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SERIES H: AUDIOVISUAL AND MULTIMEDIA SYSTEMS

Infrastructure of audiovisual services – Systems and terminal equipment for audiovisual services

Terminal for low bit-rate multimedia communication

ITU-T Recommendation H.324

ITU-T

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ITU-T Recommendation H.324

Terminal for low bit-rate multimedia communication

Summary

This Recommendation describes terminals for low bit-rate multimedia communication, utilizing V.34 modems operating over the GSTN. H.324 terminals may carry real-time voice, data, and video, or any combination, including videotelephony.

H.324 terminals may be integrated into personal computers or implemented in stand-alone devices such as videotelephones. Support for each media type (voice, data, video) is optional, but if supported, the ability to use a specified common mode of operation is required, so that all terminals supporting that media type can interwork. This Recommendation allows more than one channel of each type to be in use. Other ITU-T Recommendations in the H.324-Series include the H.223 multiplex, H.245 control, H.263 video codec, and G.723.1 audio codec.

This Recommendation makes use of the logical channel signalling procedures of ITU-T Rec. H.245, in which the content of each logical channel is described when the channel is opened. Procedures are provided for expression of receiver and transmitter capabilities, so transmissions are limited to what receivers can decode, and so that receivers may request a particular desired mode from transmitters. Since the procedures of this Recommendation are also planned for use by ITU-T Rec. H.310 for ATM networks, and ITU-T Rec. H.323 for non-guaranteed bandwidth LANs, interworking with these systems should be straightforward.

H.324 terminals may be used in multipoint configurations through MCUs, and may interwork with H.320 terminals on the ISDN, as well as with terminals on wireless networks.

Annex A defines the data protocol stack for use with the H.324 control channel.

Annex B defines HDLC frame structure transparency for asynchronous transmission.

Annex C defines the use of H.324 terminals in error-prone transmission environments ("also referred to elsewhere as H.324/M").

Annex D defines the use of H.324 terminals on ISDN circuits ("also referred to elsewhere as H.324/I").

Annex E defines timer T401 initialization for operation over geostationary satellite channels.

Annex F supports multilink operation on the GSTN and ISDN.

Annex G defines the use of ISO/IEC 14496-1 ("MPEG-4 Systems") generic capabilities in H.324 terminals.

Annex H supports multilink operation on error-prone mobile networks.

Annex I defines the use of HTTP in H.324 terminals, enabling non-conversational services with a user interface through web-like menus.

Annex J summarizes the OIDs defined in ITU-T Rec. H.324 and defines H.324 generic capabilities which are used in H.245 signalling-based systems.

This 2005 revision of H.324 integrates into H.324 (March 2002) the changes introduced by Corrigendum 1 (November 2002) and Amendment 1 (January 2005) to H.324, and incorporates the following new elements: new clause 6.5.6 and modified clause 7.7.1 giving information on resolution of logical channel conflicts and session reset procedures, which will help to resolve interoperability problems experienced in the field, new clause A.4 with WNSRP, which will permit quicker session startup, and clarifications to C.8.1.2.2 regarding the maximum CCSRL-SDU size.

Source

ITU-T Recommendation H.324 was approved on 13 September 2005 by ITU-T Study Group 16 (2005-2008) under the ITU-T Recommendation A.8 procedure.

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g. interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

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As of the date of approval of this Recommendation, ITU had received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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ITU-T Recommendation H.324

Terminal for low bit-rate multimedia communication

1 Scope

This Recommendation covers the technical requirements for very low bit-rate multimedia telephone terminals operating over the General Switched Telephone Network (GSTN).

H.324 terminals provide real-time video, audio, or data, or any combination, between two multimedia telephone terminals over a GSTN voice band network connection. Communication may be either 1-way or 2-way. Multipoint communication using a separate MCU among more than two H.324 terminals is possible. MCUs and other non-terminal devices are not bound by the requirements in this Recommendation, but they should comply where practical.

The multimedia telephone terminals defined in this Recommendation can be integrated into PCs or workstations, or be stand-alone units.

Interworking with visual telephone systems on the ISDN (known as the H.320-series of Recommendations) and on mobile radio networks are also covered.

1.1 Block diagram and functional elements

A generic H.324 multimedia videophone system is shown in Figure 1. It consists of terminal equipment, GSTN modem, GSTN network, Multipoint Control Unit (MCU) and other system operation entities. H.324 implementations are not required to have each functional element.

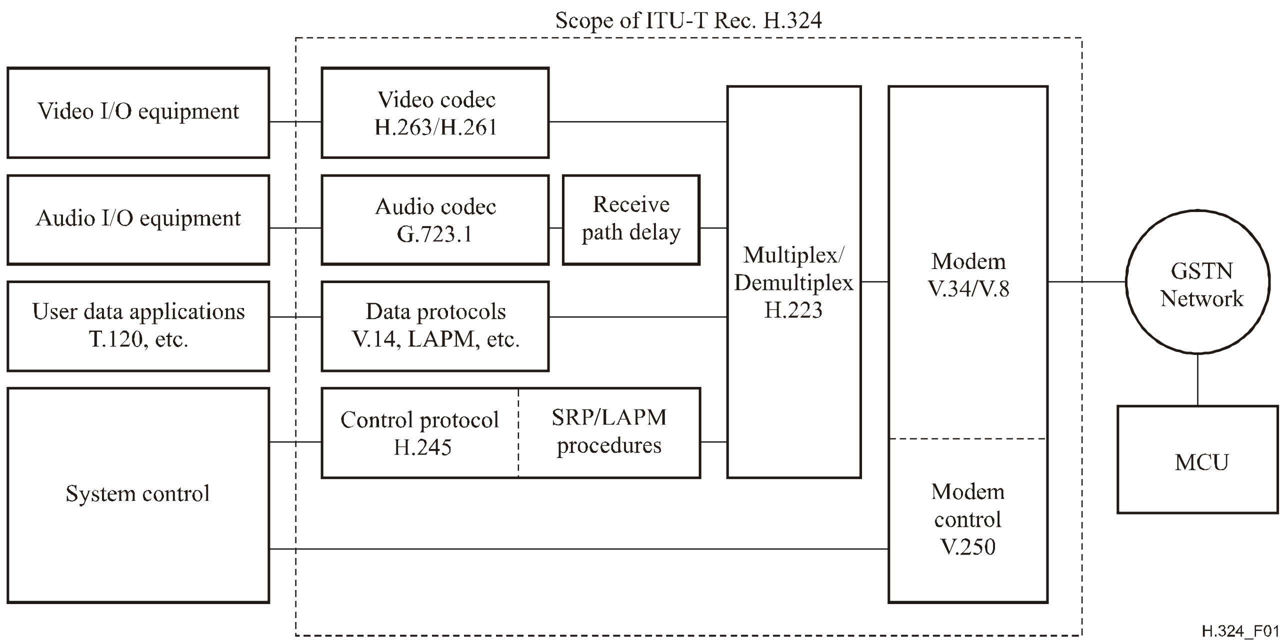

Figure 1/H.324 – Block diagram for H.324 multimedia system

1.2 System elements outside the scope of this Recommendation

The following system elements are covered by other Recommendations or are not subject to standardization, and are therefore not defined in this Recommendation:

- Video I/O equipment including cameras and monitors, their control and selection, video processing to improve compression or provide split-screen functions.

- Audio I/O equipment including microphone and loudspeaker, telephone instrument or equivalent, attached audio devices providing voice activation sensing, multiple microphone mixers, acoustic echo cancellation.
- Data application equipment such as computers, non-standardized data application protocols, telematic visual aids such as electronic whiteboards, etc.
- GSTN network interface supporting appropriate signalling, ringing functions and voltage levels, in accordance with national standards.
- Human user system control, user interface and operation.

1.3 Functional elements covered by this Recommendation

The scope of this Recommendation is indicated by the elements within the dashed line of Figure 1, which include:

- The Video codec (H.263 or H.261) carries out redundancy reduction coding and decoding for video streams.
- The Audio codec (G.723.1) encodes the audio signal from the microphone for transmission, and decodes the audio code which is output to the speaker. Optional delay in the receiving audio path compensates for the video delay, so as to maintain audio and video synchronization.
- The Data protocols support data applications such as electronic whiteboards, still image transfer, file exchange, database access, audiographics conferencing, remote device control, network protocols, etc. Standardized data applications include T.120 for real-time audiographics conferencing, T.84 simple point-point still image file transfer, T.434 simple point-point file transfer, H.224/H.281 far-end camera control, ISO/IEC TR 9577 network protocols including PPP and IP, and transport of user data using buffered V.14 or LAPM/V.42. Other applications and protocols may also be used via H.245 negotiation.
- The Control protocol (H.245) provides end-to-end signalling for proper operation of the H.324 terminal, and signals all other end-to-end system functions including reversion to analogue speech-only telephony mode. It provides for capability exchange, signalling of commands and indications, and messages to open and fully describe the content of logical channels.
- The Multiplex protocol (H.223) multiplexes transmitted video, audio, data and control streams into a single bit stream, and demultiplexes a received bit stream into various multimedia streams. In addition, it performs logical framing, sequence numbering, error detection, and error correction by means of retransmission, as appropriate to each media type.
- The Modem (V.34) converts the H.223 synchronous multiplexed bit stream into an analogue signal that can be transmitted over the GSTN, and converts the received analogue signal into a synchronous bit stream that is sent to the Multiplex/Demultiplex protocol unit. ITU-T Rec. V.250 (*ex*-V.25 *ter*) is used to provide control/sensing of the modem/network interface, when the modem with network signalling and V.8/V.8 *bis* functional elements is a separate physical item.

2 References

2.1 Normative references

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[1] ITU-T Recommendation H.223 (2001), *Multiplexing protocol for low bit rate multimedia communication*.

[2] ITU-T Recommendation H.245 (2005), *Control protocol for multimedia communication*.

[3] ITU-T Recommendation G.723.1 (1996), *Speech coders: Dual rate speech coder for multimedia communications transmitting at 5.3 and 6.3 kbit/s*.

[4] ITU-T Recommendation H.263 (2005), *Video coding for low bit rate communication*.

[5] ITU-T Recommendation H.261 (1993), *Video codec for audiovisual services at* $p \times 64$ *kbit/s*.

[6] ITU-T Recommendation H.320 (2004), *Narrow-band visual telephone systems and terminal equipment*.

[7] ITU-T Recommendation H.233 (2002), *Confidentiality system for audiovisual services*.

[8] ITU-T Recommendation H.234 (2002), *Encryption key management and authentication system for audiovisual services*.

[9] ITU-T Recommendation H.224 (2005), *A real time control protocol for simplex applications using the H.221 LSD/HSD/MLP channels*.

[10] ITU-T Recommendation H.281 (1994), *A far-end camera control protocol for videoconferences using H.224*.

[11] ITU-T Recommendation V.8 (2000), *Procedures for starting sessions of data transmission over the public switched telephone network*.

[12] ITU-T Recommendation V.8 *bis* (2000), *Procedures for the identification and selection of common modes of operation between data circuit-terminating equipments (DCEs) and between data terminal equipments (DTEs) over the public switched telephone network and on leased point-to-point telephone-type circuits*.

[13] ITU-T Recommendation V.14 (1993), *Transmission of start-stop characters over synchronous bearer channels*.

[14] ITU-T Recommendation V.250 (2003)[1], *Serial asynchronous automatic dialling and control*.

[15] ITU-T Recommendation V.42 (2002), *Error-correcting procedures for DCEs using asynchronous-to-synchronous conversion*.

[16] ITU-T Recommendation V.42 *bis* (1990), *Data compression procedures for data circuit-terminating equipment (DCE) using error correction procedures*.

[17] ITU-T Recommendation V.34 (1998), *A modem operating at data signalling rates of up to 33 600 bit/s for use on the general switched telephone network and on leased point-to-point 2-wire telephone-type circuits*.

[18] ITU-T Recommendation T.84 (1996) | ISO/IEC 10918-3:1997, *Information technology – Digital compression and coding of continuous-tone still images: Extensions*.

[19] ITU-T Recommendation T.120 (1996), *Data protocols for multimedia conferencing*.

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1 Former ITU-T Rec. V.25 *ter* (1997), renumbered as V.250 in 1998.

[20] ITU-T Recommendation T.434 (1999), *Binary file transfer format for the telematic services*.

[21] ISO/IEC 3309:1993, *Information technology – Telecommunications and information exchange between systems – High-level data link control (HDLC) procedures – Frame structure*.

[22] ITU-T Recommendation G.711 (1988), *Pulse code modulation (PCM) of voice frequencies*.

[23] ITU-T Recommendation H.221 (2004), *Frame structure for a 64 to 1920 kbit/s channel in audiovisual teleservices*.

[24] ITU-T Recommendation X.691 (2002) | ISO/IEC 8825-2:2002, *Information technology – ASN.1 encoding rules – Specification of Packed Encoding Rules (PER)*.

[25] ISO/IEC TR 9577:1999, *Information technology – Protocol identification in the network layer*.

[26] ITU-T Recommendation T.30 (2005), *Procedures for document facsimile transmission in the general switched telephone network*.

[27] ITU-T Recommendation T.140 (1998), *Protocol for multimedia application text conversation*.

[28] ITU-T Recommendation T.134 (1998), *Text chat application entity*.

[29] ITU-T Recommendation H.226 (1998), *Channel aggregation protocol for multilink operation on circuit-switched networks*.

[30] ITU-T Recommendation H.239 (2005), *Role management and additional media channels for H.300-series terminals*.

[31] ITU-T Recommendation V.140 (2005), *Procedures for establishing communication between two multiprotocol audiovisual terminals using digital channels at a multiple of 64 or 56 kbit/s*.

[32] ITU-T Recommendation G.725 (1988), *System aspects for the use of the 7 kHz audio codec within 64 kbit/s*.

[33] ISO/IEC 14496-1:2001, *Information technology – Coding of audio-visual objects – Part 1: Systems*.

[34] ISO/IEC 14496-2:2004, *Information technology – Coding of audio-visual objects – Part 2: Visual*.

[35] ISO/IEC 14496-3:2001, *Information technology – Coding of audio-visual objects – Part 3: Audio*.

[36] IETF RFC 2616 (1999), *Hypertext Transfer Protocol – HTTP/1.1*.

2.2 Informative references

– ITU-T Recommendation G.728 (1992), *Coding of speech at 16 kbit/s using low-delay code excited linear prediction*.

– ITU-T Recommendation H.230 (2004), *Frame-synchronous control and indication signals for audiovisual systems*.

– ITU-T Recommendation H.262 (2000) | ISO/IEC 13818-2:2000, *Information technology – Generic coding of moving pictures and associated audio information: Video*.

– ITU-T Recommendation T.35 (2000), *Procedure for the allocation of ITU-T defined codes for non-standard facilities*.

– ITU-T Recommendation T.51 (1992), *Latin-based coded character sets for telematic services*.

– ITU-T Recommendation X.680 (2002) | ISO/IEC 8824-1:2002, *Information technology – Abstract Syntax Notation One (ASN.1): Specification of basic notation*.

– IETF RFC 1490 (1993), *Multiprotocol Interconnect over Frame Relay*.

– IETF RFC 1661 (1994), *The Point-to-Point Protocol (PPP)*.

3 Definitions

For the purposes of this Recommendation, the definitions given in clause 3 of both ITU-T Recs H.223 and H.245 apply along with the following.

3.1 AL-SDU: The logical unit of information exchanged between the H.223 multiplex and the audio codec, video codec, or data protocol above.

3.2 channel: A unidirectional link between two end-points.

3.3 codec: Coder/decoder, used to convert audio or video signals to/from digital format.

3.4 connection: A bidirectional link between two end-points.

3.5 control channel: Dedicated logical channel number 0 carrying system control protocol per ITU-T Rec. H.245.

3.6 data: Information streams other than control, audio and video, carried in a logical data channel (see ITU-T Rec. H.223).

3.7 in-band signalling: Control signals sent within a specific logical channel other than the control channel, carrying information applicable only to that logical channel.

3.8 interworking adapter: A device connected to terminals or MCUs working according to two or more Recommendations, which translates the content of one or more logical channels to allow interoperation between otherwise incompatible equipment.

3.9 lip synchronization: Operation to provide the feeling that speaking motion of the displayed person is synchronized with the voice sounds.

3.10 logical channel: One of several logically distinct channels carried over a single bitstream.

3.11 media: One or more of audio, video or data.

3.12 multilink: The use of more than one physical connection to obtain a larger aggregate bit rate.

3.13 multipoint: The simultaneous interconnection of three or more terminals to allow communication among several sites through the use of multipoint control units (bridges) which centrally direct the flow of information.

3.14 MUX-PDU: The logical unit of information exchanged between the H.223 multiplex layer and the underlying physical layer. It is a packet framed by HDLC flags and using HDLC zero-bit insertion for transparency.

3.15 non-segmentable: The H.223 mode of operation in which AL-SDUs must be sent as consecutive octets in a single MUX-PDU. See ITU-T Rec. H.223.

3.16 segmentable: The H.223 mode of operation in which AL-SDUs may be sent in separate multiplex slots carried on one or more MUX-PDUs. See ITU-T Rec. H.223.

3.17 support: The ability to operate in a given mode; however a requirement to "support" a mode does not mean that the mode must actually be used at all times. Unless prohibited, other modes may be used by mutual negotiation.

3.18 videophone: A terminal capable of sending and receiving audio and video information simultaneously.

4 Abbreviations

This Recommendation uses the following abbreviations:

AL-SDU	Adaptation Layer Service Data Unit (see ITU-T Rec. H.223)
ASN.1	Abstract Syntax Notation One
CIF	Common Intermediate Format
CRC	Cyclic Redundancy Check
DCE	Data Circuit-terminating Equipment
DTE	Data Terminal Equipment
EIV	Encryption Initialization Vector
GSTN	General Switched Telephone Network
H.324/I	Systems or endpoints conforming to Annex D/H.324
H.324/M	Systems or endpoints conforming to Annex C/H.324
HDLC	High-level Data Link Control (per ISO/IEC 3309)
ISDN	Integrated Services Digital Network
ITU-T	International Telecommunication Union – Telecommunication Standardization Sector
LAPM	Link Access Procedures for Modems (per ITU-T Rec. V.42)
LCN	Logical Channel Number (per ITU-T Rec. H.223)
MCU	Multipoint Control Unit
NLPID	Network Layer Protocol Identifier (per ISO/IEC TR 9577)
NSRP	Numbered SRP Response Frames
PER	Packed Encoding Rules
QCIF	Quarter CIF
SE	Session Exchange (per ITU-T Rec. H.233)
SQCIF	Sub QCIF
SRP	Simple Retransmission Protocol (see Annex A)
WNSRP	Windowed NSRP

5 Conventions

The word "shall" is used in this Recommendation to specify a mandatory requirement.

The word "should" is used in this Recommendation to specify a suggested, but not required, course of action.

The word "may" is used in this Recommendation to specify an optional course of action, without expressing a preference.

References in this Recommendation to specific H.245 ASN.1 message structures are presented in **this typeface**.

6 Functional requirements

6.1 Required elements

H.324 implementations are not required to have each functional element, except for the V.34 modem, H.223 multiplex and H.245 system control protocol, all of which shall be supported by all H.324 terminals.

H.324 terminals offering audio communication shall support the G.723.1 audio codec. H.324 terminals offering video communication shall support the H.263 and H.261 video codecs. H.324 terminals offering real-time audiographic conferencing should support the T.120 protocol suite. In addition, other video and audio codecs, and other data protocols, may optionally be used via negotiation over the H.245 control channel.

If a modem external to the H.324 terminal is used, terminal/modem control shall conform to ITU-T Rec. V.250 (*ex*-V.25 *ter*).

The presence of optional facilities is signalled via the H.245 control channel. If both ends support an optional facility, and choose to make use of it, the opening of a path to carry such information streams is negotiated according to the procedures of ITU-T Rec. H.245.

NOTE – This Recommendation does not specify a particular implementation. Any implementation that provides the required functionality, and that conforms to the bitstream format ultimately described by this Recommendation, is considered compliant.

6.2 Information streams

Multimedia information streams are classified into video, audio, data and control as follows:

- Video streams are continuous traffic carrying moving colour pictures. When used, the bit rate available for video streams may vary according to the needs of the audio and data channels.
- Audio streams are real-time, but may optionally be delayed in the receiver processing path to maintain synchronization with the video streams. In order to reduce the average bit rate of audio streams, voice activation may be provided.
- Data streams may represent still pictures, facsimile, documents, computer files, computer application data, undefined user data, and other data streams.
- Control streams pass control commands and indications between remote counterparts. Terminal-to-modem control conforms to ITU-T Rec. V.250 (*ex*-V.25 *ter*) for terminals using external modems connected by a separate physical interface. Terminal-to-terminal control is according to ITU-T Rec. H.245.

6.3 Modem

Modems used for H.324 terminals shall operate in full duplex, synchronous mode and conform to ITU-T Recs V.34 and V.8. Support of ITU-T Rec. V.8 *bis* is optional. The output of the H.223 multiplex shall be applied directly to the V.34 synchronous data pump. When an external, non-integrated V.34 modem is used, control between the modem and the terminal shall be via V.250 (*ex*-V.25 *ter*). In such cases the physical interface is implementation-specific. The use of the optional V.34 auxiliary channel is reserved for further study.

6.4 Multiplex

Logical channels of video, audio, data or control information may be transmitted, after the channels have been established according to the procedures of ITU-T Rec. H.245. Logical channels are unidirectional, and are independent in each direction of transmission. Any number of logical channels of each media type may be transmitted, except for the H.245 control channel of which there shall be one. The multiplex method used to transmit these logical channels shall conform to

ITU-T Rec. H.223. The optional exclusive-OR procedure of 6.4.2/H.223 shall not be used by H.324 terminals.

The H.223 multiplex consists of a multiplex layer, which mixes the various logical channels into a single bitstream, and an adaptation layer, which handles error control and sequence numbering, as appropriate to each information stream. The multiplex layer transfers logical channel information in packets called MUX-PDUs, delimited by HDLC flags and using HDLC zero-bit insertion for transparency. Each MUX-PDU contains a one-octet header followed by a variable number of information field octets. The header octet includes a multiplex code, which specifies, by reference to a multiplex table, the mapping of the information field octets to various logical channels. Each MUX-PDU may contain a different multiplex code, and therefore a different mix of logical channels.

H.324 terminals shall signal their H.223 capabilities via the H.245 **H223Capability** message.

6.4.1 Logical channel numbers

Each logical channel is identified by a Logical Channel Number (LCN), in the range 0 to 65535, which serves only to associate logical channels with the corresponding entries in the H.223 multiplex table. Logical channel numbers are selected arbitrarily by the transmitter, except that logical channel 0 shall be permanently assigned to the H.245 control channel.

6.4.2 Multiplex table entries

Multiplex table entries are independent in each direction of transmission, and are sent from transmitters to receivers using the H.245 **MultiplexEntrySend** request message. Multiplex table entry 0 shall not be sent, but shall be permanently assigned to logical channel 0, used for the control channel. Multiplex table entry 0 shall therefore be used for initial capability exchanges and transmission of initial multiplex table entries.

6.4.3 Flow control

H.324 terminals shall respond to the **FlowControlCommand** message of H.245, which commands a limit to the overall bit rate of one or more logical channels, or the entire multiplex.

When one or more logical channels are limited by the **FlowControlCommand**, other less restricted logical channels may increase their transmission rate. The limit applies to the content of the logical channel at the input to the multiplex layer, before flags or zero-bit insertion is applied.

