates the re-initialization of SCCP sequence numbers. Only required for connection-oriented communication with flow control (protocol class 3).
SBR – Subsystem Backup Routing		Used by an adjacent node (e.g. STP) to inform a backup system that its partner is out of service.
SNR – Subsystem Normal Routing		Used by an adjacent node (e.g. STP) to inform a backup system that its partner is back in service.
SOR – Subsystem Out-of-Service Request	SOG – Subsystem Out-of-Service Grant	Used by a replicated system to tell its backup that it is going out of service.
SRT – Subsystem Routing Status Test		Used to verify the status of a subsystem for which backup routing is being used (i.e. reported out of service by an SBR message).
SSA – Subsystem Allowed		Reports that communications with a subsystem (e.g. SCCP application) is now allowed. See SSP.
SSP – Subsystem Prohibited		Reports that communications with a subsystem (e.g. SCCP application) is not allowed. See SSA.
SST – Subsystem Test		Used to verify the status of a subsystem marked prohibited by an SSP message.
UDT – Unitdata	UDTS – UDT Service	Basic method of transporting data through SCCP without establishing a connection first (protocol class 0 or 1). Limited to a single 252 octet packet. Response (UDTS) is optional, and is only sent if an error occurs.
XUDT – Extended Unitdata	XUDTS - XUDT Service or UDTS	Similar to the UDT, but allows segmentation of large messages into multiple packets up to 251 octets in length.