When the entire H.223 multiplex is limited by the **FlowControlCommand**, or when the terminal has no information to send, the terminal shall send HDLC flags in place of logical channel information. The limit applies to the entire multiplex output, including opening flags, header octets, and inserted zero bits, but not including idle flags.

6.4.4 Error control

The multiplex layer of H.223 does not perform error control, except for a CRC on the header octet. Error control for each logical channel is handled separately by the adaptation layers of H.223, which may use a variety of error control techniques, including but not limited to error detection and retransmission.

6.4.5 Adaptation layers

ITU-T Rec. H.223 defines three adaptation layers, AL1, AL2, and AL3. AL1 is intended primarily for variable-rate framed information, including unframed octets treated as a single frame of indefinite length. AL2 is intended primarily for digital audio, and includes an 8-bit CRC and optional sequence numbers. AL3 is intended primarily for digital video and includes provision for retransmission.

The logical unit of information exchanged between the H.223 multiplex and the audio codec, video codec, data protocol, or control protocol above is called an AL-SDU.

Logical channels carried by the H.223 multiplex may be of either "segmentable" or "non-segmentable" type, as defined in ITU-T Rec. H.223, and signalled by ITU-T Rec. H.245 when each channel is opened. AL-SDUs of segmentable logical channels may be segmented by the H.223 multiplex. AL-SDUs of non-segmentable logical channels are not segmented by the H.223 multiplex. Generally, segmentable channels should be used for variable bit-rate information streams such as control, video, and data, while non-segmentable channels should be used for constant bit-rate streams such as audio.

Receivers shall signal their capability to process various adaptation layers and channel types according to ITU-T Rec. H.245. Transmitters shall signal which adaptation layers, options, and channel type are used for each logical channel when opening the channel, according to ITU-T Rec. H.245.

6.5 Control channel

The control channel carries end-to-end control messages governing operation of the H.324 system, including capabilities exchange, opening and closing of logical channels, mode preference requests, multiplex table entry transmission, flow control messages, and general commands and indications.

There shall be exactly one control channel in each direction within H.324, which shall use the messages and procedures of ITU-T Rec. H.245. The control channel shall be carried on logical channel 0. The control channel shall be considered to be permanently open from the establishment of digital communication until the termination of digital communication; the normal procedures for opening and closing logical channels shall not apply to the control channel.

General commands and indications shall be chosen from the message set contained in ITU-T Rec. H.245. In addition, other command and indication signals may be sent which have been specifically defined to be transferred in-band within video, audio or data streams (see the appropriate Recommendation to determine if such signals have been defined).

H.245 messages fall into four categories: Request, Response, Command, and Indication. Request messages require a specific action by the receiver, including an immediate response. Response messages respond to a corresponding request. Command messages require a specific action, but do not require a response. Indication messages are informative only, and do not require any action or response. H.324 terminals shall respond to all supported H.245 commands and requests as specified in ITU-T Rec. H.245, and shall transmit accurate indications reflecting the state of the terminal.

NOTE 1 – All control channel messages are sent over a link layer protocol which acknowledges correct receipt. This acknowledgement is distinct from the response messages, which convey content beyond that of correct receipt of the message.

H.324 terminals shall be capable of parsing all H.245 **MultimediaSystemControlPDU** messages, and shall send and receive all messages needed to implement required H.324 functions and those optional functions which are supported by the terminal. All messages and procedures of ITU-T Rec. H.245 related to required H.324 functions are required, except for those explicitly described as optional, or which are related to defined optional capabilities the terminal does not support. H.324 terminals shall send the **FunctionNotSupported** message in response to unrecognized request, response, or command messages.

A control channel indication, **UserInputIndication**, is available for transport of user input alphanumeric characters from a keypad or keyboard, equivalent to the DTMF signals used in analogue telephony. This may be used to manually operate remote equipment such as voice mail or video mail systems, menu-driven information services, etc. H.324 terminals shall support the transmission of user input characters 0-9, '*', and '#'. Transmission of other characters is optional.

NOTE 2 – If the encryption procedures of this Recommendation are in use, the control channel will not be encrypted. Users are therefore cautioned regarding the carriage of user data in the control channel, the use of non-standard messages, and the confidentiality risk from traffic analysis of the control channel.

6.5.1 Capabilities exchange

Capabilities exchange shall follow the procedures of ITU-T Rec. H.245, which provides for separate receive and transmit capabilities, as well as a system by which the terminal may describe its ability to operate in various combinations of modes simultaneously.

Receive capabilities describe the terminal's ability to receive and process incoming information streams. Transmitters shall limit the content of their transmitted information to that which the receiver has indicated it is capable of receiving. The absence of a receive capability indicates that the terminal cannot receive (is a transmitter only).

Transmit capabilities describe the terminal's ability to transmit information streams. Transmit capabilities serve to offer receivers a choice of possible modes of operation, so that the receiver may request the mode which it prefers to receive. The absence of a transmit capability indicates that the terminal is not offering a choice of preferred modes to the receiver (but it may still transmit anything within the capability of the receiver).

The transmitting terminal assigns each individual mode the terminal is capable of operating in a number in a **capabilityTable**. For example, G.723.1 audio, G.728 audio and CIF H.263 video would each be assigned separate numbers.

These capability numbers are grouped into **AlternativeCapabilitySet** structures. Each **AlternativeCapabilitySet** indicates that the terminal is capable of operating in exactly one mode listed in the set. For example, an **AlternativeCapabilitySet** listing {G.711, G.723.1, G.728} means that the terminal can operate in any one of those audio modes, but not more than one.

These **AlternativeCapabilitySet** structures are grouped into **simultaneousCapabilities** structures. Each **simultaneousCapabilities** structure indicates a set of modes the terminal is capable of using simultaneously. For example, a **simultaneousCapabilities** structure containing the two **AlternativeCapabilitySet** structures {H.261, H.263} and {G.711, G.723.1, G.728} means that the terminal can operate either of the video codecs simultaneously with any one of the audio codecs. The **simultaneousCapabilities** set { {H.261}, {H.261, H.263}, {G.711, G.723.1, G.728} } means the terminal can operate two video channels and one audio channel simultaneously: One video channel per ITU-T Rec. H.261, another video channel per either ITU-T Rec. H.261 or H.263, and one audio channel per either ITU-T Rec. G.711, G.723.1 or G.728.

NOTE – The actual capabilities stored in the **capabilityTable** are often more complex than presented here. For example, each H.263 capability indicates details including ability to support various picture formats at given minimum picture intervals, and ability to use optional coding modes. For a complete description, see ITU-T Rec. H.245.

The terminal's total capabilities are described by a set of **CapabilityDescriptor** structures, each of which is a single **simultaneousCapabilities** structure and a **capabilityDescriptorNumber**. By sending more than one **CapabilityDescriptor**, the terminal may signal dependencies between operating modes by describing different sets of modes which it can simultaneously use. For example, a terminal issuing two **CapabilityDescriptor** structures, one { {H.261, H.263}, {G.711, G.723.1, G.728} } as in the previous example, and the other { {H.262}, {G.711} }, means the terminal can also operate the H.262 video codec, but only with the low-complexity G.711 audio codec.

Terminals may dynamically add capabilities during a communication session by issuing additional **CapabilityDescriptor** structures, or remove capabilities by sending revised **CapabilityDescriptor** structures. All H.324 terminals shall transmit at least one **CapabilityDescriptor** structure.

Non-standard capabilities and control messages may be issued using the **NonStandardParameter** structure defined in ITU-T Rec. H.245. Note that while the meaning of non-standard messages is defined by individual organizations, equipment built by any manufacturer may signal any non-standard message, if the meaning is known.

Terminals may reissue capability sets at any time, according to the procedures of ITU-T Rec. H.245.

6.5.2 Logical channel signalling

Each logical channel carries information from a transmitter to a receiver, and is identified by a logical channel number unique for each direction of transmission.

Logical channels are opened and closed using the **OpenLogicalChannel** and **CloseLogicalChannel** messages and procedures of ITU-T Rec. H.245. When a logical channel is opened, the **OpenLogicalChannel** message fully describes the content of the logical channel, including media type, algorithm in use, H.223 adaptation layer and any options, and all other information needed for the receiver to interpret the content of the logical channel. Logical channels may be closed when no longer needed. Open logical channels may be inactive, if the information source has nothing to send.

Logical channels in ITU-T Rec. H.324 are unidirectional, so asymmetrical operation, in which the number and type of information streams is different in each direction of transmission, is allowed. However, if a receiver is capable only of certain symmetrical modes of operation, it may send a receive capability set that reflects its limitations. Terminals may also be capable of using a particular mode in only one direction of transmission.

Certain media types, including data protocols such as T.120 and LAPM, and video carried over AL3, inherently require a bidirectional channel for their operation. In such cases a pair of unidirectional logical channels, one in each direction, may be opened and associated together to form a bidirectional channel using the bidirectional channel opening procedures of ITU-T Rec. H.245. Such pairs of associated channels need not share the same logical channel number, since logical channel numbers are independent in each direction of transmission.

6.5.2.1 Channel muting

Logical channels may be temporarily inactive. Such temporary inactivation (muting) should be indicated to the far-end terminal using the H.245 Miscellaneous Indication **logicalChannelInactive**.

The H.245 Miscellaneous Indication **logicalChannelActive** should be used to indicate when a normal signal has resumed on the logical channel. These indications are intended to be used to inform the human user that the far-end has muted or unmuted the channel.

Before sending the **logicalChannelInactive** message, the transmitter should ensure that no data is sent on the logical channel.

However, regardless of whether or not **logicalChannelInactive** or **logicalChannelActive** messages are received, receivers shall decode the contents of the logical channel normally.

6.5.3 Mode preferences

Receivers may request transmitters to send a particular mode using the H.245 **RequestMode** message, which describes the desired mode. Except when in receipt of **multipointModeCommand,** transmitters may deny such requests, but should comply if possible.

6.5.4 Interface to multiplex

The control channel shall be segmentable and use logical channel 0. All H.324 terminals shall support transmission of H.245 control messages over the framed AL1 layer of H.223 according to the procedures in Annex A, which ensure reliable delivery by retransmission of errored frames.

Annex A defines a Simple Retransmission Protocol (SRP) as a data link layer for H.245. All H.324 terminals shall support the SRP defined in Annex A. Terminals may optionally use LAPM/V.42 as a data link layer instead of the SRP, if this mode is negotiated per the procedure in Annex A. In the LAPM/V.42 mode, several control messages may be streamed using the procedures of LAPM, avoiding a wait for acknowledgement of each frame before the next message may be sent.

More than one H.245 control message may be sent in each SRP or LAPM frame.

6.5.5 Timer and counter values and protocol errors

All timers defined in ITU-T Rec. H.245 shall have periods of at least the maximum data delivery time allowed by the data link layer carrying H.245, including any retransmissions. For SRP, a period of at least T401 × (N400 + 1) [that is, acknowledgement timer × (retransmit counter + 1)].

The H.245 retry counter N100 should be at least 3.

If a H.245 protocol error occurs, the terminal may optionally retry the H.245 procedure or may take other appropriate action, such as disconnection or reversion to analogue telephony, depending on predetermined configuration.

6.5.6 Resolution of logical channel conflicts

In the event of a conflict when requests to open logical channels are initiated at the same time, H.324 terminals should follow the optional recommended procedure in C.4.1.3/H.245 or C.5.1.3/H.245 as appropriate.

The master which experiences such a conflict shall reject the channel with a **masterSlaveConflict** reason. The slave which receives the **OpenLogicalChannelReject** message with the **masterSlaveConflict** reason should retry to open logical channel with the media type most preferred by the master terminal, unless the master terminal has already opened a logical channel which suits the purpose intended by the slave terminal.

6.6 Video channels

All H.324 terminals offering video communication shall support both the H.263 and H.261 video codecs, except that H.320 Interworking Adapters (which are not terminals) do not have to support H.263 (see 8.2). The H.261 and H.263 codecs shall be used without BCH error correction and without error correction framing. There are five standardized image formats: 16CIF, 4CIF, CIF, QCIF and SQCIF. Video may be supported in either one direction (transmit or receive) or both directions.

CIF and QCIF are defined in ITU-T Rec. H.261. For the H.263 algorithm, SQCIF, 4CIF and 16CIF are defined in ITU-T Rec. H.263. For the H.261 algorithm, SQCIF is any active picture size less than QCIF, filled out by a black border, and coded in the QCIF format. For all these formats, the pixel aspect ratio is the same as that of the CIF format.

NOTE 1 – The resulting *picture* aspect ratio for H.263 SQCIF is different from the other formats.

Table 1 shows which picture formats are required, and which are optional for H.324 terminals which support video.

Table 1/H.324 – Picture formats for video terminals

Picture format	Luminance pixels	Encoder		Decoder	
		H.261	H.263	H.261	H.263
SQCIF	128×96 for H.263 (Note 1)	Optional (Note 1)	Required (Notes 2 and 3)	Optional (Note 1)	Required (Note 2)
QCIF	176×144	Required	Required (Notes 2 and 3)	Required	Required (Note 2)
CIF	352×288	Optional	Optional	Optional	Optional
4CIF	704×576	Not defined	Optional	Not defined	Optional
16CIF	1408×1152	Not defined	Optional	Not defined	Optional
NOTE 1 – H.261 SQCIF is any active size less than QCIF, filled out by a black border, coded in QCIF format. NOTE 2 – Optional for H.320 interworking adapters. NOTE 3 – Mandatory to encode one of the picture formats QCIF and SQCIF; optional to encode both formats.					

All video decoders shall signal the maximum bit rate which can be decoded in the H.245 **maxBitRate** parameter.

Which picture formats, minimum number of skipped pictures and algorithm options can be accepted by the receiver is determined during the capability exchange using H.245. After that, the transmitter is free to open any video LC which is in line with the receiver's capability. Receivers which indicate capability for a particular algorithm option shall also be capable of accepting video bitstreams which do not make use of that option as specified in ITU-T Rec. H.245.

When each video logical channel is opened, all supported operating modes for that channel are signalled to the receiver via H.245. The picture header within the video bitstream indicates which mode is actually used for each picture, within the capabilities stated in the **OpenLogicalChannel** message. Receivers may signal, via H.245, a preference for a certain mode.

NOTE 2 – In previous versions of this Recommendation this paragraph was incorrect and inconsistent with ITU-T Rec. H.245. The semantics of ITU-T Rec. H.245 shall be followed.

Other video codecs, and other picture formats, may also be used via H.245 negotiation. More than one video channel may be transmitted, as negotiated via the H.245 control channel.

NOTE 3 – The method of continuous presence multipoint operation, in which a single picture is divided into multiple sub-pictures, should not be used by H.324 terminals. Instead, multiple logical channels of video should be used.

6.6.1 Interface to multiplex

All H.324 terminals offering video communication shall support the required video codecs in segmentable logical channels using H.223 adaptation layer AL3, and using a control field of at least one octet. Support of retransmission is required in encoders, with a minimum AL3 **SendBufferSize** of 1024 octets.

The size of each AL-SDU, and their alignment with the video bitstream, is determined by video encoders, within the limit of the maximum AL3 SDU size the receiver indicates it is capable of. Video pictures may span more than one AL-SDU. H.261 AL-SDUs are not required to align with logical structures in the video bitstream. H.263 encoders shall align picture start codes with the start of an AL-SDU.

NOTE – H.263 pictures are a whole number of octets in length, since encoders add fill zero bits at the end of each picture as needed to fill out the final octet.

If video communication is supported only in one direction (transmit or receive), the H.223 adaptation layer AL3 protocol for the reverse direction shall also be supported, even if no video information will be sent on the reverse channel. Since the AL3 protocol requires a reverse channel for operation, logical channels using AL3 shall be opened using the H.245 procedures for opening associated logical channels in each direction of transmission (bidirectional channels).

While H.223 AL3 allows for the retransmission of video information with detected errors, the receiving terminal may decide not to request a retransmission, based on factors including but not limited to the measured network delay, the error rate, whether the terminal is part of a multipoint conference, whether there is interworking with a H.320 terminal, and the effectiveness of its error concealment techniques.

When a video codec receives an AL-DRTX indication from H.223 AL3, indicating that the local AL3 layer was unable to satisfy a retransmission request, it should encode the next video picture in the INTRA coding mode.

Other video codecs, adaptation layers and options may be used via H.245 negotiation.

6.6.1.1 H.263 reference picture selection mode support

Annex N/H.263 reference picture selection mode, may optionally be supported. In this mode, video backchannel messages may be mixed with the video data in the opposite direction according to ITU-T Rec. H.263, or video backchannel messages may be carried on an additional separate logical channel.

In the case where Annex N/H.263 video backchannel messages are carried on a separate LC, the procedure to set up the LC for the video backward channel is different depending on whether the video communication is unidirectional or bidirectional.

In the case of bidirectional video communication, the LCs for original video data shall first be opened as bidirectional LCs which shall support H.223 AL3. The LCs for the video backchannel messages shall next be opened by the terminal which originated the video LCs. The backchannel LCs shall be opened as bidirectional LCs with the LC dependency parameters indicating dependency on the corresponding video LC flowing in the same direction. The backchannel LCs shall support H.223 AL2. Until the backchannel LCs are established, the terminal shall not send any video data which requests backchannel messages.

In the case of unidirectional video communication, a single bidirectional LC shall be opened, which shall support H.223 AL3. Variable length Stuffing (BSTUF) defined in ITU-T Rec. H.263 shall be used to make all the backward channel messages whole numbers of octets in length.

6.6.2 Multiple channels of video

More than one channel of video may be transmitted, as negotiated, via H.245.

The procedures of ITU-T Rec. H.239 may be used with H.324 systems. These procedures should be used when more than one channel of video is in use, in order to indicate the role of each channel in a conference, for example, "live" video of conference participants or video of "presentation" materials.

6.7 Audio channels

All H.324 terminals offering audio communication shall support both the high and low rates of the G.723.1 audio codec. G.723.1 receivers shall be capable of accepting silence frames. The choice of high rate, low rate, or silence is made by the transmitter, and is signalled to the receiver in-band in the audio channel, as part of the syntax of each audio frame. Transmitters may switch G.723.1 rates on a frame-by-frame basis, based on bit rate, audio quality, or other preferences. Receivers may signal, via H.245, a preference for a particular audio rate or mode. Audio may be supported in either one direction (transmit or receive) or both directions.

Alternative audio codecs may also be used, via H.245 negotiation. Coders may omit sending audio signals during silent periods after sending a single frame of silence, or may send silence background fill frames if such techniques are specified by the audio codec Recommendation in use.

More than one audio channel may be transmitted, as negotiated via the H.245 control channel.

NOTE – Each audio channel is independent. Grouping of audio channels into stereo pairs or other synchronized groups is for further study.

6.7.1 Delay compensation

The H.263 and H.261 video codecs require some processing delay, while the G.723.1 audio codec involves much less delay. Lip synchronization is not mandatory, but if it is to be maintained, additional delay must be added in the audio path to compensate.

An H.324 terminal shall not add delay for this purpose in its transmitting audio path. Instead, since video and audio coder delays may vary according to implementation, H.324 terminals shall signal, via **H223SkewIndication** messages in the H.245 control channel, the average skew by which their transmitted video signal trails the audio signal.

Intermediate processing points such as MCUs or interworking adapters may alter the video/audio skew (see 10.3), and shall transmit appropriately modified video/audio skew indications, reflecting their transmitted streams. Video signals shall not precede audio signals; if necessary, video path delay shall be added to prevent this.

Receiving terminals may optionally use this information to add appropriate delay in the audio path to achieve lip synchronization.

6.7.2 Maximum delay jitter

Audio AL-SDUs shall be transmitted periodically at an interval determined by the audio codec Recommendation in use (audio frame interval). The transmission of each audio AL-SDU at the H.223 multiplex shall commence no later than 10 milliseconds after a whole multiple of the audio frame interval, measured from transmission of the first audio frame (audio delay jitter). Transmitters capable of further limiting their audio delay jitter may so signal using the H.245 **maximumDelayJitter** parameter of the **H223Capability** message, so that receivers may optionally reduce their jitter delay buffers.

6.7.3 Interface to multiplex

All H.324 terminals offering audio communication shall support the G.723.1 codec using H.223 adaptation layer AL2. The use of the Sequence Number option of AL2 is optional, but is not recommended for G.723.1, since sequence numbers are generally not useful when the maximum delay jitter is less than the audio frame interval.

For all frame-oriented audio codecs, AL-SDUs shall be transmitted in non-segmentable logical channels. Receivers shall signal the maximum number of audio frames they are capable of accepting in a single audio AL-SDU. Transmitters may send any whole number of audio frames in each AL-SDU, up to the maximum stated by the receiver. Transmitters shall not split audio frames across AL-SDUs, and shall send whole numbers of octets in each audio AL-SDU.

NOTE 1 – Sample-based codecs, such as G.711, shall be considered to be frame-oriented, with a frame size of one sample.

For audio algorithms such as G.723.1 which use more than one size of audio frame, audio frame boundaries within each AL-SDU shall be signalled in-band to the audio channel. For audio algorithms which use a fixed frame size, audio frame boundaries shall be implied by the ratio of AL-SDU size to audio frame size.

Other adaptation layers and options may be used via H.245 negotiation.

NOTE 2 – Transmitters using alternative audio codecs should also support AL2, unless another adaptation layer has been specified for use with a particular codec.

6.7.4 Use of ITU-T Rec. G.722.1 for wideband audio

ITU-T Rec. G.722.1 may be used for wideband audio applications. G.722.1 frames shall be sent using AL2. Audio frame boundaries within each AL-SDU shall be implied by the ratio of AL-SDU size to G.722.1 frame size at the currently selected G.722.1 bit rate.

6.8 Data channels

All data channels are optional. Standardized options for data applications include:

- T.120-series for point-to-point and multipoint audiographic teleconferencing including database access, still image transfer and annotation, application sharing, real-time file transfer, etc;
- T.84 (SPIFF) point-to-point still image transfer cutting across application borders;
- T.434 point-to-point telematic file transfer cutting across application borders;
- H.224 for real-time control of simplex applications, including H.281 far-end camera control;
- network link layer, per ISO/IEC TR 9577 (supports IP and PPP network layers, among others);
- unspecified user data from external data ports;
- T.30 facsimile transfer;
- T.140 text conversation protocol.

These data applications may reside in an external computer or other dedicated device attached to the H.324 terminal through a V.24 or equivalent interface (implementation-dependent), or may be integrated into the H.324 terminal itself. Each data application makes use of an underlying data protocol for link layer transport. For each data application supported by the H.324 terminal, this Recommendation requires support for a particular underlying data protocol to ensure interworking of data applications.

NOTE – The H.245 control channel is not considered a data channel.

Standardized link layer data protocols used by data applications include:

- buffered V.14 mode for transfer of asynchronous characters, without error control;
- LAPM/V.42 for error-corrected transfer of asynchronous characters. Additionally, depending on application, V.42 *bis* data compression may be used;
- HDLC frame tunnelling for transfer of HDLC frames;
- transparent data mode for direct access by unframed or self-framed protocols.

All H.324 terminals offering real-time audiographic conferencing should support the T.120 protocol suite.

All data protocols shall operate within H.223 logical channels. All protocol procedures referring to link establishment or link termination (including set-up and disconnection of physical channels) shall be interpreted as referring to opening and closing of logical channels, and shall not affect the H.324 physical link. For all protocol procedures which distinguish between an originator and an answerer, the H.324 master terminal, determined according to the **MasterSlaveDetermination** procedure of ITU-T Rec. H.245, shall be the originator, and the slave terminal shall be the answerer.

More than one data channel, or more than one protocol may be used at the same time (each in a separate logical channel), as negotiated via the H.245 control channel. Other data protocols and applications may be used via H.245 negotiation.

6.8.1 Data protocols

This clause describes these data protocols as if they are resident in the H.324 terminal, connected through a V.24 interface to an external computer or other dedicated device running the data application, as shown in Figure 2. The V.24 interface may be replaced by a logical equivalent. H.324 terminals with integrated data applications need not implement procedures related to the V.24 interface which have no net effect on the transmitted bitstream.

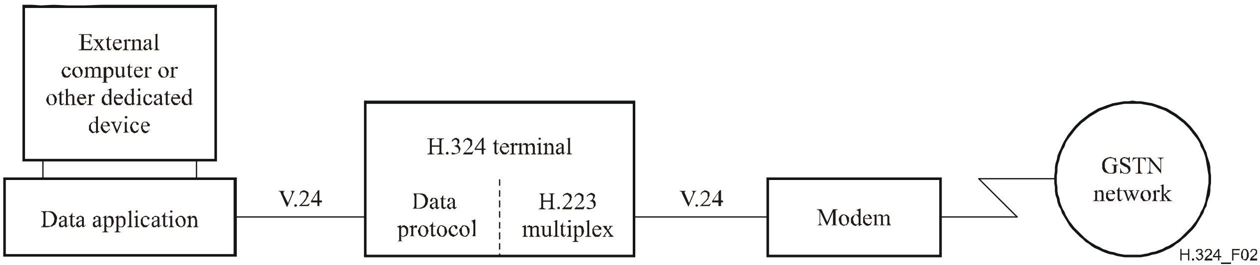

Figure 2/H.324 – Data application – Data protocol interface

H.324 terminals offering any data protocol described here shall support that protocol using segmentable logical channels and H.223 adaptation layer AL1, in the framed or unframed mode as specified below. Other ALs may be used if receivers indicate the capability to do so via H.245 negotiation.

6.8.1.1 Buffered V.14

In the buffered V.14 mode, asynchronous characters and BREAK signals arriving at the V.24 interface shall be converted to a synchronous bitstream using the procedures of ITU-T Rec. V.14. Operation at the V.24 interface shall use buffering and flow-control across the DTE/DCE interface as described in 7.9/V.42 and 1.3/V.14.

The resulting bitstream shall be placed into the octets of an unframed AL1 AL-SDU, preserving the original bit ordering (least significant bit first). The unframed AL-SDU should be transferred to the underlying AL in a streaming mode, without waiting for the end of the AL-SDU (which will never occur).

If receipt of characters at the V.24 interface pauses, the terminal may omit transmission of octets containing only stop bits (because the line is idle), after transmitting the octet containing the final character, plus at least two stop bits.

The receiver shall perform the reverse operation.

6.8.1.2 LAPM/V.42

In the LAPM/V.42 mode, asynchronous characters and BREAK signals arriving at the V.24 interface shall be transferred to the far-end using the procedures of ITU-T Rec. V.42 in the LAPM mode. The alternative procedure of Annex A/V.42 is not required.

The procedures of ITU-T Rec. V.42 shall be followed, except that:

- the flag sequence and transparency procedures of 8.1.1.2/V.42 shall not be performed, as the H.223 multiplex provides equivalent functions. Instead, the entire content of each frame between the opening and closing flags shall be placed in a single framed AL1 AL-SDU, without application of the zero-bit insertion transparency procedure;

- the detection phase of ITU-T Rec. V.42 shall be bypassed, proceeding directly to the protocol establishment phase;
- aborts shall be sent using the procedure of ITU-T Rec. H.223, instead of the procedure in ITU-T Rec. V.42;
- only frames shall be sent; interframe time filling flags shall not be sent.

The receiver shall perform the reverse operations.

If V.42 *bis* data compression is to be used, it shall be negotiated in-band to the LAPM/V.42 channel according to the procedures of ITU-T Rec. V.42 *bis*.

Since the LAPM/V.42 protocol requires a reverse channel for operation, LAPM/V.42 logical channels shall be opened using the H.245 procedures for opening associated logical channels in each direction of transmission (bidirectional channels).

H.324 terminals declaring capability for LAPM/V.42 in only one direction of transmission shall support the V.42/LAPM protocol for the reverse direction, even if no payload data will be sent on the reverse channel.

6.8.1.3 HDLC frame tunnelling

In the HDLC frame tunnelling mode, HDLC frames arrive at the V.24 interface from the data application.

If the V.24 interface is operating synchronously, inserted zero bits shall be removed and the entire content of each frame between the opening and closing flags shall be placed in a single framed AL1 AL-SDU, for transmission through the H.223 multiplex. Aborts shall be sent using the procedure of ITU-T Rec. H.223. Only frames shall be sent; flags (including interframe time filling flags) shall not be sent.

If the V.24 interface is operating asynchronously, HDLC frames arrive at the V.24 interface encoded as a sequence of asynchronous characters using octet-stuffing according to 4.5.2 of ISO/IEC 3309 instead of the usual zero-bit insertion transparency procedure of HDLC. This recognized alternative to the zero-bit insertion procedure makes the implementation of HDLC protocols over asynchronous serial links possible. Typical personal computer serial ports do not support synchronous operation, making this operation mode important. In particular, the PSTN basic mode profile of ITU-T Rec. T.123 specifies this mode of operation.

If operating asynchronously, the terminal shall receive HDLC frames at the V.24 interface according to the procedure given in Annex B. After execution of the receiver procedure given there, the entire content of each frame between the opening and closing flags shall be placed in a single framed AL1 AL-SDU, without application of the zero-bit insertion or octet-stuffing transparency procedures, for transmission through the H.223 multiplex. Aborts shall be sent using the procedure of ITU-T Rec. H.223. Only frames shall be sent; flags (including interframe time filling flags) shall not be sent.

The receiver shall perform the reverse operation. The choice of asynchronous or synchronous V.24 interface is a local matter and does not need to be signalled to the far end.

NOTE – Since the HDLC octet-stuffing transparency procedure serves only to transport HDLC frames across an asynchronous interface, integrated terminals containing the HDLC protocol (T.120, H.224 or other) may omit the octet stuffing/unstuffing procedure, directly placing each HDLC frame in an AL-SDU, since the stuffing and unstuffing procedures cancel each other out inside the terminal. However, such integrated terminals shall still signal the HDLC frame tunnelling data protocol, for proper interworking with far-end terminals.

6.8.1.4 Transparent data

In the transparent data mode, octets arriving at the V.24 interface shall be placed directly into the octets of an unframed AL-SDU, preserving the original bit ordering (least significant bit first). No framing or transparency procedure shall be applied. The unframed AL-SDU should be transferred to the underlying AL in a streaming mode, without waiting for the end of the AL-SDU (which will never occur).

The receiver shall perform the reverse operation.

NOTE – The transparent data protocol may be considered equivalent to a variable-rate synchronous data channel, as it simply transports octets without any additional framing or protocol.

6.8.2 Data applications

Data applications make use of an underlying data protocol, as described in the previous subclause. This subclause describes these data applications as if they are resident in an external computer running the application, connected through a V.24 interface to the H.324 terminal. The V.24 interface may be replaced by a logical equivalent. Data applications integrated with the H.324 terminal may choose to omit procedures related to the V.24 interface which have no net effect on the transmitted bitstream.

6.8.2.1 T.120 multimedia teleconferencing applications

The T.120-series of Recommendations is for point-to-point and multipoint audiographic teleconferencing including database access, still image transfer and annotation, application sharing, real-time file transfer, etc.

All H.324 terminals offering real-time audiographic conferencing should support the T.120 protocol suite.

H.324 terminals supporting T.120 shall use the PSTN basic mode profile protocol stack specified in ITU-T Rec. T.123, except that when arriving at the V.24 interface from the T.120 protocol implementation, the HDLC frame tunnelling data protocol described above shall be used. H.324 terminals shall declare the T.120 capability and mode if, and only if, they are compliant with this paragraph.

Since T.120 requires a reverse channel for operation, T.120 logical channels shall be opened using the H.245 procedures for opening associated logical channels in each direction of transmission (bidirectional channels).

NOTE – T.120 data can also be transported as unspecified user data, but this mode is discouraged, since H.324 terminals will not be able to automatically negotiate use of T.120 in this mode.

6.8.2.2 T.84 (SPIFF) point-to-point still image transfer cutting across application borders

This application supports the point-to-point transfer of T.84 (SPIFF – Still Picture Interchange File Format) still images (JPEG, JBIG or Facsimile group 3/4 coded) through application borders (e.g., a digital photocamera connected through a V.24 interface to the sending H.324 terminal, and a digital photoprinter connected through another V.24 interface to the receiving H.324 terminal).

The file exchange format to be used for ITU and ISO/IEC applications crosscutting application borders is defined in ITU-T Rec. T.84 | ISO/IEC 10918-3.

ITU-T Rec. H.245 should be used for the determination of still image profiles supported by the end-applications and the selection of an appropriate profile.

The data protocol used shall be LAPM/V.42 as described in 6.8.1.2.

NOTE – The T.120 protocol series (ITU-T Rec. T.126) also performs still image transfer, among many other functions, within the framework of audiographic teleconferencing, and is preferred for such applications. ITU-T Rec. T.84 is concerned with passing still images over one or more application borders using the ITU-T | ISO/IEC standardized common file-interchange format. The T.84 (SPIFF) file exchange format is backwards compatible with JFIF, the predecessor "*de facto* standard" JPEG file format, widely used in PC applications and on the Internet. ITU-T Rec. T.126 is also compatible with this file format.

6.8.2.3 T.434 point-to-point telematic file transfer cutting across application borders

This application supports the point-to-point transfer of T.434 defined telematic files through application borders (e.g., an intelligent memory card connected to the sending H.324 terminal, and a computerized database connected through an V.24 interface to the receiving H.324 terminal).

The data protocol used shall be LAPM/V.42 as described in 6.8.1.2.

NOTE – The T.120 protocol series (ITU-T Rec. T.127, which also uses ITU-T Rec. T.434) also performs file transfer, among many other functions, within the framework of audiographic teleconferencing, and is preferred for such applications. The T.434 application is concerned with point-to-point passing of telematic files over one or more application borders without implementing the entire protocol set of the T.120-series, which is indeed needed for file sharing among many users in a collaborative working environment.

6.8.2.4 H.224 real-time control protocol for H.281 far-end camera control

ITU-T Rec. H.224 is for real-time simplex device control. The only currently standardized application is ITU-T Rec. H.281 for far-end camera control.

H.324 terminals supporting H.224 shall use the HDLC frame tunnelling protocol to transport HDLC frames. There shall be no more than one H.224 channel in use, and references in ITU-T Rec. H.224 to the LSD channel of ITU-T Rec. H.221 shall be interpreted as referring to the H.224 logical channel. The maximum transmission time requirements of ITU-T Rec. H.224 shall be met, with the H.224 logical channel considered as operating at 4800 bit/s, regardless of the actual bit rate of the channel.

6.8.2.5 Network link layer

The network link layer data application supports ISO network layer protocols defined by ISO/IEC TR 9577, which include Internet Protocol (IP) and IETF Point-to-Point Protocol (PPP), among others. The particular network layer protocol to be used shall be identified in H.245 data application capability and data mode messages using the Network Layer Protocol Identifier (NLPID) as defined in ISO/IEC TR 9577.

For the NLPID application, the link layer which is defined for use with asynchronous GSTN modems shall be used. If this link layer uses HDLC framing, the HDLC Frame Tunnelling protocol shall be supported by the H.324 terminal. Otherwise, the transparent data protocol shall be supported by the H.324 terminal.

NOTE – Use of the NLPID is extensively described in IETF RFC 1490, "Multiprotocol Interconnect over Frame Relay".

6.8.2.6 External data ports and unspecified user data

All H.324 terminals offering external data ports for transport of unspecified user data shall support both the buffered V.14 data protocol mode and the HDLC frame tunnelling mode. Means shall be provided to configure the H.324 terminal for T.120 protocol on external data ports. If so configured, the HDLC frame tunnelling protocol and T.120 capability and mode shall be used by the terminal.

Other data protocols may optionally be used by H.245 negotiation.

6.8.2.7 T.30 facsimile

This application supports document facsimile transmission according to Annex C/T.30, and is signalled by the **t30fax** data application codepoint in ITU-T Rec. H.245. The facsimile data channel shall be carried within a H.223 logical channel using the AL1 adaptation layer in the segmentable mode. The data channel carrying the T.30 protocol shall be opened using the bidirectional logical channel procedures of ITU-T Rec. H.245.

Error correction is inherent in the use of Annex C/T.30 for facsimile communication. Therefore, the HDLC frame tunnelling data protocol shall be used for T.30 operation.

NOTE – This T.30 operation mode is the same as that used by ITU-T Rec. T.39, and will interwork with T.39 terminals in the MSVF mode. However, full conformance with ITU-T Rec. T.39 involves additional requirements beyond those of ITU-T Rec. H.324.

6.8.2.8 T.140 text conversation protocol

This application supports text conversation according to ITU-T Rec. T.140, and is signalled by the **t140** data application codepoint in H.245. H.324 terminals supporting T.140 shall use the AL1 Transparent Data protocol to transport T.140.

Terminals which support T.140 via T.120 (using T.134) shall also support point-to-point T.140 via the AL1 Transparent Data protocol.

7 Terminal procedures

The provision of the communication is made in the following steps:

- Phase A: Call set-up of voiceband channel;
- Phase B: Initial analogue telephony communication;
- Phase C: Establishment of digital communication, modem training;
- Phase D: Initialization;
- Phase E: Communication;
- Phase F: End of session;
- Phase G: Supplementary services and call clearing.

7.1 Phase A – Call set-up of voiceband channel

The calling terminal shall request the connection according to procedures for analogue telephony, according to national standards.

When a call is initiated by a terminal which is external to the modem (a separate physical item connected by an interface), the procedures of ITU-T Rec. V.250 (*ex*-V.25 *ter*) shall be used. Upon successful completion of call set-up, the H.324 terminal shall proceed to phase B.

7.2 Phase B – Initial analogue telephony communication

7.2.1 V.8 procedure

When the procedures of ITU-T Rec. V.8 are in use, phase B shall be bypassed, proceeding directly to phase C.

7.2.2 V.8 *bis* procedure

When the procedures of ITU-T Rec. V.8 *bis* are in use, an optional phase B begins when the called party has answered. Phase B is normal analogue telephony voice mode. In this mode users have the opportunity to speak before proceeding to multimedia telephony.

If the terminal is conditioned to go directly into digital communication mode, phase B shall be bypassed, proceeding directly to phase C. If the terminal is conditioned for initial analogue telephony voice mode, the terminal shall proceed to phase C when:

- the user manually causes the terminal to initiate a V.8 *bis* transaction; or
- the terminal detects an initiation signal from the distant terminal.

7.3 Phase C – Establishment of digital communication, modem training

7.3.1 V.8 procedure

The terminal shall follow the call start-up procedure described in ITU-T Rec. V.8. The calling terminal should not transmit V.8 calling tones CT or CNG, and should transmit calling tone CI. The answer terminal shall support V.8 CM/JM exchanges, and shall transmit answer tone without waiting for call signals. H.324 terminals should signal the "H.324" V.8 call function (value 0x21), and shall not signal a V.8 protocol category.

If the V.8 start-up procedure detects a V.34 modem, the start-up procedure for that modem shall be followed. Upon completion of the modem start-up procedure and establishment of digital communication, the terminal shall proceed to phase D – Initialization.

If the V.8 procedure fails to detect a V.34 modem, or the handshake and the establishment of the digital connection is not successful after a suitable period the calling terminal may, depending on predetermined configuration, go to telephony mode, disconnect the line, or go to another operating mode more suitable for the detected modem. Such other modes are outside the scope of this Recommendation.

NOTE – The terminal shall wait for a suitable call set-up period, in addition to processing, signal detection, and maximum round-trip delays, before deciding on further action.

7.3.2 V.8 *bis* procedure

The terminal shall follow the call start-up procedure described in ITU-T Rec. V.8 *bis*. If the V.8 *bis* procedure detects that the distant terminal is not capable of V.8 *bis*, but is capable of V.8, the Phase C procedure for V.8 (above) shall be followed. If the V.8 *bis* procedure detects a distant H.324 terminal supporting the capabilities desired for this call, the V.34 start-up procedure shall be followed.

Upon completion of the V.8 *bis* procedures and establishment of digital communication, the terminal shall proceed to phase D – Initialization.

NOTE – Some successful V.8 *bis* transactions result in a return to telephony mode (phase B).

If the V.8 *bis* procedure fails, results in a return to analogue telephony, or the handshake and the establishment of the digital connection is not successful after the period specified in ITU-T Rec. V.8 *bis*, the calling terminal may, depending on predetermined configuration, go to telephony mode, disconnect the line, or go to another operating mode more suitable for the detected modem. Such other modes are outside the scope of this Recommendation.

7.4 Phase D – Initialization

After digital communication has been established, a minimum of 16 HDLC flags shall be transmitted in order to ensure synchronization. Following this, system-to-system communication shall be initiated using the H.245 control channel. Since no multiplex table entries have yet been sent to the receiver, initial control messages shall be sent using multiplex table entry 0.

Terminal system capabilities are exchanged by transmission of the H.245 **TerminalCapabilitySet** message. This capability PDU shall be the first message sent. The H.245 **MasterSlaveDetermination** message shall also be sent at this time, in which the terminals exchange random numbers, according to the procedure in ITU-T Rec. H.245, to determine the master and slave terminals. H.324 terminals shall be capable of operating in both master and slave modes, and shall set **terminalType** to 128 and set **statusDeterminationNumber** to a random number in the range 0 to $2^{24} - 1$. Only one random number shall be chosen by the terminal for each call, except in the case of identical random numbers, as described in ITU-T Rec. H.245.

If the initial capability exchange or master/slave determination procedures fail, these should be retried at least two additional times before the terminal abandons the connection attempt and proceeds to phase G.

NOTE – The range of **terminalTypes** from 0 to 127 is reserved for possible use by MCUs or other non-terminal devices which may need to be slave at all times, and the range 129 to 255 is reserved for possible use by MCUs or other non-terminal devices which may need to be master at all times.

After these procedures are complete, and the far-end's capabilities have been received, the procedures of ITU-T Rec. H.245 may then be used to open logical channels for various information streams. Multiplex table entries may be sent before or after logical channels are opened, but information shall not be transmitted over a logical channel until the channel is open, and an appropriate H.223 multiplex table entry has been defined.

7.4.1 Exchange of video by mutual agreement

The indication **videoIndicateReadyToActivate**, "Video Indicate Ready-to-activate", is defined in ITU-T Rec. H.245. Its use is optional, but when used the procedure shall be as follows:

Terminal X has been set so that video is not transmitted unless, and until, the remote terminal has also indicated readiness to transmit video. Terminal X shall send the indication **videoIndicateReadyToActivate** when the initial capability exchange has been completed, but shall not transmit a video signal until it has received either **videoIndicateReadyToActivate** or incoming video.

A terminal which has not been set in this optional way is not obliged to wait until receipt of **videoIndicateReadyToActivate** or video before initiating its video transmission.

7.5 Phase E – Communication

During a session, the procedures for changing logical channel attributes, capability, receive mode etc. shall be carried out as defined in ITU-T Rec. H.245.

7.5.1 Rate changes and retrains

During phase E communication, the modem may retrain or alter its rate of data transmission, with or without momentary disruption of data transmission and loss of data. Upon any such momentary disruption of data transfer, the terminal shall not restart phase D, but shall remain in phase E and execute the normal H.324 error recovery procedures according to ITU-T Rec. H.223.

7.5.2 Involuntary disconnection

Should the terminal detect involuntary, unrecoverable loss of modem communication, or of the underlying GSTN connection, the terminal shall immediately proceed to phase G, analogue telephony mode or line disconnection, bypassing phase F.

7.6 Phase F – End of session

Either terminal may initiate the end of the session. The initiating terminal shall use the following procedure:

1) For each logical channel carrying video, it shall stop sending video at the end of a complete picture and then close the logical channel.
2) It shall close all outgoing logical channels carrying data and audio.

3) It shall transmit the H.245 message **EndSessionCommand**, and then discontinue all H.245 message transmissions. This message shall contain an indication to the far end regarding the mode the terminal will enter after the end of the session (disconnect line, analogue telephony, or other mode).

4) On subsequent receipt of **EndSessionCommand** from the remote end, it shall proceed to phase G, except that if the initiating terminal indicated an intention to disconnect the line after the end of session, the terminal shall not wait for receipt of **EndSessionCommand** from the remote end, but shall proceed directly to phase G.

A terminal receiving **EndSessionCommand** without first having transmitted it shall:

a) if the initiating terminal's **EndSessionCommand** message indicated "disconnect line", optionally follow 3) above, then proceed to phase G;

b) otherwise, follow 3) above, then proceed to phase G. If possible, the responding terminal should proceed to the new mode indicated in the initiating terminal's **EndSessionCommand** message.

7.7 Phase G – Supplementary services and call clearing

If the terminal arrived at phase G by involuntary disconnection, it shall disconnect or revert to analogue telephony, depending on predetermined configuration.

A terminal wishing to terminate a call shall first initiate session end procedure described in phase F.

In phase G, the terminal should proceed as it indicated in the **EndSessionCommand** message. If it indicated a change to another digital communication mode, it shall begin the new mode at the equivalent of phase D. Otherwise, it shall initiate the cleardown procedures defined in ITU-T Rec. V.34, except that it shall not physically disconnect the GSTN connection if it indicated an intention to revert to analogue telephony mode.

These procedures ensure that:

- the distant terminal does not erroneously invoke a fault procedure;
- the human user gets the right indications via tones and announcements from the network exchange;
- relevant messages can be displayed for the human user by the terminal.

7.7.1 Reset of H.324 session

In phase G, if both the terminal and the far-end have the **SessionResetCapability**, defined in Annex J, in **Capability.genericControlCapability**, and the mode indicated in the **EndSessionCommand** message is **gstnOptions.v34H324**, the terminal shall reset the H.324 session by moving immediately to phase D without changing communication mode and without disconnecting the physical connection. Before sending synchronization flags as indicated in phase D, the receiver of the **EndSessionCommand** message with **gstnOptions.v34H324** shall answer with the same message and then transmit one's complemented synchronization flags to distinguish the new session from the old one. The amount of one's complemented synchronization flags transmitted shall be at least 10 consecutive flags. The maximum number of one's complemented synchronization flags transmitted shall be equivalent to the number of synchronization flags possible to be sent in a period of 500 ms. If the initiator of the session reset procedure received one's complemented synchronization flags without receiving the **EndSessionCommand** message first, it shall start transmitting one's complemented synchronization flags of its own and proceed with the procedure.

8 Interoperation with other terminals

8.1 Speech only terminals

H.324 videophones shall support interoperation with analogue speech-only telephones.

8.2 H.320 multimedia telephone terminals over the ISDN

Interoperation with multimedia telephone terminals over the ISDN (ITU-T Rec. H.320) can be provided by:

- using on the ISDN an interworking adapter; or
- using dual-mode (ISDN and GSTN) terminals on the ISDN.

An H.324/H.320 interworking adapter is located at the interface between ISDN and GSTN signals. It transcodes the H.223 and H.221 multiplexes, and the content of control, audio, and data logical channels between the H.324 and H.320 protocols.

In order to ease communication between H.324 and H.320 terminals via interworking adapters, H.324 terminals which support video shall support the H.261 video codec in the QCIF picture format so that the additional delay of video transcoding can be avoided. When this mode is in use, interworking adapters shall insert and remove H.261 and H.263 BCH error correction and error correction framing as appropriate for each terminal type. H.324 terminals shall respond to the H.245 **FlowControlCommand**, so that transmitted H.324 video streams can be matched to the H.320 video bit rate in use by the H.221 multiplex.

Dual-mode (H.320 and H.324) terminals on the ISDN shall send H.324 GSTN signals by the use of a "virtual modem", which generates and receives a V.34 analogue signal encoded as a G.711 audio bitstream over the ISDN.

8.3 Multimedia telephone terminals over mobile radio

It is expected that multimedia telephone terminals will also be used on mobile radio networks. Rate matching between wireless terminals and GSTN terminals can be achieved by the use of the H.245 **FlowControlCommand**. Wireless operation is for further study.

9 Optional enhancements

9.1 Data facilities

A terminal may have physical I/O ports for external telematic and other equipment, or there may be data applications within the terminal itself. Data transmission may be activated and deactivated by local action.

When a logical channel is opened to carry data originating at a port, the **portNumber** parameter of the H.245 **OpenLogicalChannel** message should contain the number of the relevant port, so that data on the logical channel may be routed to a corresponding port at the far end, if so desired by the far-end user. For example, in the case where a terminal has general purpose physical I/O ports intended for connection to telematic or other equipment, such ports might be labelled "1", "2", "3", etc., up to the number of actual ports.

9.2 Encryption

Encryption may optionally be used by H.324 terminals. Encryption, including selection of algorithm and key exchange, shall conform to the procedures of ITU-T Recs H.233 and H.234 with the following modifications to the procedures defined in ITU-T Rec. H.233. The ability to support encryption shall be signalled by the presence of the **h233EncryptionTransmitCapability** and **h233EncryptionReceiveCapability** parameters of the **Capability** message of H.245.

In ITU-T Rec. H.233, specific reference is made to ITU-T Rec. H.221 in describing how encryption takes place. In applying ITU-T Rec. H.233 to H.324 terminals, references to ITU-T Rec. H.221, FAS, and BAS channels therein shall be ignored and appropriate substitute recommendations be taken from this subclause. Messages referred to as carried in the H.221 ECS channel shall be re-interpreted as being carried within the **encryptionSE** parameter of the H.245 **EncryptionCommand** or Encryption Initialization Vector (EIV) logical channel, as specified below.

9.2.1 EncryptionSE messages

H.233 Session Exchange (SE) messages shall be carried in the **encryptionSE** parameter of the H.245 **EncryptionCommand** message. Since the H.245 control channel is carried on a reliable data link layer using retransmission of errored frames, the error protection bits described in ITU-T Rec. H.233 shall not be applied to SE messages.

The H.233 header for SE messages shall have the value binary 00000000, indicating an SE message in a single block, not followed by related blocks.

The H.233 media identifier value shall be binary 00000000, which shall indicate encryption of all logical channels except for the EIV and H.245 control channels. The use of other values is for further study.

NOTE – Non-standard encryption algorithms may be referenced in SE messages after associating a non-standard algorithm with a H.233 Algorithm Identifier value using the **encryptionAlgorithmID** parameter of the **EncryptionCommand** message.

9.2.2 Encryption initialization vector (EIV) channel

The Encryption Initialization Vector (EIV) logical channel is used for the transmission of H.233 Initialization Vector (IV) messages.

To ensure accurate synchronization of the IV messages with the H.223 multiplex bitstream, the EIV channel is an independent logical channel which shall be non-segmentable, and shall use adaptation layer AL2 of the H.223 multiplex. The entire IV message, exactly as defined in ITU-T Rec. H.233, including error protection bits, shall be placed in a single AL-SDU. The sequence number option of AL2 shall not be used.

Messages carried within the EIV channel shall retain the error protection mechanism of ITU-T Rec. H.233.

9.2.3 Encryption procedure

The encryptor shall produce a pseudo-random bitstream (cipher stream) corresponding to all bits output by the H.223 multiplex prior to insertion of flags and application of the HDLC zero-bit insertion procedure.

When encryption is activated according to ITU-T Rec. H.233, the H.223 bitstream shall, prior to flag insertion and application of the HDLC zero-bit insertion procedure, be exclusive-ORed with the pseudo-random bitstream generated by the encryptor. However, the exclusive-OR procedure shall not be applied to the H.223 header octet nor to the octets belonging to the H.245 control channel or EIV channel, which shall all be passed transparently to the HDLC zero-bit insertion and flag insertion stage.

For each transmitted H.223 header octet or octet belonging to the EIV or control channels, eight bits shall be discarded from the pseudo-random bitstream generated by the encryptor. Nothing is discarded from the pseudo-random bitstream for transmitted flags or for bits added by the HDLC zero-bit insertion process.

The receiver shall apply the reverse procedure.

9.2.4 Encryption initialization vectors

Once an encrypted session is in progress, the transmitter should periodically send new IV messages in order to limit the duration of repeated pseudo-random bitstream in the event of a collision with a previously used state of the pseudo-random bitstream generator. The frequency of these messages is left to the discretion of the implementor.

As shown in Figure 3, new Initialization Vectors (IVs) take effect at the start of the next H.223 MUX-PDU following the MUX-PDU containing an IV message. The old IV continues in effect through the entirety of the MUX-PDU containing the IV message, at the end of which any remaining pseudo-random bits generated using the old IV are discarded. In order for the receiver to have time to process the new IV before needing to use it, the transmitter shall wait a minimum time after sending the last octet of the IV message, as specified by the receiver's **h233IVResponseTime** capability, before starting transmission of the next MUX-PDU. If necessary, the transmitter shall send idle flags to meet the receiver's **h233IVResponseTime** requirement.

NOTE – Definition, by the implementor, of an appropriate H.223 multiplex table entry allows octets from other logical channels to follow an IV message within the same MUX-PDU so that no transmission bandwidth is squandered in meeting the receiver's IV processing delay requirement.

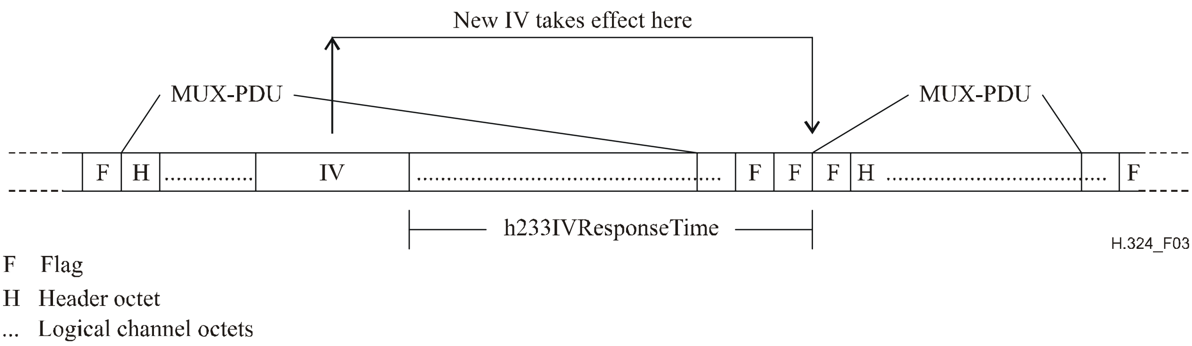

Figure 3/H.324 – Encryption IV synchronization

9.2.5 Error recovery

In the event of line errors that cause flag emulation, flag erasure, or erroneous HDLC zero-bit removal, it is possible that a newly received flag, signifying the end of the previous MUX-PDU, will not align with the octet boundaries of the preceding data. In order to maximize the resilience of the encryption system against synchronization loss under these circumstances, the decryptor should, for each new flag received, re-align its pseudo-random bitstream generator to the nearest octet boundary. This allows recovery from up to at least three zero-bit removal errors between valid flags, although it does not provide any protection against flag emulation or erasure.

In the event that the receiver suspects that it has lost encryption synchronization it shall send an **encryptionIVrequest** command, except that it should not re-send such commands at intervals less than the maximum expected round-trip response time.

Upon receipt of an **encryptionIVrequest** command, the transmitter shall, at its earliest opportunity, send a new IV message, except that it should ignore **encryptionIVrequest** commands received within the minimum expected round-trip response time since sending the last IV message.

9.3 Multilink

ITU-T Rec. H.226 describes a protocol for aggregation of data over multiple independent channels.

Annex F defines the operation of H.324 over multiple independent physical connections, aggregated together according to ITU-T Rec. H.226 to provide a higher total bit rate. These connections may be

GSTN circuits, or ISDN circuits as defined in Annex D. The use of both GSTN and ISDN connections in the same call is supported.

Annex H defines the operation of H.324/M over up to eight independent physical connections, aggregated together according to the mobile multilink layer defined in this annex to provide a higher total bit rate. These connections are error prone mobile channels, as defined in Annex C, all having the same transmission rate.

10 Multipoint considerations

H.324 terminals may be used in multipoint configurations via interconnection through MCUs, as indicated in Figure 4. (Note that cascaded MCU operation is for further study.)

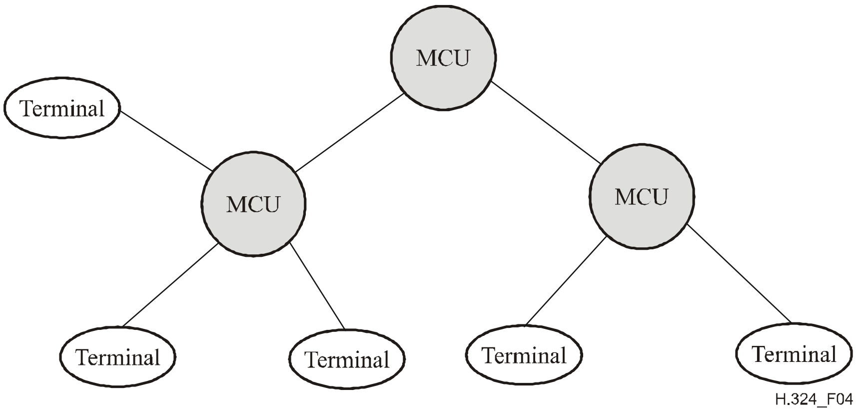

Figure 4/H.324 – Multipoint configuration

10.1 Establishment of common mode

MCUs may force terminals into a particular common mode of transmission by sending to the terminal a receive capability set listing only the desired mode of transmission. H.324 terminals shall obey the **MultipointModeCommand** message of ITU-T Rec. H.245.

10.2 Multipoint rate matching

Since the modems on each link in a multipoint configuration may be operating at different bit rates, MCUs may choose to send H.245 **FlowControlCommand** messages to limit the transmitted bit rates to those which can be sent to receivers.

10.3 Multipoint lip synchronization

In a multipoint configuration, each terminal may be transmitting a different **H223SkewIndication** message for associated video and audio channels. To enable lip synchronization at receiving terminals, MCUs shall transmit accurate **H223SkewIndication** messages. MCUs may accomplish this by adding delay to equalize the audio/video skew for all transmitting terminals, or, when switching between broadcasting terminals, may transmit a new **H223SkewIndication** message reflecting the audio/video skew of the current broadcaster.

10.4 Multipoint encryption

In a multipoint configuration, the MCU is considered to be a trusted entity. Each port of the MCU encrypts/decrypts the H.223 bitstream from the H.324 terminal or MCU attached to that port as though it were an H.324 terminal in accordance with 9.2.

10.5 Cascaded MCU operation

Multipoint operation in a cascaded MCU configuration is for further study.

11 Maintenance

11.1 Loopbacks for maintenance purposes

Some loopback functions are defined in ITU-T Rec. H.245 to allow verification of some functional aspects of the terminal, to ensure correct operation of the system and satisfactory quality of the service to the remote party. The message loopback off (**MaintenanceLoopOffCommand**) requires that all loopbacks currently in effect be turned off.

11.1.1 Normal mode

Normal (no loopback) operation mode is illustrated in Figure 5-a.

11.1.2 System loopback

Operation in system loopback mode is for further study.

11.1.3 Media loopback

Media loopback operates at the analogue I/O interface (toward modem). Upon receiving the **mediaLoop** request as defined in ITU-T Rec. H.245, loopback of the content of the selected logical channel shall be activated as close as possible to the analogue interface of the video/audio codec towards the video/audio codec, so that decoded and re-coded media content is looped, as indicated in Figure 5-c. While in this mode, the terminal shall respond normally to received data, including H.245 messages. Media loopback provides a subjective test of H.324 operation through the far-end codec for human user evaluation. It should be used only on video and audio channels.

This loopback is optional, and should be used only on logical channels opened using the bidirectional channel procedures of ITU-T Rec. H.245.

11.1.4 Logical channel loopback

Logical channel loopback operates in the H.223 multiplex (toward modem). Upon receiving the **logicalChannelLoop** request, each received H.223 MUX-SDU for the specified logical channel shall be looped back to the transmitter on the corresponding reverse logical channel, as indicated in Figure 5-d. While in this mode, the terminal shall respond normally to received data, including H.245 messages.

This loopback is optional, and should be used only on logical channels opened using the bidirectional channel procedures of ITU-T Rec. H.245.

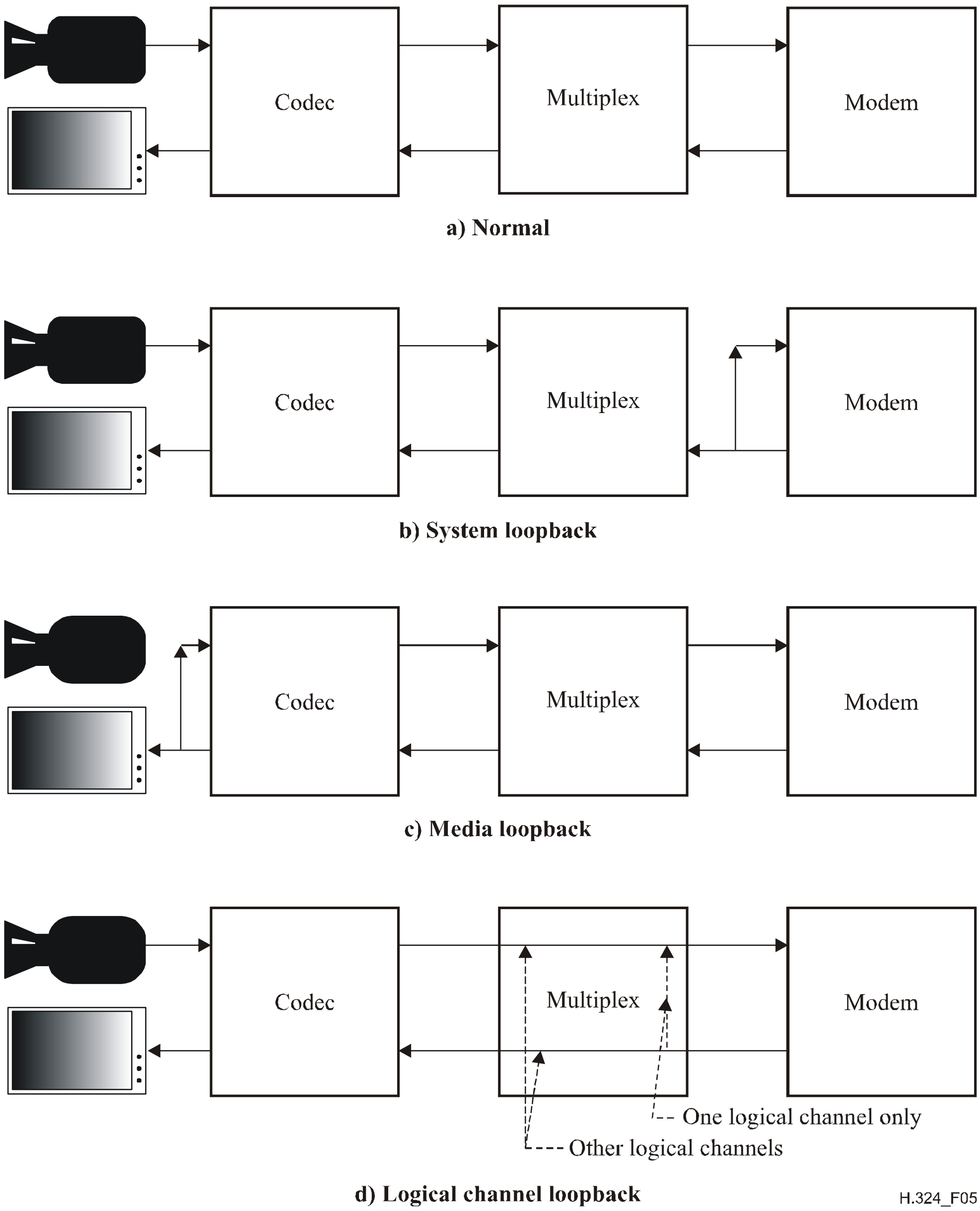

Figure 5/H.324 – Loopback

Annex A

Protocol stack for control channel

This annex defines the data protocol stack for use with the H.324 control channel.

A.1 General

Figure A.1 shows the control channel protocol stack for use with this Recommendation.

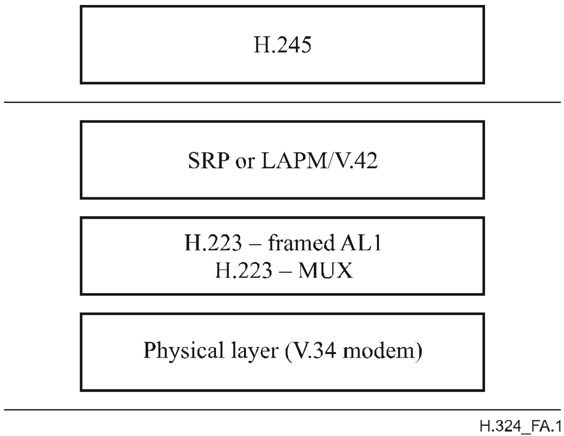

Figure A.1/H.324 – Protocol stack for H.324 control channel

The control protocol of ITU-T Rec. H.245 requires a reliable link layer for proper operation.

Two means of transporting **MultimediaSystemControlPDU** messages are defined: Simple Retransmission Protocol (SRP) frames and LAPM/V.42 I frames. In the SRP mode each SRP command frame must be acknowledged with an SRP response frame before the next command can be transmitted. In the LAPM/V.42 mode multiple frames may be sent in a streaming mode, before an acknowledgement is received for the first frame. All H.324 terminals shall support the SRP mode, and shall use SRP as the H.245 link layer upon initial communication. The LAPM/V.42 mode is optional, and is preferred for use by complex terminals.

In both cases, bits produced by the X.691 encoding process shall be put into the octets of an information field, with the first bit generated going into the Most Significant Bit (MSB) of the first octet, and progressing down to the Least Significant Bit (LSB) of the last octet. One or more complete H.245 **MultimediaSystemControlPDU** messages may be sent in each information field, to be transported in a single SRP or LAPM frame.

NOTE 1 – The specified X.691 encoding process produces **MultimediaSystemControlPDU** messages which are each a multiple of 8 bits in length (10.1.3/X.691), so all messages begin on an octet boundary.

H.324 terminals capable of using LAPM/V.42 as the control channel link layer shall so indicate by setting the **transportWithI-frames** parameter of the **H223Capability** structure true. Such terminals, upon receiving the corresponding indication from the far-end terminal, shall henceforth, and without further notification of intent, proceed to establish an error-corrected connection according to the procedures given in 6.8.1.2 and subsequently transmit control channel messages only using LAPM/V.42 for the duration of the connection. The terminal shall, however, transmit a SRP response message in reply to any SRP command message received.

The transition to LAPM/V.42 mode shall take place regardless of the state of any H.245 transactions in progress; any pending transactions shall proceed using LAPM/V.42 for transfer of additional messages.

NOTE 2 – Since the H.245 control channel is not considered a data channel, ability to operate the control channel over LAPM/V.42 is signalled only in the **transportWithI-frames** parameter of **H223Capability**, and is not signalled as a data protocol.

A.2 SRP mode

All terminals shall support the transfer of **MultimediaSystemControlPDU** messages using SRP mode. Each SRP frame shall be placed in a single framed AL1 AL-SDU.

NOTE – The procedures of the SRP mode are based on those of XID frame transfer in ITU-T Rec. V.42.

A.2.1 SRP command frames

SRP command frames, as shown in Figure A.2, shall be used to send H.245 control messages. All fields shall be formatted as specified in ITU-T Rec. H.223 (note that these formats are consistent with ITU-T Rec. V.42).

Header (1 octet)	Sequence number (1 octet)	Information field (one or more ASN.1 messages)	FCS (2 octets)

H.324_FA.2

Figure A.2/H.324 – Format of SRP command frames for MultimediaSystemControlPDU messages

The SRP command frame header octet shall have the value binary 11111001 (decimal 249). This may be considered equivalent to an HDLC address octet with the DLCI value 62, C/R bit set to 0, and EA bit set to 1.

The sequence number shall be set arbitrarily by a terminal for the first SRP command frame sent and shall be incremented modulo 256 for each new SRP command frame sent. Retransmissions of the same SRP frame, sent according to the procedures below, shall not increment the sequence number, but shall use the same sequence number as the original transmission, so that receivers can distinguish between separate valid messages and retransmissions of a single message (possibly sent in error if the original SRP response frame was lost).

The information field shall contain a whole number of octets, not to exceed 2048 octets, representing one or more H.245 **MultimediaSystemControlPDU** messages. The procedure specified by ITU-T Rec. X.691 shall be used to fill any spare bits in the last octet.

The FCS field shall contain a 16-bit CRC, applied to the entire frame content, as described in 8.1.1.6.1/V.42.

A.2.2 SRP response frames

SRP response frames shall be used to acknowledge correct receipt of SRP command frames from the far end. Each SRP response frame shall consist of a header octet and FCS field only, and shall not contain any other fields.

The SRP response frame header octet shall have the value binary 11111011 (decimal 251). This may be considered equivalent to an HDLC address octet with the DLCI value 62, C/R bit set to 1, and EA bit set to 1.

The FCS field shall contain a 16-bit CRC, applied to the entire frame content, as described in 8.1.1.6.1/V.42.

A.2.3 SRP procedure at transmitter

The SRP procedure makes use of an acknowledgement timer T401 and retransmission counter N400.

The period of T401 is a local matter; the two terminals may operate with different periods of T401. Appendix IV/V.42 shows the various factors that influence T401.

The maximum value of N400 is a local matter; the two terminals may operate with different maximum values of N400. While no default maximum is specified for N400, it should be at least 5.

When the terminal transmits a new SRP command frame, timer T401 shall then be started and the retransmission counter, N400, reset. No additional SRP command frames shall be sent until a response SRP frame with correct header and FCS is received, or timer T401 expires.

If a valid SRP response frame is received, a new SRP command frame, with an incremented sequence number, may be transmitted.

If timer T401 expires before receipt of a valid SRP response frame, the terminal shall:

- retransmit the SRP command (with the same sequence number) as above;
- restart timer T401; and
- increment the retransmission counter (N400).

After retransmission of the SRP command N400 times and failure to receive a valid SRP response, the terminal shall consider modem communication to be lost, and take appropriate action.

A.2.4 SRP procedure at receiver

On receipt of an SRP command frame with correct header and FCS, the receiving terminal shall acknowledge by transmitting an SRP response frame within 500 milliseconds.

If the received SRP command frame has the same sequence number as the previously received command frame, it shall not be passed to the H.245 layer, since it is a retransmission of an already-processed command.

Receipt of all other frames shall be ignored, except that if the terminal has signalled ability to operate in LAPM/V.42 mode, the receiver shall check the DLCI value of received frame header. If the DLCI value matches that specified for use in the LAPM/V.42 mode, the terminal shall respond according to the procedures of LAPM/V.42, as described below.

A.2.5 Numbered SRP response frames (NSRP)

The standard SRP response frame does not include a sequence number, which can result in transmitter uncertainty as to which SRP command frame is being acknowledged. Therefore this optional Numbered SRP response frame (NSRP) procedure is strongly preferred. Use of the NSRP allows smaller values of T401 and more reliable control channel operation.

Each NSRP response frame, as shown in Figure A.3, shall consist of a header octet, sequence number, and FCS field.

Header (1 octet)	Sequence number (1 octet)	FCS (2 octets)

H.324_FA.3

Figure A.3/H.324 – Format of NSRP response frame

The NSRP response frame header octet shall have the value binary 11110111 (decimal 247). This may be considered equivalent to an HDLC address octet with the DLCI value 61, C/R bit set to 1, and EA bit set to 1. The FCS field shall contain a 16-bit CRC, applied to the entire frame content, as described in 8.1.1.6.1/V.42.

Terminals supporting NSRP shall signal this capability via ITU-T Rec. H.245.

Terminals which support the NSRP mode shall transmit SRP response frames until receipt of the NSRP capability in ITU-T Rec. H.245. After that time, only NSRP response frames shall be sent to acknowledge received SRP command frames.

Terminals shall accept received SRP response frames until receipt of the first NSRP response frame. After that time, only NSRP response frames shall be accepted.

All other SRP procedures are as described in previous subclauses.

A.3 LAPM/V.42 mode

Terminals may optionally support the transfer of **MultimediaSystemControlPDU** messages using LAPM/V.42.

SRP frames shall be used to transfer **MultimediaSystemControlPDU** messages before LAPM/V.42 transmission is initiated but shall not be used for this purpose after LAPM/V.42 transmission has been used.

In the LAPM/V.42 mode, the information field, as defined for the SRP mode above, shall be placed into a single LAPM/V.42 I-frame and transferred using procedures of LAPM/V.42, as in 6.8.1.2, except that the procedures for opening logical channels shall not be used, as the control channel is considered already open at the start of digital communication.

The address field shall be one octet with the 6-bit DLCI field set to binary 111111 (decimal 63).

V.42 *bis* data compression should not be used.

Default values for all V.42 parameters shall be as specified in ITU-T Rec. V.42, except for N401, maximum number of octets in an information field, which shall have a default value of 2048 octets, in order to accommodate large capability sets.

A.4 WNSRP control frame signalling on the control channel

Windowed NSRP (WNSRP) control frames shall be assigned to the control channel with LCN 0 using multiplex table entry 15.

For backward compatibility reasons, SRP/NSRP command and response frames, depending on the involved multiplexer level, are the only control frames sent using multiplex table entry 0 before receiving any indication from the remote terminal regarding its capabilities.

A receiver terminal that does not support multiplex table entry 15 from the beginning of the call shall ignore it as stated in 6.4.1.1/H.223. Furthermore, a receiver terminal receiving a control frame using multiplex table entry 15 with a header it does not recognize shall ignore that frame.

A.4.1 WNSRP command frames

WNSRP command frame format is the same as that of an SRP command frame except that the WNSRP command frame header octet shall be 11110001 (decimal 241).

Header (1 octet)	Sequence number (1 octet)	Information field (one or more ASN.1 messages)	FCS (2 octets)

H.324_FA.4

Figure A.4/H.324 – Format of WNSRP command frames for MultimediaSystemControlPDU messages

The standard SRP command frame does not allow the use of the sequence number for a window of SRP commands, which causes each SRP command frame to be acknowledged using a full round-trip. During call setup, the number of control messages passed between the terminals can reach more than 5, which accounts for too many round-trips for call setup. Use of the WNSRP allows reduction of the sequential round-trips needed by parallelizing them.

Terminals supporting WNSRP shall support the following additional capabilities:

- Terminals do not signal this capability via ITU-T Rec. H.245.
- For WNSRP mode detection, terminals shall transmit WNSRP command frames using multiplex table entry 15 until the receipt of the first incoming WNSRP response or command frame. After switching to WNSRP mode, all WNSRP control frames shall be sent using multiplex table entry 0.
- Terminals shall transmit both SRP command frames and WNSRP command frames until the receipt of the first incoming WNSRP response or command frame, in which case they shall stop sending SRP command frames and switch to the WNSRP mode only.
- Received SRP command frames shall always be acknowledged using SRP/NSRP response frames.
- Terminals shall have an additional mode counter N402. The maximum value of this mode counter is a local matter; the two terminals may operate with different mode counters. The minimal value of this mode counter N402 shall be 1. On receipt of an SRP or NSRP response, frame N402 shall be incremented.
- Terminals that do not receive WNSRP response or command frames, but receive N402 number of SRP or NSRP response frames shall stop sending WNSRP command frames and use SRP or NSRP only.
- The sequence number used for the first SRP and WNSRP command frames shall be zero and shall be incremented by modulo 256 for each new SRP and WNSRP command frame sent. This allows sending multiple WNSRP command frames from the beginning of the call.
- Terminals that switched to WNSRP mode cannot revert back to using SRP or NSRP.

A.4.2 WNSRP response frames

WNSRP response frame format is the same as that of an NSRP response frame except that the WNSRP response frame header octet shall be 11110011 (decimal 243).

WNSRP response frames shall be used to acknowledge correct receipt of WNSRP command frames from the far end.

Header (1 octet)	Sequence number (1 octet)	FCS (2 octets)

H.324_FA.5

Figure A.5/H.324 – Format of WNSRP response frame

After switching to WNSRP mode, the terminal shall stop transmitting SRP command frames and start transmitting one or more WNSRP command frames without waiting for the response of the previous transmitted frame. Each transmitted WNSRP command frame shall make use of an acknowledgement timer T401 and a retransmission counter N400.

A.4.3 WNSRP procedure at the transmitter

The WNSRP procedure makes use of the same acknowledgement timer T401 and the retransmission counter N400 that are used for the SRP procedure in A.2.3.

The period of T401 is a local matter; the two terminals may operate with different periods of T401. Appendix IV/V.42 shows the various factors that influence T401.

The maximum value of N400 is a local matter; the two terminals may operate with different maximum values of N400. While no default maximum is specified for N400, it should be at least 5.

Each WNSRP command frame shall be associated with its own acknowledgement timer T401 and a retransmission counter N400.

When the terminal transmits a new WNSRP command frame, timer T401 shall then be started for that specific command frame and the retransmission counter, N400, reset.

A new WNSRP command frame can be sent by incrementing the sequence number, without the need to wait for a WNSRP response frame on pending WNSRP command frames.

The transmitter shall store each WNSRP command frame until it receives the WNSRP response frame that acknowledges its receipt.

If a valid WNSRP response frame is received for a WNSRP command frame, the associated timer T401 shall be stopped.

If timer T401 expires before receipt of a valid WNSRP response frame for a given WNSRP command frame, the terminal shall:

- retransmit the WNSRP command (with the same sequence number) as above;
- restart timer T401; and
- increment the retransmission counter (N400).

On receipt of a WNSRP response frame, the terminal shall:

- retransmit any WNSRP command that was created before the acknowledged WNSRP command frame;
- restart timer T401 for the retransmitted WNSRP commands; and
- increment the retransmission counter (N400) for the retransmitted WNSRP commands.

NOTE – This retransmission reduces the timeout on WNSRP command frames that the transmitter knows it will not get acknowledgements for.

After retransmission of the WNSRP command N400 times and failure to receive a valid WNSRP response, the terminal shall consider modem communication to be lost, and take appropriate action.

A.4.4 WNSRP procedure at the receiver

On receipt of a WNSRP command frame with correct header and FCS, the receiving terminal shall acknowledge by transmitting a WNSRP response frame.

If the received WNSRP command frame has the same sequence number as the previously received command frame, it shall not be passed to the H.245 layer, since it is a retransmission of an already-processed command.

If the received WNSRP command frame has a sequence number that is higher than the expected sequence number, the receiver shall store the WNSRP command frame until the receipt of the expected sequence number frame(s) and only then forward the stored WNSRP command frame to the H.245 layer. If the receiver cannot store the WNSRP command frame (because its window is too small or because of low memory) it shall ignore the WNSRP command frame and shall not send an acknowledgement for the ignored WNSRP command frame.

On receipt of the first SRP command frame with a sequence number other than zero, the terminal shall consider the call as a call without WNSRP and revert to using SRP or NSRP.

Annex B

HDLC frame structure transparency for asynchronous transmission

When operating in the HDLC frame tunnelling mode, the H.324 terminal shall implement at the asynchronous V.24 interface the following procedures taken from 4.5.2 of ISO/IEC 3309.

The control escape octet is a transparency identifier that identifies an octet occurring within a frame to which the following transparency procedure is applied. The encoding of the escape octet is given in Figure B.1.

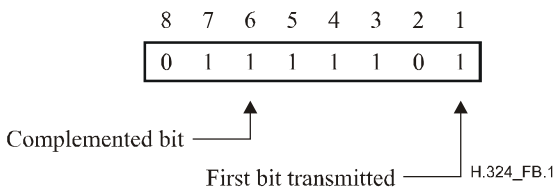

Figure B.1/H.324 – Control escape octet for HDLC frame tunnelling procedure

The transmitter shall examine the frame content between the opening and closing flag sequences (01111110) including the address, control, and FCS fields and, following completion of the FCS calculation, shall:

a) upon the occurrence of the flag or a control escape octet, complement the 6th bit of the octet; and

b) insert a control escape octet immediately preceding the octet resulting from the above prior to transmission.

The receiver shall examine the frame content between the two flag octets and shall, upon receipt of a control escape octet and prior to FCS calculation:

a) discard the control escape octet; and

b) restore the immediately following octet by complementing its 6th bit.

Other octet values may optionally be included in the transparency procedure by the transmitter.

Annex C

Multimedia telephone terminals over error prone channels

C.1 Abstract

This annex describes specific issues to allow the use of H.324 terminals in error-prone transmission environments. These issues include specific options for H.324 terminals, e.g.:

- the mandatory use of NSRP;
- the use of robust versions of the terminal multiplexer (several different levels of robustness are provided);
- procedure for level set-up;
- procedure for dynamic change between levels during a session.

C.2 General

This annex describes multimedia terminals that use a robust multiplexing procedure to improve operation over error-prone channels. In this annex, terminals supporting robust multiplexing will be referred to as "mobile terminals". Except as noted below, all features of H.324 terminals apply to these terminals. Four different multiplexer levels are described, offering progressively increased robustness at the cost of progressively increased overhead and complexity.

- H.223 Level 0: This term is used to described ITU-T Rec. H.223.
- H.223 Level 1: Described in Annex A/H.223. The HDLC flag in H.223 used to delimit MUX-PDUs in Level 0 is replaced with a longer flag that leads to improved MUX-PDU synchronization. HDLC bit stuffing is not used. The Control Channel Segmentation and Reassembly Layer (CCSRL) is introduced for the transmission of the control channel. The transmitter side shall take necessary precautions to prevent possible flag emulation for the control channel. Flag emulation can be prevented, e.g., by detecting N 16-bit flags in each MUX-SDU for the channel and by breaking the SDU into N+1 segments. This may also apply to data channels.
- H.223 Level 2: Described in Annex B/H.223. Includes the features of Annex A/H.223. In addition, the header describing the MUX-PDU contents includes error protection.
- H.223 Level 3: Described in Annex C/H.223. Includes the features of Annex B/H.223. In addition, error protection and other features are provided to increase the protection of the AL-PDUs. Described in Annex D/H.223 as an optional definition of Annex C/H.223.

In addition to the hierarchy offered by the level structure, some of the multiplex levels contain options.

If the terminal is connected to an octet-oriented network interface, the transmitter shall align the first transmitted bit to the network octet timing. Note that the MUX-PDU of H.223 level 1 and higher levels have an octet-aligned structure. Therefore, the receiver may use the octet timing information from the network interface to detect the start of a MUX-PDU to reduce the mis-synchronisation.

Mobile terminals shall support the NSRP and the SRP mode of Annex A. If both terminals start the session in level 0 initially the SRP mode shall be used. Otherwise, both terminals shall start with NSRP mode.

If both terminals in a session support level 3 of H.223, then adaptation layers AL1M, AL2M, and AL3M as defined in level 3 of H.223 may also be used in H.223, H.223 Annexes A and B (levels 1 and 2). However, bidirectional channels shall use either the H.223 adaptation layers, or the Annex C/H.223 adaptation layers for level 3 of H.223, but not a mixture of the two.

It is possible that the level may differ in the two directions of a session.

C.3 Changes to procedures

The procedures to be used when making and using a mobile terminal based on a robust multiplexing protocol are exactly the same as those for H.324 with the following exceptions:

- Mobile terminals may be implemented with any appropriate wireless interface in place of the V.34 modem. The specification of this interface is not within the scope of this annex. All references to the "V.34 modem" in this Recommendation shall for wireless terminals be replaced with "wireless interface".
- If V.34 is not used, V.8 shall not be used.
- All H.324 terminals should support Annex C/G.723.1.

C.4 Interworking

Since all mobile terminals support H.223 level 0, no interworking function is needed when communicating with an H.324 terminal that does not support any of the robust multiplexing annexes (Annexes A, B, C, and D of ITU-T Rec. H.223).

C.5 Terminal procedures

The steps for provision of communication are as listed in clause 7 with the following modifications:

- Depending on the access procedures to be used for wireless telephony, phase A and phase B may be bypassed.
- Phase C: The terminal shall establish digital communications using local standards.
- Phase D: The value of timer T401 shall be defined using the procedures in Annex E. The transmission of 16 consecutive HDLC flags is replaced with the level set-up procedure defined in C.6.
- Phase G: If the terminal arrived at phase G by involuntary disconnection, it shall disconnect or revert to the set-up procedures in phases A and C, depending on predetermined configuration.

C.6 Initialization of multiplex level at the start of a session

All mobile terminals based on this Recommendation support level 0. However, if two terminals want to establish connection in an error-prone environment, it is more likely that this will succeed in the higher levels.

This set-up procedure describes a method for achieving the highest level, which is supported by both terminals. It is used after the physical line has been established and before any capability exchange (phase D) for both terminals take place. This procedure is not used in H.223 level 0; however, it shall be used in all terminals which support level 1 or higher, unless outband signalling for this purpose is available. The use of out-of-band signalling is for further study.

C.6.1 Definition of stuffing sequences

The level set-up procedure shall use the stuffing methods described in the appropriate Recommendations as listed in Table C.1. The stuffing sequences are also used when the entire H.223 multiplex is limited by the **FlowControlCommand**.

Table C.1/H.324 – Definition of stuffing sequences according to Recommendations

Level	Stuffing sequence	Comments
0	Consecutive HDLC-flags	See 6.3.1/H.223
1	Consecutive PN-flags	See A.2.1.1/H.223
2	Consecutive combination of PN-flag + header field (MC = 0000, MPL = 0000000)	See B.3.2.3/H.223
3	Consecutive combination of PN-flag + header field (MC = 1111, MPL = 0000000)	See C.3.1/H.223

C.6.2 Definition of level set-up procedure

Each terminal shall start transmitting the stuffing sequence of its highest supported level. The terminal shall also search for the stuffing sequences at its receiving entity until it recognizes that the other terminal also supports either:

a) the same level; or

b) a lower level.

If the other terminal supports the same level, the procedure described in phase D of the call set-up procedure in this Recommendation shall be used.

If the terminal detects a stuffing sequence of a level that is lower than its own highest supported level, it shall immediately change the stuffing sequence of its transmitting entity according to the detected lower level. This ensures that all sessions will be initialized with both terminals operating at the same level. Then the terminals shall continue with the procedure described in phase D of the call set-up procedure in this Recommendation.

Each terminal shall start searching for the stuffing sequence of level 0 first. It should be noted that H.223 compliant terminals will send a sequence of at least 16 consecutive HDLC flags.

For improving reliability the receiving entity may only detect a stuffing sequence if it was sent n times, e.g., $n = 5$. However, this is only valid for the level set-up procedure.

The stuffing mode shall be determined entirely by the multiplex level, and has no dependence on the adaptation layer used.

If both terminals start with level 3, the stuffing mode of Annex C/H.223 shall be used, even if one channel is opened in AL1, AL2 or AL3.

C.6.3 Definition of the parameters for the control channel

After both terminals are running in the same level, the highest supported level is known for both terminals. For achieving a very error-robust control channel (logical channel 0), the control channel shall be defined according to the highest level (see Table C.2).

The CCSRL defined in this annex shall be used by all mobile levels to transport the control channel.

Table C.2/H.324 – Definition of the parameters of the control channel according to the level

Level	Definition of the parameters	Comments
0	The same as in 6.5.4	
1	The same as in 6.5.4, except that NSRP or LAPM/V.42 as defined in Annex A shall be used, and CCSRL defined in this annex shall be used	
2	The same as level 1	
3	The same as level 1	

This configuration shall not be changed during the entire session even if the levels for the other channels are changed to lower levels.

C.6.4 Definition of other parameters

The minimum size of the send buffer, B_s, for AL1M and AL3M shall be set to 4096 octets.

C.7 Dynamic change of level or option during session

The procedure described below for changing multiplex options during a session assumes that a capabilities exchange has taken place between a receiver (Terminal A) and a transmitter (Terminal B), and that an H.245 command for a level change will be sent by the receiver terminal to the transmitter terminal. A terminal, which has the capability to change H.223 multiplex levels or options during a session, shall set **modeChangeCapability** in **mobileOperationTransmitCapability** to True. Levels and options supported by the terminal are indicated using the codepoint in **mobileOperationTransmitCapability**.

A terminal, which has the above capability and has received the H.245 message with **modeChangeCapability** of **True,** may start the H.223 mode change procedure, illustrated in Figure C.1. Only levels supported by both terminals may be commanded. Note that the "**replacementFor**" procedure described in ITU-T Rec. H.245 may be used when changing from a mobile adaptation layer (ALXM) to a regular H.223 adaptation layer (ALX) or vice versa.

The recommended procedure for changing levels and level option between mobile terminals is the following:

1) The receiver side of terminal A sends the H.245 command **H223MultiplexReconfiguration.h223ModeChange** to the corresponding transmitter side in Terminal B indicating that a level change has to be made.
2) Soon after detecting this command, the transmitter side of terminal B shall:
   - stop transmitting MUX-PDUs with payload;
   - begin transmitting successive ones complemented synchronization flags of the current level. The number of ones complemented synchronization flags transmitted shall be at least 10. The maximum number of ones complemented synchronization flags transmitted should be equivalent to the number of synchronization flags possible to be sent in a period of 500 ms;
   - begin transmitting valid MUX-PDUs of the new level.
3) The receiver side of terminal A uses the transition between the last ones complemented synchronization flag of the series in Step 2 and the first regular (non-complemented) synchronization flag of the new level to synchronize to the multiplex of the new level.

If Terminal A does not receive the successive complemented synchronization flags within the value specified by T401 plus a margin, Terminal A should restart this procedure.

If Terminal B receives a command to change to a level option in which it already is, Terminal B shall take no action.

While servicing an option change command, Terminal B shall not initiate an option change procedure for the other direction.

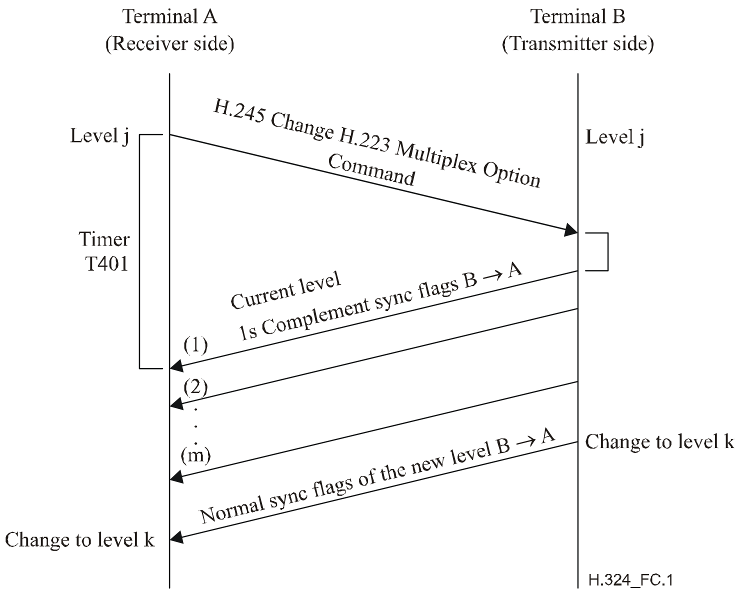

Figure C.1/H.324 – Level or option change procedure

Note that after changing from level 0 to some higher levels, MUX-PDU octet alignment shall be preserved. Therefore, the transmitter shall add as many "0" bits after the level change sequence to octet align the first synchronization flag of the new level. In the transmitter, the reference for the octet alignment is the first bit of the first transmitted synchronization flag. In the receiver, the reference for the octet alignment is the first bit of the first detected synchronization flag in the initial level set-up procedure.

C.8 Control channel definition for mobile terminals

Annex A defines the protocol stack for control channels for use with generic H.324 terminals. For mobile applications, however, a reliable link layer may not be available under certain high bit error rate channels. These high bit error rates make the successful transmission of large H.245 messages unlikely, in particular the Capability Exchange message. This problem is circumvented by defining a segmentation layer between the H.245 and NSRP or LAPM/V.42 layers (see Annex A), as illustrated in Figure C.2. This modified protocol stack shall be used for the Control Channel in terminals defined by this annex.

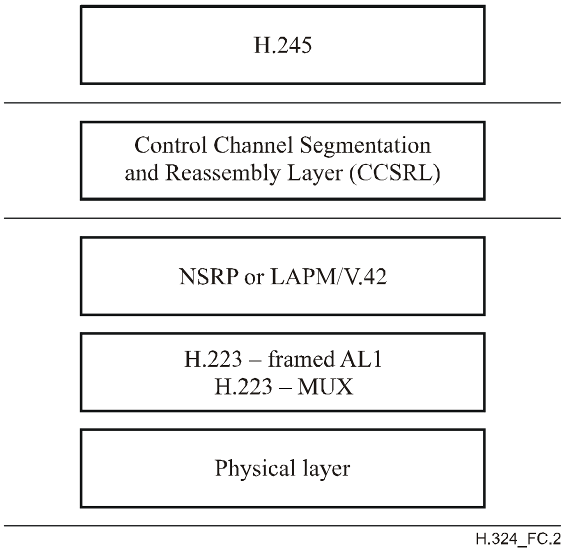

Figure C.2/H.324 – Protocol stack for H.324 control channel

C.8.1 Control Channel Segmentation and Reassembly Layer (CCSRL)

C.8.1.1 Framework of CCSRL

CCSRL is designed for segmenting **MultimediaSystemControlPDU** messages (CCSRL-SDUs) into one or more segments (CCSRL-PDUs). The CCSRL User shall always be ITU-T Rec. H.245.

C.8.1.2 Primitives exchanged between CCSRL and the CCSRL User

The information exchanged between CCSRL and the CCSRL User includes the following primitives:

- CCSRL-DATA.request (CCSRL-SDU).
- CCSRL-DATA.indication (CCSRL-SDU).

C.8.1.2.1 Description of primitives

- CCSRL-DATA.request: This primitive is issued by the CCSRL User to CCSRL to request the transfer of an CCSRL-SDU to a corresponding CCSRL User.
- CCSRL-DATA.indication: This primitive is issued to an CCSRL User by CCSRL to indicate the arrival of an CCSRL-SDU.

C.8.1.2.2 Description of parameters

- CCSRL-SDU: This parameter specifies the information exchanged between CCSRL and the CCSRL User. The length of the CCSRL-SDU may be variable. Each transmitted CCSRL-SDU shall contain an integral number of octets. The maximum size of CCSRL-SDUs that a CCSRL receiver can accept shall be 256 octets.

  NOTE – The maximum size of CCSRL-SDUs is 256 octets, even though the maximum H.245 **MultimediaSystemControlPDU** message length is 2048 octets according to A.2.1. This effectively limits the maximum **MultimediaSystemControlPDU** message length to 256 octets for "H.324/M" systems. This limitation is required for interworking with deployed "H.324/M" endpoints. Sending more than 256 octets in a single CCSRL-SDU is for further study.

- CCSRL-PDU: This parameter specifies the information exchanged between the CCSRL and the lower layer. The length of the CCSRL-PDU is variable.

C.8.1.3 Functions of CCSRL

CCSRL provides the function of segmenting an CCSRL-SDU containing one or more ASN.1 messages (encoded as defined in ITU-T Rec. X.691) into one or more CCSRL-SDU segments.

C.8.1.4 Format and coding of CCSRL

The format of the CCSRL-PDU is illustrated in Figure C.3.

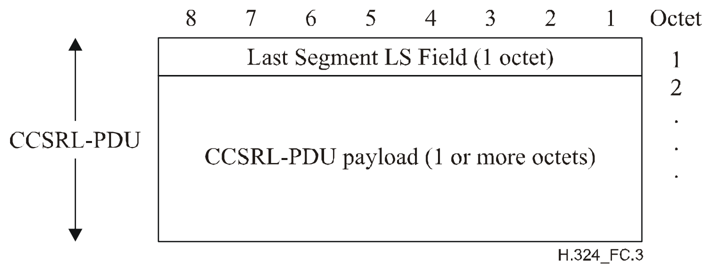

Figure C.3/H.324 – CCSRL-PDU format

C.8.1.4.1 Last Segment (LS) field

The 8-bit LS field indicates the last segment of an CCSRL-SDU. It shall be set to "1111 1111" on the CCSRL-PDU containing the last segment of an CCSRL-SDU. It shall be set to "0000 0000" otherwise. All other combinations for an LS field are invalid.

C.8.1.4.2 CCSRL-PDU payload field

The payload field of an CCSRL-PDU shall contain an CCSRL-SDU segment of at least one octet. The first octet of the CCSRL-PDU payload field shall be the first octet of the CCSRL-SDU segment.

C.8.1.5 Procedures for encoding

Information received from the CCSRL User in an CCSRL-SDU by means of an CCSRL-DATA.request primitive shall be passed to the layer below using the following procedure:

i) Break the CCSRL-SDU into an appropriate number of segments;

ii) for each CCSRL-SDU segment:

  a) set LS to "1111 1111" if this is the last segment of an CCSRL-SDU. Otherwise, set LS to "0000 0000";

  b) pass the generated CCSRL-PDU to the underlying layer.

C.8.1.6 Procedures for Error Control

An invalid CCSRL-PDU is one which:

- does not contain an integral number of octets; or
- is longer than the maximum CCSRL-PDU size; or
- is equal to 0 octets; or
- contains an invalid LS field.

CCSRL-PDUs which are invalid shall be discarded.

C.8.1.7 Interface to ITU-T Rec. H.245

Interface to ITU-T Rec. H.245 is defined by primitives defined in C.8.1.2.

C.8.1.8 Interface to NSRP or LAPM/V.42

Interface to NSRP or LAPM/V.42 are defined in C.8.2 and C.8.3 respectively as delivery of CCSRL-PDUs.

C.8.2 NSRP mode

The general description of the NSRP protocol given in A.2 shall be followed with the following exceptions: The terminal shall transmit frames generated by the segmentation layer defined above whereby complete H.245 **MultimediaSystemControlPDU** messages of A.2 are replaced by CCSRL frames. This is a generalization of the NSRP protocol concept, where a H.245 message no longer needs to be transmitted within a single NSRP frame, but can be transmitted in segments.

C.8.3 LAPM/V.42 mode

The description of the LAPM/V42 for H.324 terminals provided in A.3 is also applicable, with the exception that counter N401, maximum number of octets in an information field, may be set to a value smaller than 2048, but not shorter than the size of the frames generated by the CCSRL. Moreover, H.245 **MultimediaSystemControlPDU** messages are not necessarily transmitted within one single LAPM/V.42 frame but may be segmented and transmitted within CCSRL frames.

Annex D

Operation on ISDN circuits (H.324/I)

D.1 Scope

This annex defines an operation mode for this Recommendation on ISDN circuits at bit rates ranging from 56 kbit/s to 1920 kbit/s. This channel capacity may be provided as a single $B/H_0/H_{11}/H_{12}$-channel or multiple B/H_0-channels, according to the multilink procedures. Operation on restricted networks (at 56 kbit/s for each channel) is also covered.

The mode of operation defined by this annex is referred to as "H.324/I".

H.324/I terminals provide backwards compatibility with the installed base of H.320 terminals, and forward compatibility with H.324 Annex C terminals (Mobile), while providing direct interoperation with:

- H.324 terminals on the GSTN (using GSTN modems);
- H.324 terminals operating on ISDN through user substitution of I.400-series ISDN interfaces for V.34 modems; and
- voice telephones (both GSTN and ISDN).

H.324/I offers users and implementors many technical improvements incorporated in the second-generation standards H.310, H.323, and H.324, and corrects limitations and problems discovered with ITU-T Rec. H.320.

D.2 References

See clause 2 of the main body of the Recommendation.

D.3 Definitions

This annex defines the following term:

D.3.1 restricted channel: A channel carried on a network whose B-channels are effectively restricted to 56 kbit/s, or whose channels at H_0 or higher are restricted by ones-density considerations. This can be because the network inherently operates at 56 kbit/s, or because it provides a 64 kbit/s local interface, of which 7 out of each 8 bits are delivered to the far end.

D.4 Functional requirements

Except as noted below, all features and requirements of ITU-T Rec. H.324 apply to H.324/I terminals.

Additionally, H.324/I terminals shall comply with the following subclauses.

Procedures and requirements in this annex relating to G.711 audio (voice telephony, V.8, V.8 *bis*, modems) do not apply to H.324/I terminals connected to networks which do not provide octet or septet timing alignment, since transmission and reception of G.711 audio telephony is impossible without such alignment.

NOTE – Octet/septet timing is needed to use G.711 audio with ordinary telephones which do not support V.140 (for modem or speech). V.24 type interfaces and some restricted (56 kbit/s) digital networks do not provide octet timing, so only H.324/I and H.320 modes can be supported.

D.4.1 Modem interface

H.324/I terminals shall use a I.400-series ISDN user-network interface in place of the V.34 modem. All references to the "V.34 modem" in this Recommendation shall for H.324/I be replaced with "I.400-series ISDN user-network interface" (see Note). The output of the H.223 multiplex shall be applied directly to each bit of the digital channel, in the order defined by ITU-T Rec. H.223.

Within each octet or septet of the channel, any bit position determined by the V.140 Phase 2 procedure to be unusable shall be skipped and filled with 1s. Each octet or septet of digital channels using octet/septet timing shall be filled in the order starting with bit 1 (most significant bit of G.711 audio) and progressing toward bit 8 (least significant bit of G.711 audio).

V.8 or V.8 *bis* shall be used only when operating with far-end terminals determined to be on the GSTN by the procedures below.

NOTE – For leased line networks, the network interface is defined in ITU-T Rec. G.703 for bit rates in the range of 64 kbit/s to 2048 kbit/s. An alternative interface is defined in ITU-T Rec. X.21. For $n \times H_0$ channels, timeslot allocation is given in clause 5/G.704 for the G.703 interface. It is stressed that interworking towards ISDN requires synchronous operation of the leased line network.

D.4.2 H.320 ISDN interoperation

In order to provide continued compatibility for existing users of H.320 systems on ISDN, H.324/I terminals shall support operation in conformance with ITU-T Rec. H.320. If video transmission or reception is supported in the H.324 mode of the H.324/I terminal, video transmission or reception shall also be supported in the H.320 mode.

D.4.3 H.324 GSTN interoperation

H.324/I terminals shall support interoperation with H.324 terminals on GSTN (using V.34 modems) according to H.324.

H.324/I terminals shall send H.324 GSTN signals by the use of a "virtual modem", which generates and receives a V.34 analogue signal encoded as a G.711 audio bitstream over the ISDN. (Note that the functional equivalent to a "virtual modem" can also be provided by attaching an ordinary V.34 modem to the analogue output of an I.400-series ISDN terminal adapter.)

D.4.4 Voice telephone interoperation

H.324/I terminals shall support interoperation with voice telephones using G.711 speech coding as a speech or 3.1 kHz audio bearer service call. Other modes such as G.722 audio may optionally be supported as well.

Interconnection between the ISDN and GSTN networks for speech or 3.1 kHz audio bearer service is provided in the network, and does not affect terminals.

D.4.5 NSRP support for H.245 control channel

H.324/I terminals shall support the NSRP mode for the H.245 control channel, as defined in Annex A. This is in addition to support for the standard SRP mode which is required by Annex A. The LAPM/V.42 protocol stack may optionally be supported as well.

D.4.6 V.140 support

H.324/I terminals shall support ITU-T Rec. V.140.

Upon initial connection of each digital channel (on the lowest numbered time-slot of a multi-channel connection such as a H_0 channel), H.324/I terminals shall use the procedures of ITU-T Rec. V.140 to determine network end-to-end connectivity and to automatically negotiate a selected mode for the call among the H.324/I, H.320, H.324, and voice telephone modes (or any other modes which the terminal supports).

In this case, the H.324/I terminal should signal the "*Recommendations H.221 and H.242*" BC and LLC information elements as described in ITU-T Rec. Q.931, and shall not signal the "*Recommendations H.223 and H.245*" BC and LLC information elements.

D.4.6.1 Exceptional bypass of V.140

The V.140 procedures may be bypassed for a particular connection when all of the following conditions apply:

1) it is known from ISDN D-channel signalling that the far-end terminal is capable of supporting H.324/I; and
2) it is known that all channels of both terminals are connected to 64 kbit/s octet-aligned network interfaces; and
3) it is known (perhaps from analysis of the national telephone number of the far-end terminal) that the interconnecting network transfers all bits end-to-end between the two terminals, without possibility of bit misalignment or loss.

In this case, the H.324/I terminal shall signal the "*Recommendations H.223 and H.245*" BC and LLC information elements in ITU-T Rec. Q.931. If phase D of the H.324 call set-up procedure is not complete within 5 seconds of the establishment of the digital channel, the H.324/I terminal shall automatically disconnect the digital channel and automatically re-establish it using the normal V.140 procedures.

This V.140 bypass procedure can be used only for single-channel H.324/I calls.

D.4.7 terminalOnHold

The terminal shall revert to voice telephony mode when it receives a H.245 **EndSessionCommand** message which signals **terminalOnHold** in **isdnOptions**. G.711 speech coding shall be used. The encoder can choose the G.711 law for the outgoing audio. The decoder shall determine the proper G.711 law of the incoming audio, for example by using the procedures of Appendix I/G.725. G.711 law is allowed to be different in each direction. The terminal shall periodically send a V.140 signature as long as it is on hold.

D.5 Terminal procedures

The steps for provision of communication are as listed in clause 7 but with the following modifications.

D.5.1 Phase A – Call set-up of digital channel

In phase A, the calling terminal shall request the connection according to procedures for the digital network in use (I.400-Series ISDN D-channel signalling, etc.).

If the call is rejected by the network due to mismatch of ISDN Bearer Capability (BC) or High Level Capability (HLC) values, the terminal shall follow the procedures of ITU-T Rec. V.140 to re-try the call with different values.

Upon successful completion of call set up, the terminal shall initiate V.140 procedures, as described below.

D.5.1.1 Transmitted signals

While executing the V.140 Phase 1 procedure, the H.324/I terminal shall transmit in bits 1-6 of each octet and in the V.140 Compatible Protocol Field (CPF), signals conforming to:

- H.320 (send H.221 FAS and BAS signalling in CPF); and
- if V.8 *bis* is supported, V.8 *bis* (send initial V.8 *bis* messages in bits 1-6 of G.711 audio); or
- if V.8 *bis* is not supported, V.8 (send initial V.8 messages in bits 1-6 of G.711 audio).

These signals are sent in order that far-end terminals of these types (which do not support H.324/I or V.140) will initiate their negotiation.

Additionally, if the far-end terminal is known from ISDN D-channel signalling to be compatible with H.324/I, bits 1-6 of each octet should be set to 1 while executing this procedure. Otherwise, H.324/I terminals should send G.711 coded speech on bits 1-6 of each octet while executing this procedure, so that voice telephony is established immediately upon connection of the circuit, if the far-end terminal supports voice telephony.

D.5.1.2 Received signals

While executing the V.140 Phase 1 procedure, the H.324/I terminal shall search the received data for signals conforming to:

- V.140 signature;
- HDLC flags followed by an H.223 MUX_PDU on the digital channel or, if Annex C is supported, all possible stuffing sequences defined in Table C.1;
- H.320 (search for H.221 FAS and BAS signalling);
- If V.8 *bis* is supported, V.8 *bis* (search for initial V.8 *bis* messages in G.711 audio);
- V.8 (search for initial V.8 messages in G.711 audio).

Additionally, bits 1-6 of each octet may be decoded as audio according to ITU-T Rec. G.711 and delivered to the user while executing this procedure, so that voice telephony is established immediately upon connection of the circuit, if the far-end terminal supports voice telephony.

D.5.1.3 Procedure

Based on the received signal, the H.324/I terminal shall follow the algorithm below.

- If V.140 signature is detected, the H.324/I terminal shall proceed with V.140 and upon completion of those procedures, proceed to the mode negotiated. Otherwise:
- If H.324 signalling is detected on the digital channel, the terminal shall proceed to phase D. Otherwise:

- If V.8 *bis* or V.8 signalling is detected, the H.324/I terminal shall proceed with V.8 *bis* or V.8 and upon completion of those procedures, proceed to the mode negotiated. Otherwise:
- If signals corresponding to any other operation mode supported by the terminal (such as H.320 or other ISDN or PSTN protocols) are detected, the terminal may enter an operation mode appropriate to the detected signal. Otherwise:
- If none of the above signals are detected after a time sufficient to detect these signals if they were present, the terminal shall enter voice telephone mode.

The mode entered as a result of this negotiation should begin at the equivalent of phase B. For H.324 GSTN mode the terminal shall begin at phase B of this Recommendation according to 7.2. For H.320 mode, the terminal shall begin at phase B1 of ITU-T Rec. H.320. For H.324/I mode, the terminal shall proceed to phase B, below.

D.5.2 Phase B – Initial telephony communication

An optional phase B is voice telephony mode. In this mode users have the opportunity to speak before proceeding to multimedia telephony.

If the terminal is conditioned to go directly into multimedia communication mode, phase B shall be bypassed, proceeding directly to phase D. If the terminal is conditioned for initial telephony voice mode, the terminal shall proceed to phase D when:

- the user manually causes the terminal to initiate a V.140 Phase 3 transaction; or
- the terminal detects a V.140 phase 3 initiation signal from the distant terminal.

D.5.3 Phase C – Establishment of digital communication

There is no phase C, as the digital connection is already established. Terminals shall proceed directly to phase D.

D.5.4 Phases D through G

All remaining phases (D through G) shall proceed as specified in the body of this Recommendation, or, as defined in C.5 if Annex C is supported.

Annex E

Timer T401 initialization for operation over geostationary-satellite channels

E.1 Introduction

Two key aspects in transmission of multimedia communications through geostationary-satellite channels are the bit error rate and the transmission delay. The raw bit error rate can be as high as 10^{-2}, or even worse in fading conditions. However, channel encoding is used to give a typical channel BER of 10^{-5} or better. One-way transmission delay depends heavily on the connection used, as illustrated in Table E.1 for a typical mobile satellite system. These delay values are much larger than for typical cable GSTN lines (examples are given in Table A.1/G.114).

Table E.1/H.324 – Example of end-to-end delay values for communications via mobile geostationary-satellite channels

	Double-hop Worst case (ms)	Single-hop Typical case (ms)
Mobile geostationary-satellite channel		
Free space transmission delay	260 (Note)	260
Coding/processing delay	170	170
GSTN		
Second GSTN satellite hop	260	–
Rest of GSTN	100	100
Total	**790**	**530**
NOTE – As per Table A.1/G.114.		

E.2 Determination of timer value

Hence, careful determination of a suitable value for timer T401 is necessary for proper operation of a H.324 terminal over geostationary-satellite channels. The use of one of the two following procedures is required:

a) *Generic T401 value definition*

The use of an initial large value for timer T401, to ensure an appropriate throughput when geostationary communication satellite channels are used. For H.324 mobile terminals, the minimum initial value for timer T401 shall be in the range of 1600-2100 ms. This value should also be used for fixed H.324 terminals to support communication over geostationary-satellite channels. Tuning of the value of the timer T401 should be performed after the connection is established (see tuning procedure below), and the optimized value of the T401 timer may be larger or smaller than the initial value.

b) *T401 value definition with V.42 and NSRP protocols*

Timer T401 shall be initialized with an arbitrarily small value. The timer tuning procedure shall be used during phase D of the communication to define an optimized value for timer T401 (see tuning procedure below). This approach will work with the Numbered SRP (NSRP) protocol and the V.42 protocol, but it will not work when the SRP protocol is used while the actual round-trip delay is larger than the initial small value of T401.

Procedure a is more generic and more robust because it is applicable to existing as well as future H.324 terminals. However, procedure a may require larger buffers and in some cases may result in a longer start-up time. In H.324 connections where V.42 or NSRP are supported, the use of procedure b could be advantageous.

E.3 Timer tuning procedure

In either of the two procedures defined above, it is recommended that the value initially defined for timer T401 be tuned to a value close to but greater than the actual round-trip delay for a given connection. This should be performed to minimize the size of the buffers in the H.324 terminal, speed up error recovery, and increase overall throughput.

The H.245 round-trip delay estimation procedure may be used to tune the value of the timer T401. However, an implementor may explore other alternatives, such as:

- observing the system response time to receive the acknowledgement for the first SRP message sent;
- exploring modem training results available in some implementations of V-series modems.

It should be noted that the total buffer size allocated for data retransmission in the error control protocol must be compatible with the T401 value obtained from the tuning procedure. This is important, especially for procedure b in E.2, to avoid buffer overrun.

Annex F

Multilink operation

F.1 Scope

This annex defines the operation of H.324 over multiple independent physical connections, aggregated together according to ITU-T Rec. H.226 to provide a higher total bit rate. These connections may be GSTN circuits, or ISDN circuits as defined in Annex D. The use of both GSTN and ISDN connections in the same call is supported.

F.2 References

See clause 2 of the main body of the Recommendation.

F.3 Functional requirements

For use on GSTN connections, terminals compliant with this annex shall comply with H.324 and support V.8 *bis* operation.

For use on ISDN connections, terminals compliant with this annex shall comply with Annex D.

F.4 Overview

In summary, the establishment of a H.324 multilink call involves the following steps:

1) Initial channel physical connection is established.
2) V.8 *bis* or V.140 is executed, selecting *H.324-Multilink* as the mode for the call.
3) H.324 operation begins on the initial channel, using H.226.
4) H.245 is used to exchange information about available additional channels, including a 32-bit **callAssociationNumber** which will be used to identify the call.
5) An additional channel physical connection is established.

6) V.8 *bis* or V.140 is executed on the new channel, selecting *Multilink-Additional-Connection* as the mode; the initiator supplies the previously received **callAssociationNumber** to identify that the new channel is associated with the existing call.

7) The new channel is added to the H.226 Channel Set as part of the H.324 multilink call.

Figure F.2 illustrates these steps. Steps 5, 6 and 7 may proceed in parallel for any number of additional channels.

F.5 Procedures

F.5.1 Establishing multilink H.324 operation

F.5.1.1 Establishment of initial physical connection

The initial physical connection shall be established according to the procedures of H.324 (for GSTN circuits) or Annex D (for ISDN circuits), call set-up phases A and B.

F.5.1.2 Execution of V.8 *bis* or V.140 procedure on initial connection

Multilink operation shall be initiated via the capabilities exchange and mode selection procedures of ITU-T Rec. V.8 *bis* (according to Phase C of the H.324 call setup procedure) in the case of a GSTN initial physical connection, or ITU-T Rec. V.140 (according to Annex D) in the case of an ISDN initial physical connection.

Using the procedures of V.8 *bis* or V.140, as appropriate, if the *H.324-Multilink* capability is present at both terminals of a connection, the terminal performing the mode selection may choose *H.324-Multilink* as the selected mode of communication.

If *H.324-Multilink* is chosen as the selected mode, the procedures defined in this annex for H.324 multilink operation shall be used for all subsequent communications until the end of the communication session or until the procedures of V.8 *bis* or V.140, as appropriate, are re-established to negotiate into a different mode.

NOTE – Since V.8 *bis* is an integral part of establishing multilink operation for H.324, V.8 *bis* is required for this mode over GSTN, unlike basic H.324 which allows the use of V.8 instead.

F.5.1.3 Initiation of H.226 and H.324 operation

If *H.324-Multilink* is the selected mode of communication, once the procedures of V.8 *bis* or V.140 have been completed, all subsequent communication shall apply the procedures of H.226 to all data transmitted over the connection. Specifically, the H.324 bitstream that would otherwise be transmitted in ordinary H.324 (or Annex D) operation is instead used as the input to the H.226 Input Queue as defined by the Transmitter Model in ITU-T Rec. H.226. Similarly, received information shall pass through the H.226 receiver and the data stream produced by the Output Queue defined in the H.226 Receiver Model shall be used as input to the ordinary H.324 (or Annex D) receiver. The model of H.324 multilink operation is shown in Figure F.1. Prior to associating any additional physical connections, H.226 shall initially operate using a Channel Set size of one.

H.324 call set-up shall complete according to Phases D and E of the H.324 call set-up procedure, using the procedures of ITU-T Rec. H.226 to transport the H.223 bitstream.

It is possible that, upon establishment of the initial connection, the terminals may not yet know if any additional connections will later be established. If no additional connections are established, H.324 multilink operation shall continue to be used, as defined for a Channel Set size of one, throughout the H.324 communication session.

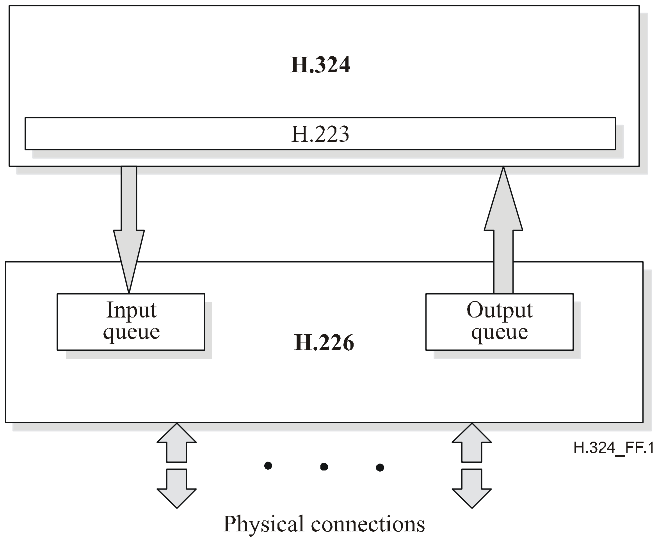

Figure F.1/H.324 – Model of H.324 multilink operation

F.5.2 Adding physical connections

The procedures for adding associated physical connections require one of the two terminals to be designated as the initiator and the other as the responder. If the initial physical connection is over GSTN, the terminal considered the *calling station* as defined in ITU-T Rec. V.8 *bis* shall be considered the initiator, and the *answering station* as defined in ITU-T Rec. V.8 *bis* shall be considered the responder. If the initial physical connection is over ISDN, the initiator and responder shall correspond to the *initiator* and *responder* as determined in Phase 3 of ITU-T Rec. V.140.

The procedures for establishing and associating additional connections may be used on multiple connections at the same time.

F.5.2.1 Exchanging call information

At any time after H.324 multilink operation is established, the initiator may begin the procedures to establish additional connections.

To request the information needed to establish and associate additional connections, the initiator shall send the H.245 **MultilinkRequest.callInformation** message to the responder. In this message, the initiator shall indicate the maximum number of additional connections that it is capable of establishing in the **maxNumberOfAdditionalConnections** parameter.

On receipt of a **MultilinkRequest.callInformation** message, the responder shall send the H.245 **MultilinkResponse.callInformation** message to the initiator. In this message, the responder shall include the **DiallingInformation** parameter, with contents as described below, as well as a **callAssociationNumber**. The **callAssociationNumber** shall contain a 32-bit random number (uniformly distributed). Any subsequent **callInformation** exchanges within the same H.324 session shall re-use the identical **callAssociationNumber**.

The **DiallingInformation** parameter should be used to provide explicit dialling information to allow the initiator to establish the additional connections. If this information is not available, it shall indicate the maximum number of additional connections available with no indication of how to dial those connections.

F.5.2.1.1 Differential automatic dialling information

If the responder chooses to provide dialling information for the additional connections, it may do so using the **differential** choice of the **DiallingInformation** parameter. In this case, the responder shall provide a list of **DiallingInformationNumber** parameters, one for each potential additional connection. The length of this list indicates implicitly the maximum number of additional connections available. For each potential additional connection, **DiallingInformationNumber** includes up to three subparameters that indicate the dialling information for this connection differentially relative to the corresponding information for the already established initial connection.

The **networkAddress** parameter shall include the least significant (rightmost) portion of the telephone number for this connection, up to and including the most significant digit that is different from the number for the initially established connection, and shall include no digits that are more significant than this. If the number for the additional connection is identical to that of the initial connection, the **networkAddress** parameter shall consist of a zero-length string (since there are no differing digits in the telephone number).

NOTE – The differential digit method is used instead of the full E.164 digit string because the first few digits of the number to be dialled can vary based on the geographic location of the two terminals; for example whether or not they are located in the same city.

If there is a subaddress used for dialling, and the subaddress of a given connection is different from that of the initial connection, the responder shall include the subaddress, in full, in the optional **subAddress** parameter.

The responder shall indicate the network types supported for the connection (GSTN, ISDN, or both) using the **networkType** parameter.

F.5.2.1.2 Automatic dialling information not available

If the responder chooses not to provide any dialling information (or if the dialling information is provided using an out-of-band mechanism), it shall indicate this using the **infoNotAvailable** setting of the **DiallingInformation** parameter. In this case, the responder shall indicate the maximum number of additional connections that are available.

NOTE – It is suggested that whenever possible, the responder should indicate the explicit dialling information to allow the initiator to automatically establish additional connections. This avoids the need for the user at the calling terminal to provide these numbers explicitly.

F.5.2.2 Establishing additional physical connections

The initiator of the initial physical connection may at any time establish additional physical connections to be used for multilink operation. It shall not establish additional connections that exceed the maximum number of additional connections indicated by the responder during the exchange of call information.

If the initiator chooses to establish additional connections, it shall do so using the following procedure.

In the case that the responder provided dialling information in a **DiallingInformation.differential** parameter, the initiator shall form the network address (telephone number) to be dialled by taking the network address used to dial the initially established connection, and replacing the least significant N digits with the contents of the **networkAddress** parameter. If this parameter has zero length, the network address used to dial the initial connection shall be used in full without modification.

For example, if the initial connection was established by dialling "0019786234349", and the **networkAddress** parameter contains "51", the number to be dialled for the additional connection is "0019786234351".

If the **subAddress** parameter is present, the contents of this parameter shall fully replace any subaddress used to establish the initial connection. Use of the **networkType** parameter by the initiator is a local matter, beyond the scope of this Recommendation.

In the case that the responder did not provide any dialling information (indicated by **infoNotAvailable**), the initiator may either choose not to add additional connections, or may attempt to determine the network address of the additional connections through other means (e.g., requesting from the local user or through an out-of-band communication mechanism). Any such means is beyond the scope of this Recommendation.

F.5.2.2.1 Responder request to add additional connections

At any time after exchange of call information according to F.5.2.1, the responder may request that the initiator add physical connections. This shall be done using the **MultilinkRequest.addConnection** message in H.245. The responder shall indicate the connections desired to be added using the **DiallingInformation** structure as described above. On receiving this message, the initiator shall respond with an **MultilinkResponse.addConnection** message indicating that it either intends to add the connections as requested, or that it does not intend to do so, along with the appropriate reason code.

NOTE – It is possible that the responder could be the terminal that establishes additional physical connections instead of the initiator. The procedures and exchange of information needed to facilitate this are for further study.

F.5.2.3 Associating additional physical connections

Upon establishment of a GSTN circuit, the procedures of ITU-T Rec. V.8 *bis* shall be executed, leading to establishment of a V-series modem data connection.

Upon establishment of an ISDN circuit, the procedures of ITU-T Rec. V.140 shall be executed.

F.5.2.3.1 V.8 *bis* or V.140 capability exchange

When an additional physical connection is established, the capability list in V.8 *bis* or V.140 shall include the *Multilink-Additional-Connection* capability.

If a terminal is only capable of establishing this connection such that it is associated with an already established session, it shall only indicate the *Multilink-Additional-Connection* capability and no others (it shall not indicate *H.324* or *H.324-Multilink* capability).

If a terminal is capable of allowing this connection to either be associated with an already established connection, or to be an independent connection, then other capabilities in addition to *Multilink-Additional-Connection* may be listed as well. The additional capabilities indicate *only* the capabilities for independent connections, therefore, the *H.324* or *H.324-Multilink* capability may or may not be included depending on whether the terminal can support a separate H.324 or H.324-Multilink session in addition to the existing H.324-Multilink session.

NOTE – The *Multilink-Additional-Connection* capability indicates the ability for the connection to be associated with an existing H.226 session. The *H.324* or *H.324-Multilink* capabilities indicate the ability for the connection to become a new H.324 or H.324-Multilink session.

F.5.2.3.2 V.8 *bis* or V.140 mode selection

To associate a connection with an existing H.324-Multilink session, the terminal that issues the V.8 *bis* or V.140 mode selection command shall indicate *Multilink-Additional-Connection* as the selected mode, and shall set the call association parameter to the value of the **callAssociationNumber** previously specified in the **MultilinkResponse.callInformation** message.

On reception of a *Multilink-Additional-Connection* mode selection command, the receiving terminal shall determine which existing H.324-Multilink session to associate the new connection with by comparing the call association number in the mode selection command with the **callAssociationNumber** corresponding to any existing sessions. If the terminal has no existing sessions with the corresponding **callAssociationNumber**, it shall reject the connection.

NOTE – Since V.8 *bis* is an integral part of establishing multilink operation for H.324, V.8 *bis* is required for this mode over GSTN, unlike basic H.324 which allows the use of V.8 instead.

F.5.3 Removing physical connections

F.5.3.1 Removing last remaining connection

Phases F and G of the H.324 call set-up procedures shall be followed to remove the last remaining physical connection at the end of a H.324 session. Note that the last remaining connection need not be the same as the initially established connection.

F.5.3.2 Removing additional connections

At any time, a terminal may remove additional physical connections. Note that the initially established connection may be removed just like any other connection. Removal of the last remaining connection (which may or may not be the same as the initially established connection) is described above.

If a connection is removed intentionally, the terminal initiating the removal shall remove this channel from the H.226 channel set prior to removal of the physical connection (allowing sufficient time for local data buffers for that channel to empty). Also prior to removal of the physical connection, it shall send the **MultilinkRequest.removeConnection** message in H.245 to the remote site. In this message it shall indicate which channel is to be removed. It shall wait until it either receives the **MultilinkResponse.removeConnection** message from the remote site indicating that the corresponding channel has stopped being used, or a locally specified time-out, and then it should remove the physical connection.

On receipt of a **MultilinkRequest.removeConnection** message, a terminal shall remove the indicated channel from its transmitted H.226 channel set (assuming that the indicated channel is bidirectional, and is in use by this terminal). In any case, it shall send the **MultilinkResponse.removeConnection** message in response to the remote site, indicating that this channel is no longer (or was never) in use.

Identification of the channel to be removed is done with respect to the channel numbering received via H.226 from the terminal to which the **MultilinkRequest.removeConnection** is being sent. The **connectionIdentifier** parameter in each message shall identify a channel by indicating a combination of **channelTag** and **sequenceNumber** corresponding to a recently received H.226 Header on the channel to be removed. If a Channel Tag was not specified at all in the Header, a value of zero shall be used for the **channelTag** parameter. In the **MultilinkResponse.removeConnection**, the **connectionIdentifier** shall be identical to the value in the corresponding **MultilinkRequest.removeConnection** message.

NOTE – Since the value of the Channel Tag is meaningful only with respect to a particular Header Set, the Sequence Number must be used in combination with the Channel Tag to uniquely specify the channel to be removed. The receiver of a **MultilinkRequest.removeConnection** must have the ability to determine from these two values, which channel the requester intends to be removed. To do this, it must have the ability to remember the correspondence between physical connections and Channel Tags for Header Sets that have already been sent. Maintaining the same value of Channel Tag for a given physical channel is a straightforward means of determining this correspondence without explicitly saving these values for all Header Sets.

If a connection is removed accidentally, each terminal should, as soon as possible, begin transmission of a new H.226 data set which no longer includes this connection in the channel set.

F.5.4 Negotiating the Maximum Header Interval

For use with this annex, the value of the H.226 Maximum Header Interval shall not be greater than 2 seconds, unless negotiated to another value as described below.

A terminal may send the **MultilinkRequest.maximumHeaderInterval** message in H.245. In this message, it may either indicate that it wishes to know the actual interval being used by the remote transmitter without altering it, or it may request a particular value to be used instead.

A terminal receiving a **MultilinkRequest.maximumHeaderInterval** message shall respond by sending a **MultilinkResponse.maximumHeaderInterval** message. If the corresponding request indicated a request for information about the current minimum rate, the terminal shall provide the value that its transmitter is currently using as the Maximum Header Interval in the response. If the corresponding request specified a particular minimum rate to use, the terminal should attempt to comply with this request by modifying the Maximum Header Interval used by its transmitter. Whether or not it makes a change to the Maximum Header Interval, the response shall indicate the new value that is in use (which may be different from the requested value).

NOTE – A receiver may use its knowledge of the Maximum Header Interval used by the remote transmitter to help ensure that data over a physical channel are continuing to be received successfully. By knowing the maximum interval between headers, long periods of time with no headers may indicate a malfunctioning channel. The ability to request a Maximum Header Interval also allows a terminal to bound the error propagation of data that it is receiving.

F.5.5 Using the optional data CRC

In ITU-T Rec. H.226, a transmitter may include an optional CRC on the data. This CRC may be used by a receiver to determine the quality of a given channel. A terminal may indicate its desire that the remote terminal send this CRC in all subsequent data sets by sending the H.245 **MultilinkIndication.crcDesired** message. The receiving terminal may optionally comply, there is no explicit acknowledgment or response required.

F.5.6 Using the excessive error indication

A terminal may indicate to the remote terminal that excessive errors are being received on a particular connection. The means for the terminal to determine the error rate or the criterion for determining what is excessive is defined locally at that terminal. It could, for example, result from receiving an excessive number of H.226 headers that contain errors, from the failure to receive H.226 headers at the minimum specified rate, or from an excessive rate of errors detected using the optional data CRC. In any case, the indication should be given with the expectation that the remote terminal will take some corrective action. This indication is made by sending the **MultilinkIndication.excessiveError** message in H.245 indicating which connection is causing problems. The connection is indicated using the **connectionIdentifier** parameter in the same manner as defined above for the **MultilinkRequest.removeConnection** message.

On receipt of this message, a terminal may choose to take corrective action. The particular corrective action that it should take is not specified. Examples include removing the connection from use or lowering the rate of the connection in hopes of reducing the error rate.

F.6 Maximum Transmit Skew

In using H.226 for H.324 multilink operation as defined in this annex, the value of the Maximum Transmit Skew shall equal 50 milliseconds.

F.7 Sequence diagram for establishment of multilink operation

Figure F.2 shows the sequence of events in establishing multilink operation. In the figure, solid lines represent exchanges over the initial connection, dotted lines represent exchanges over additional connection(s), and heavy solid lines represent exchanges over all connections.

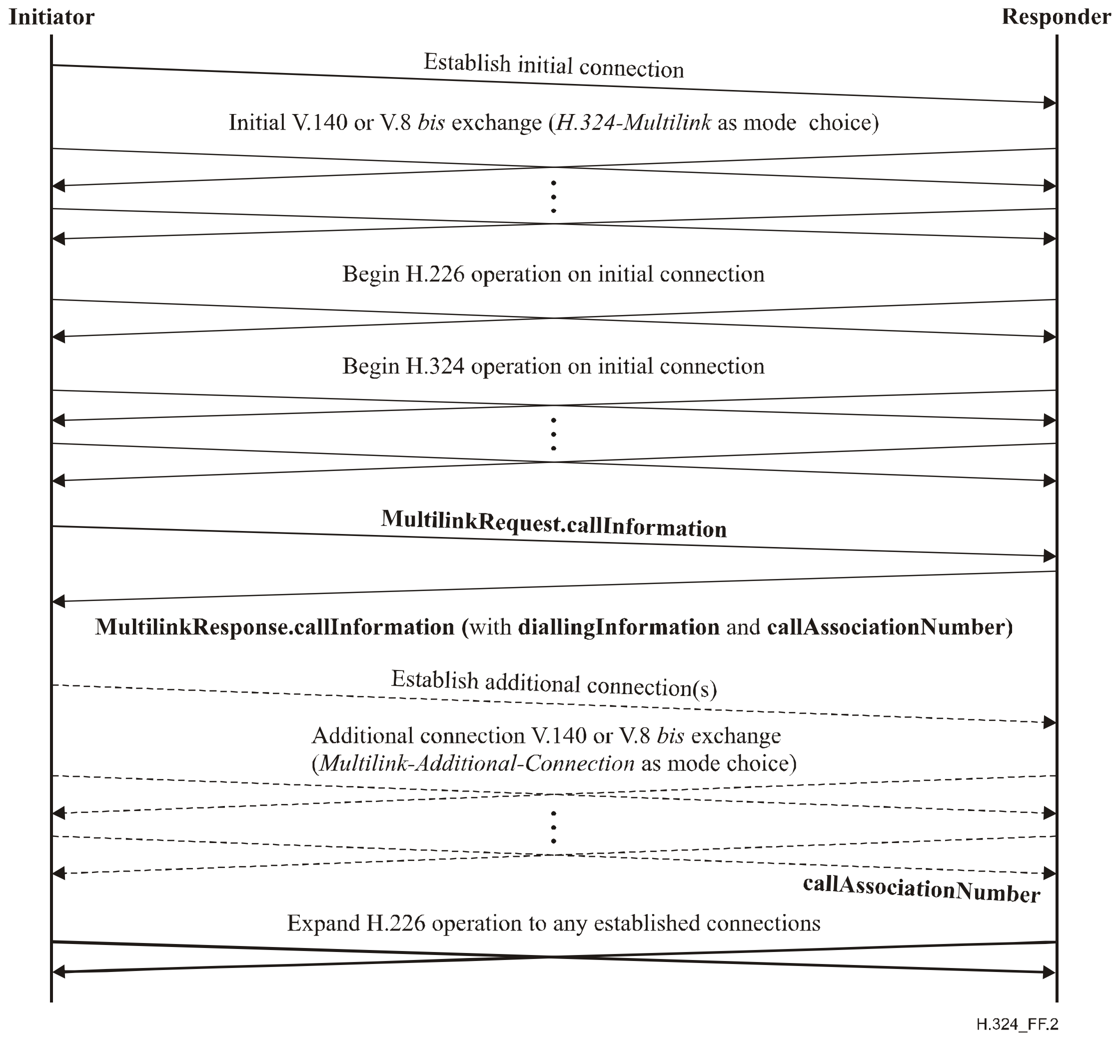

Figure F.2/H.324 – Sequence diagram for establishing multilink operation

Annex G

Usage of ISO/IEC 14496-1 generic capabilities in H.324 terminals

G.1 Scope

This annex defines the usage of ISO/IEC 14496-1 ("MPEG-4 Systems") generic capabilities in H.324 terminals and the framing and error protection of the corresponding data streams.

G.2 References

See clause 2 of the main body of the Recommendation.

G.3 General

The codepoint for ISO/IEC 14496-1 presented herein shall only be used for applications that want to make use of the object descriptor and scene description capability of ISO/IEC 14496-1. In this case, any type of ISO/IEC 14496 data stream to be used shall be indicated by means of the ISO/IEC 14496-1 generic capability during capability exchange as defined in ITU-T Rec. H.245.

Applications that only want to use ISO/IEC 14496-2 ("MPEG-4 Visual") and/or ISO/IEC 14496-3 ("MPEG-4 Audio") data streams, shall use the ISO/IEC 14496-2 generic capability and/or the ISO/IEC 14496-3 generic capability, respectively, as defined in ITU-T Rec. H.245 for a fast set-up.

NOTE – H.324 terminals using these ISO/IEC 14496 codepoints shall support the mandatory audio and video codecs as applicable.

G.4 Choice of error protection for ISO/IEC 14496 data streams

The error protection of the ISO/IEC 14496 data streams can be arbitrarily negotiated, requested and chosen by use of the "transport" field in the generic capability for ISO/IEC 14496-1. By usage of this field, an appropriate DataProtocolCapability shall be indicated.

G.5 Framing of ISO/IEC 14496-1 data streams

Each individual SL packet (as defined in ISO/IEC 14496-1) to be transmitted shall be mapped on exactly one H.223 AL-SDU as defined in ITU-T Rec. H.223.

Annex H

Mobile multilink operation

H.1 Scope

This annex defines the operation of H.324 over up to eight independent physical connections, aggregated together according to the mobile multilink layer defined in this annex to provide a higher total bit rate. These connections are error prone mobile channels as defined in Annex C all having the same transmission rate.

The difference between Annexes H and F is that Annex H is primarily intended to be used on error prone connections by not using HDLC framing and with less flexibility in terms of the number, the bit rate, and the delay differences of the channels involved in the aggregation than Annex F in order to work on mobile connections. Annex H is not intended to be a replacement of Annex F on connections with very low bit error rates.

H.2 Definitions and format conventions

H.2.1 Definition of terms

This annex defines the following terms:

H.2.1.1 header: A collection of parameters whose beginning is marked by one Flag.

H.2.1.2 sample: The smallest unit of data which is always kept contiguous when distributing data among multiple channels. The size of the Sample is an integer number of octets.

H.2.2 Format conventions

See 3.2/H.223.

H.3 Functional requirements

For use on mobile connections, terminals compliant with this annex shall comply with Annex C. The multilink operation is limited to channels having the same characteristics. In particular the channels to be aggregated shall have the same bit rate. Since the channels as defined in Annex C do not utilise V.8 *bis* or V.140, in-band signalling is defined in this annex for the purpose of setting up the mobile multilink, as well as the addition, and the removal of additional connections.

H.4 Overview

In summary, the establishment of a mobile multilink call involves the following steps:

1) Initial channel physical connection is established.
2) The mobile multilink is set up using the in-band joint multilink and multiplex set-up procedure.
3) H.324 operation begins on the initial connection.
4) H.245 is used to exchange information about available additional channels, including a 32-bit **callAssociationNumber**, which will be used to identify the call.
5) An additional physical connection is established.
6) In-band control frames are exchanged between the initiator and the responder to set up an additional connection to be associated with the mobile multilink. The initiator supplies the previously received **callAssociationNumber** to identify that the new connection is associated with the existing call.
7) The new connection is added to the mobile multilink layer as part of the H.324 mobile multilink call.

H.5 Mobile multilink layer specification

H.5.1 Overview

The mobile multilink is a layer between an H.223 multiplex and up to eight physical channels (Figure H.1). Its function is to aggregate the physical channels in order to provide a higher total bit rate for an Annex C. The transmission rate of each of the physical channels involved shall have the same value.

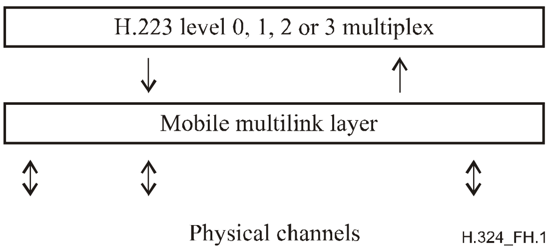

Figure H.1/H.324 – Overview of the mobile multilink layer

The input to the mobile multilink layer shall be a bitstream from an H.223 level 0, 1, 2, or 3 multiplex as defined in ITU-T Rec. H.223 and in Annexes A, B, C, and D of ITU-T Rec. H.223. The output from the multilink layer shall be distributed onto the physical channels.

In order to recover the multiplexed stream at the receiving side from one or more physical channels, a synchronization mechanism is needed. This is achieved by a framing format where header information is inserted at regular intervals into the physical channels.

H.5.2 Mobile multilink framing

Data to be sent over the physical channels shall be segmented into frames. A frame shall start with a 16-bit flag, followed by a 2 or 5-octet header after which the payload follows as shown in Figure H.2. The number of octets in the payload is signalled in the header.

Flag (2 octets)
Header (2 or 5 octets)
Payload (0 to SS*SPF octets)

NOTE – The SS and SPF parameters are defined in H.5.2.2.

Figure H.2/H.324 – Mobile multilink layer framing format

H.5.2.1 Flag

A mobile multilink frame shall begin with the 16-bit flag shown in Figure H.3 or its one's complement flag if the full header is used or the compressed header is used, respectively. If synchronization is lost on the receiving side a search for this flag should be performed to reacquire synchronization. Since this sequence of bits is not unique in the bitstream but can be emulated by data in the payload part of the framing format, a multilink receiver should also check that a valid header can be decoded before synchronization is accepted.

8	7	6	5	4	3	2	1	Octet
1	0	1	1	0	1	1	0	1
0	0	0	1	1	0	0	0	2

Figure H.3/H.324 – 16-bit flag pattern for the mobile multilink

NOTE – The flags defined in Annex A/H.223 are at a Hamming distance of 8 from this flag.

H.5.2.2 Header

Two types of headers are defined: full header and compressed header. The full header contains all information for initial operation, whereas the compressed header contains minimum information, which can be used after information frame synchronization has been acquired. The distinction between these headers is made by the polarity of flag field. The full header is preceded by flag field as shown in Figure H.3 and the compressed header is preceded by the one's complemented flag.

H.5.2.2.1 Full header configuration

The full header is shown in Figure H.4.

<table>
<tr><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>Octet</td></tr>
<tr><td>FT</td><td>L</td><td colspan="3">SN</td><td colspan="3">CT</td><td>1</td></tr>
<tr><td colspan="8">SS</td><td>2</td></tr>
<tr><td colspan="8">SPF</td><td>3</td></tr>
<tr><td colspan="8" rowspan="2">16-bit CRC field</td><td>4</td></tr>
<tr><td>5</td></tr>
</table>

Figure H.4/H.324 – Full header format

Two types of frames are defined, control frames and information frames, as indicated by the FT (frame type) bit. FT shall be set to "1" for control frames used for in-band signalling to add connections. FT shall be set to "0" for information frames carrying H.223 multiplexed data in the payload part.

The 3-bit sequence number (SN) field shall be incremented by one modulo 8 for each new information frame and shall have the same value for all channels in use.

The 3-bit channel tag (CT) field is a unique identifier for a channel in multilink session.

The L bit shall be set to "1" for the channel that is the highest numbered channel. For all other channels the L bit shall be set to "0".

The 8-bit sample size (SS) field indicates the size of a sample in octets (see H.5.4). The value 0 of SS is reserved for future use.

The 8-bit samples per frame (SPF) field indicates the length in samples of the payload (see H.5.4).

The product of SS and SPF gives the size of the payload in octets.

The last two octets of the header hold a 16-bit CRC field (see 7.4.3.2.3/H.223) as protection for the 3 octets following the flag.

H.5.2.2.2 Compressed header configuration

The compressed header is shown in Figure H.5.

8	7	6	5	4	3	2	1	Octet
X	L	SN			CT			1
8-bit CRC field								2

Figure H.5/H.324 – Compressed header format

The CT, SN and L fields are identical to those described in H.5.2.2.1.

The X bit is set to "0". The value "1" is reserved for future use.

The 8-bit CRC field (see 7.3.3.2.3/H.223) is used as protection for the octet following the one's complemented flag.

H.5.2.3 Control frames

To support in-band signalling for the handling of initial and additional connections to the multilink layer control frames are used.

Control frames use the full header format with the FT bit set to "1". There are three types of control frames defined as shown in Figure H.6.

Control Frame	Mux Level	Control Field						Payload
		L	FT	CT	SN	SS	SPF	
Initial	0	0	1	0	0	1	0	–
	1	0	1	0	1	1	0	–
	2	0	1	0	2	1	0	–
	3	0	1	0	3	1	0	–
Request additional	–	1	1	0	0	1	6	6-octet payload as described in H.6.2.3.1
Accept additional	–	1	1	0	0	1	0	–

Figure H.6/H.324 – Header and payload for control frames

initial control frames are used for setting up a multilink session between two terminals including multiplex level set-up. The SN field is set to the level of the multiplex, i.e., 0, 1, 2, or 3.

request additional control frames are used for requesting to add a physical connection to an already existing multilink session.

accept additional control frames are used for accepting the request to add a physical connection to an already existing multilink session.

The use of these control frames is described in H.6.

H.5.3 Stuffing frames

In the event that the mobile multilink layer has no information to send on a channel, such as when a channel is no longer part of the multilink session but has not been disconnected yet, a flag shown in Figure H.3, followed by 5 zero octets shall be sent as the stuffing sequence.

For connections that are part of a multilink session it is the responsibility of the H.223 multiplex to supply the multilink with the correct amount of data, taking into account the overhead for the multilink framing.

H.5.4 Information frames

Information frames use either the full header format with the FT bit set to "0" or the compressed header. For all channels in use the same type of header (full header or compressed header) shall be used.

Information frames are generated for each block of H.223 bit stream. The size of a block is (number of channels * SS * SPF) octets. A block is divided into samples of SS-octets. Then samples are put onto the payload part of information frames. The first sample shall be placed on the frame with the lowest CT value, the next sample on the next lowest numbered frame, and so on. After a sample has been placed on the highest numbered frame, the process shall be repeated using the lowest numbered frame until all samples in the block have been sent.

NOTE 1 – On channels having a burst characteristic it may be advantageous to choose a value for a sample larger than one octet. For instance a value that is related to the mean burst length may be a good choice.

NOTE 2 – All the information frames for this block have the same values of SS and SPF.

The L bit shall be set to "1" for the highest numbered channel and to "0" for the remaining channels.

The SN field shall be incremented by one modulo eight for each block of H.223 bit stream.

The CT value indicates the channel onto which the information frame is transmitted.

NOTE 3 – In the case that a header cannot be interpreted due to a CRC error, a receiver may assume that the header contained a CT value identical to a previously correct received header.

H.6 Procedures

H.6.1 Establishing mobile multilink operation

H.6.1.1 Establishment of initial connection

The procedure described in C.5 and C.6 shall be applied except for C.6.2, which is replaced by the H.6.1.2.

H.6.1.2 Joint multilink and multiplex set-up over the initial connection

After the establishment of the initial physical connection a terminal that intends to use the mobile multilink shall start transmitting control frames for *initial connection* (Figure H.6). This sequence of control frames jointly sets up both the mobile multilink layer and the H.223 multiplex level. The terminal shall set the SN field of the header to its highest supported multiplex level, which shall be 0, 1, 2, or 3.

If the terminal detects an Annex C stuffing sequence in place of mobile multilink control frames, it shall immediately start the Annex C set-up procedure according to C.6.2.

If the terminal detects control frames for *initial connection* with a multiplex level lower than its own transmitted level, it shall immediately change its value in the SN field according to the detected lower level.

When the terminal detects control frames with a multiplex level that is identical to its own transmitted level, multilink and multiplex set-up has been completed. The H.223 multiplex shall then start its operation using the multiplex level indicated in the SN field.

H.6.1.3 Initiation of mobile multilink operation

If the mobile multilink is set up, all subsequent communication shall apply the mobile multilink mode to all data transmitted over the connection. Specifically, the H.324 bitstream that would otherwise be transmitted in Annex C operation is instead used as the input to the mobile multilink. Similarly, received information shall pass through the mobile multilink receiver and the data output stream produced shall be used as input to the ordinary Annex C receiver.

It is possible that, upon establishment of the initial connection, the terminals may not yet know if any additional connections will later be established. If no additional connections are established, H.324 mobile multilink operation shall continue to be used, on the initial connection, throughout the H.324 communication session.

The initial connection shall be assigned a CT value of "0" initially until another connection is added to the session.

The H.245 **TerminalCapabilitySet** message shall include the **mobileMultilinkFrameCapability** in **H223Capability**.

H.6.2 Adding physical connections

The procedures for adding associated physical connections require one of the two terminals to be designated as the initiator and the other as the responder. The terminal that originates the first physical connection shall be the initiator, and the terminal that answers the first physical connection shall be the responder.

The procedures for establishing and associating additional connections may be performed on multiple connections at the same time.

When one or more channels are added to a multilink session, the transmitting entity of the multilink shall assign a channel tag from 0 to (N–1) to each of the channels before the next information frames are transmitted, where N is the number of connections in use.

H.6.2.1 Exchanging call information

See F.5.2.1 with multilink replaced with mobile multilink.

H.6.2.1.1 Differential automatic dialling information

See F.5.2.1.1

The responder may use the **networkType** of **mobile**.

H.6.2.1.2 Automatic dialling information not available

See F.5.2.1.2

H.6.2.2 Establishing additional physical connections

See F.5.2.2 with multilink replaced with mobile multilink.

H.6.2.2.1 Responder request to add additional connections

See F.5.2.2.1

H.6.2.3 Associating additional physical connections

Upon establishment of an additional physical connection, the exchange of control frames between the initiator and the responder will determine if the connection can be associated with an existing mobile multilink session or if the connection is an independent connection by using the following procedure.

H.6.2.3.1 Procedure for initiator

The initiator shall immediately start to send control frames for *request additional*. The payload for *request additional* control frames shall contain the **callAssociationNumber** that was determined in H.6.2.1 and a 16-bit CRC field, see Figure H.7.

	Octet
CallAssociationNumber field	1 2 3 4
CRC field (see 7.4.3.2.3/H.223)	5 6

Figure H.7/H.324 – Payload for *request additional* control frames

If it detects control frames for *accept additional*, it shall add this connection to the existing session that has the same **callAssociationNumber**. If it cannot detect a control frame for *accept additional* until the appropriate timer expires, it shall disconnect this additional connection.

H.6.2.3.2 Procedure for responder

H.6.2.3.2.1 Responder capable of an independent session

If the responder allows another independent session of either mobile multilink or Annex C, it shall immediately start to send control frames for *initial connection* with its highest supported multiplex level.

If it detects a control frame for *request additional* that has the same **callAssociationNumber** as that of an existing session, it shall immediately start to send multiple control frames for *accept additional*, and shall add this connection to the session. The number of control frames sent should be sufficient for the receiver to detect taking into account the mobile channel condition.

If it detects a control frame for *initial connection*, it shall start a new session according to the procedure in H.6.1. If it detects a stuffing sequence for Annex C, it shall start the Annex C set-up procedure according to C.6.

H.6.2.3.2.2 Responder not capable of an independent session

If the responder is not capable of another independent session, it shall immediately start to send control frames for *accept additional*.

If it detects control frames for *request additional* that has the same **callAssociationNumber** as that of an existing session, it shall add this connection to the session. If it detects control frames for *initial connection* or stuffing sequence for Annex C, it shall disconnect this additional connection.

H.6.3 Removing physical connections

H.6.3.1 Removing last remaining connection

Phase F and G in C.5 shall be followed to remove the last remaining physical connection at the end of an H.324 session.

H.6.3.2 Removing additional connections

See F.5.3.2 with references to H.226, H.226 channel set, H.226 Header, and H.226 data set replaced by the mobile multilink, mobile multilink connections, mobile multilink header, and mobile multilink frames, respectively except for the procedure when a connection is removed accidentally. If a connection is removed accidentally, each terminal shall assign a channel tag to each of the remaining channels before the next information frames are transmitted.

When one or more channels are removed from a multilink session, the transmitting entity of the multilink shall assign a channel tag from 0 to (N–1) to each of the channels, where N is the number of connections in use.

H.7 Header modes

Mobile multilink operation has two modes for information frame transmission: full header mode and compressed header mode. This clause defines these modes and the mode transition procedures.

H.7.1 Full header mode

In full header mode, the full header defined in Figure H.4 is used for information frames on all channels. In this mode, the transmitter may change the value of SS and SPF in the information frame header, but the transmitter shall send the **MobileMultilinkReconfigurationIndication** message to the receiver before changing the values.

Mobile multilink starts with this mode, and the initial value of SS shall be set to "1", and that of SPF shall be set to "255".

H.7.2 Compressed header mode

In compressed header mode, the compressed header defined in Figure H.5 is used for information frames on all channels. In this mode, the transmitter shall use the same SS and SPF values with those used for the last information frames in full header mode.

H.7.3 Mode Transition (from full header to compressed header)

When the receiver has synchronized the frame timing of the information frames in full header mode, the receiver shall send the **MobileMultilinkReconfigurationCommand** with the detected SS and SPF values and the status of **synchronized**. On the receipt of this command, the transmitter shall assess the SS and SPF values in the command message. If these values are the same as the values in use, then the transmitter shall change the mode from full header mode to compressed header mode. Otherwise, the transmitter shall continue the operation in full header mode.

H.7.4 Transition from compressed header mode to full header mode

If the receiver finds that better SS and SPF values for the current channel conditions (e.g., bit error rate or burst error characteristics), the receiver may request to change these values by sending **MobileMultilinkReconfigurationCommand** with the detected SS and SPF values and the status of **reconfiguration**. On the receipt of this command, the transmitter shall move to the full header mode. The receiver should use the values for SS and SPF in the command message, but the actual value used for the information frames is up to the transmitter.

Annex I

Usage of HTTP Generic Capability in H.324 terminals

I.1 General

This annex defines the usage of HTTP (Hypertext Transfer Protocol) [36] Capability in H.324 terminals. HTTP is an application-level protocol for distributed, collaborative, hypermedia information systems, and its technical specifications are provided in IETF RFC 2616. The capability presented in this annex is used for applications that want to make use of HTTP capabilities in H.324 terminals.

The purpose of using a HTTP channel associated with an H.324 call is to permit the HTTP client (e.g., Web browser) to remotely operate a far-end H.324 endpoint (in which the HTTP server is implemented). This is especially useful in cases where the far-end H.324 endpoint is an automatic device.

For example, by selecting items on a Web page, the human user could cause the far-end system to switch input video or audio sources, or control far-end audio pickup. In another example, the human user could choose via a Web page to view one of a set of stored audiovisual streams, which might contain entertainment or educational material.

Figure I.1 illustrates such an example. In this example, an H.324 Annex I terminal (on the left) receives audiovisual content from a Content server where H.324 Annex I is implemented. The logical channel for HTTP transactions, which is used to select the audiovisual content to be sent, is opened using H.245 logical channel signalling. Separate logical channels for delivery of audio and video data may be opened using H.245 logical channel signalling, if necessary.

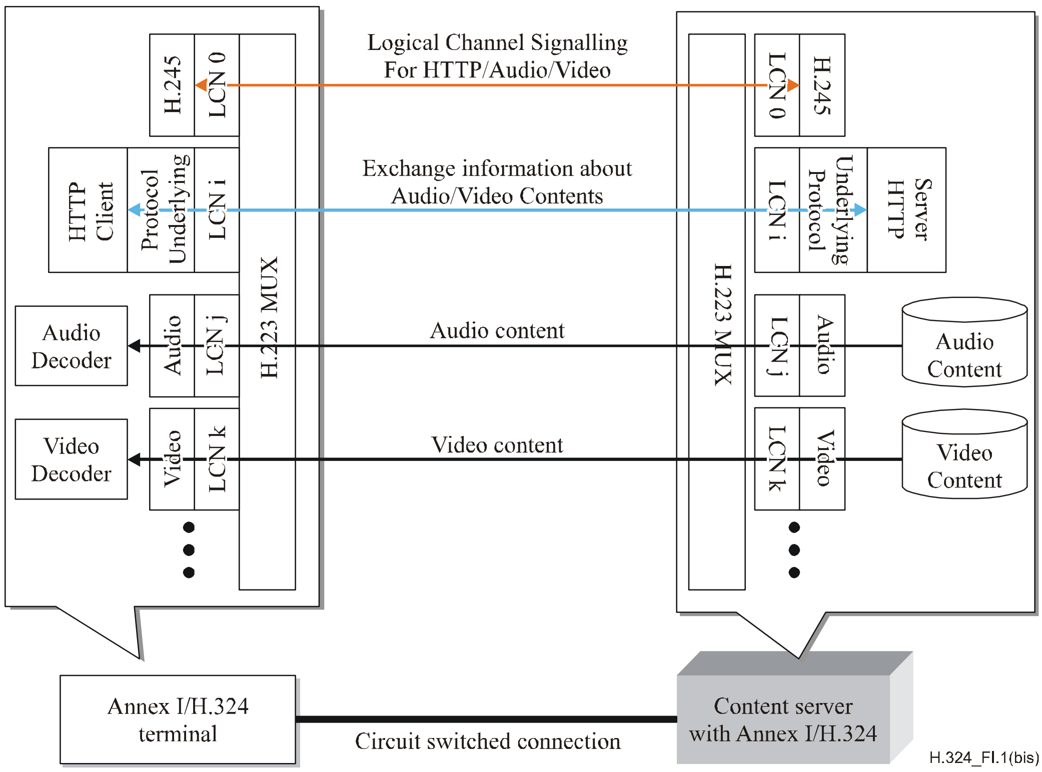

Figure I.1/H.324 – An application using Annex I/H.324

I.2 Logical channel for HTTP

The terminals which intend to use the HTTP capability shall open bidirectional logical channels for HTTP messages encapsulated by the underlying protocol specified in Table I.3.

The error protection for these logical channels may be arbitrarily negotiated, requested and chosen by use of the "transport" field in the Generic Capability.

I.3 HTTP Generic Capability

Table I.1 defines the capability identifier for HTTP Generic Capability. Tables I.2 and I.3 define the associated capability parameters.

Table I.1/H.324 – Capability identifier for HTTP capability

Capability name	HTTP
Capability class:	Data application
Capability identifier type:	Standard
Capability identifier value:	itu-t (0) recommendation (0) h (8) 324 generic-capabilities (1) 0
maxBitRate:	This field shall be included.
nonCollapsingRaw:	This field shall not be included.
transport:	This field shall be included.

Table I.2/H.324 – Mode for HTTP capability

Parameter name	mode
Parameter description:	This is a nonCollapsing GenericParameter. mode indicates the operating mode of the terminal: 1: Server 2: Client 3: Server & Client (this mode may be used in Capability exchange, but shall not be set in Logical Channel Signalling)
Parameter identifier value:	0
Parameter Status:	Mandatory
Parameter type:	UnsignedMin
Supersedes:	–

Table I.3/H.324 – Underlying protocol for HTTP capability

Parameter name	underlyingProtocol
Parameter description:	This is a nonCollapsing GenericParameter. underlyingProtocol indicates the protocol under HTTP: 0: None 1: TCP/IP/PPP
Parameter identifier value:	1
Parameter Status:	Mandatory
Parameter type:	UnsignedMin
Supersedes:	–

I.4 References

See clause 2 of the main body of the Recommendation.

Annex J

ASN.1 OIDs defined in this Recommendation

This annex summarizes the OIDs defined in this Recommendation H.324 and defines H.324 generic capabilities which are used in H.245 signalling-based systems.

J.1 Summary of OIDs defined in this Recommendation

Table J.1/H.324 – Summary of OIDs defined in this Recommendation

OID	Clause reference
{ itu-t(0) recommendation(0) h(8) 324 generic-capabilities(1) SessionResetCapability(1) }	7.7.1

J.2 Session reset capability identifier

Table J.2/H.324 – SessionResetCapability capability identifier

Capability name	SessionResetCapability
Capability identifier type	Standard
Capability identifier value	{ itu-t(0) recommendation(0) h(8) 324 generic-capabilities(1) SessionResetCapability(1) }
maxBitRate	This parameter is not used.
Collapsing	This field shall not be used and shall be ignored by receivers.
nonCollapsing	This field shall not be used and shall be ignored by receivers.
nonCollapsingRaw	This field shall not be used and shall be ignored by receivers.
Transport	This field shall not be used and shall be ignored by receivers.

Appendix I

Bit and octet order

This appendix is supplied as a summary of bit and octet order in this Recommendation, including ITU-T Recs H.223, H.261, H.263, H.245 and G.723.1. In case of any discrepancy, the normative text of the various Recommendations shall take precedence over this appendix.

ITU-T Recs H.261, H.263, G.723.1 and H.245 each produce a sequence of bits which are delivered as octets to the H.223 multiplex. Within this sequence of bits there are fields of various lengths, in some cases aligned with octet boundaries. In the case of ITU-T Recs H.261, H.263, G.723.1 and H.245, these fields are ordered Most-Significant-Bit (MSB) first. Figure I.1 illustrates this, with "M" indicating the MSB of each field and "L" indicating the least-significant-bit (LSB) of each field.

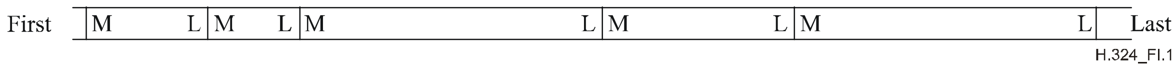

Figure I.1/H.324 – Output from ITU-T Recs H.261/H.263/G.723.1/H.245

Upon delivery to the H.223 multiplex, this bit sequence is split into octets, each with a defined MSB/LSB position, as shown in Figure I.2.

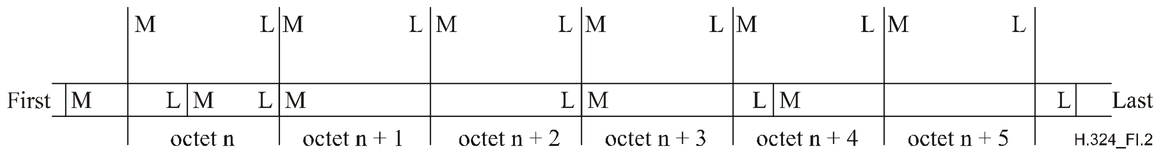

Figure I.2/H.324 – Output split into octets

The H.223 multiplex then transmits each of these octets in the order LSB first (the reverse of the original order), applying the transparency procedure (inserting a '0' after each sequence of five '1's) as it does so.

For example, a sequence of six octets, with hexadecimal values 0x92, 0xF1, 0x39, 0x35, 0x31, 0x30 would be transmitted as shown in Figure I.3.

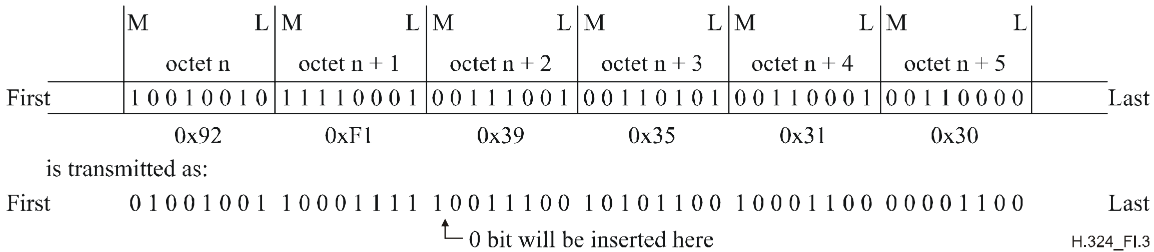

Figure I.3/H.324 – Example sequence

Appendix II

V.8 *bis* codepoints

V.8 *bis* capability exchange may be used during call set-up to help terminals quickly decide, in the most common cases, if operation in H.324 mode is desired. V.8 *bis* capabilities indicate only the most basic and commonly used modes, and are not a substitute for H.245 procedures. If an H.324 operation mode not signalled by V.8 *bis* is desired, the terminal must complete call establishment and perform a H.245 capabilities exchange to determine if the far-end terminal supports the desired mode.

Within the V.8 *bis* Communications Capabilities (CC) field for this Recommendation, the CC field is formatted into one or more subfields. Each subfield ends with the octet in which bit [n] is set to 1. Following the first subfield, the remaining subfields, if present, shall appear in the same order in which the bits indicating their presence are transmitted.

NOTE 1 – Implementors should refer directly to ITU-T Rec. V.8 *bis* for the actual bit assignments.

In the first subfield, the following bits are allocated:

Name	*Meaning*
Video	Shall be set only if bidirectional video is supported per 6.6.
Audio	Shall be set only if bidirectional audio is supported per 6.7.
Encryption	Shall be set only if encryption is supported per 9.2.
Data	Indicates that a data subfield is present. Shall be set only if one or more bits in the data subfield are set.

NOTE 2 – Possible future allocations include Profiles (new subfield).

In the Data subfield, the following bits are allocated:

Name	*Meaning*
T.120	Shall be set only if T.120 conferencing is supported per 6.8.2.1.
T.84	Shall be set only if T.84 still image transfer is supported per 6.8.2.2.
T.434	Shall be set only if T.434 file transfer is supported per 6.8.2.3.
V.42	Shall be set only if V.42 user data is supported per 6.8.1.2/6.8.2.6.
V.14	Shall be set only if V.14 user data is supported per 6.8.1.1/6.8.2.6.
PPP	Shall be set only if IETF Point-to-Point protocol is supported via the Network Layer Protocol Identifier (NLPID) per 6.8.2.5.
T.140	Shall be set only if T.140 Text Conversation Protocol for Multimedia Application is supported per 6.8.2.8.

NOTE 3 – Other modes beside those indicated in ITU-T Rec. V.8 *bis*, such as unidirectional modes, may be supported by terminals as signalled via H.245 capabilities exchange.

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