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TRANSMISSION OF NON-TELEPHONE SIGNALS

SYNCHRONIZED AGGREGATION OF MULTIPLE 64 OR 56 kbit/s CHANNELS

ITU-T Recommendation H.244

(Previously “CCITT Recommendation”)

FOREWORD

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The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, March 1-12, 1993).

ITU-T Recommendation H.244 was prepared by ITU-T Study Group 15 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 10th of July 1995.

NOTE

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

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Recommendation H.244

SYNCHRONIZED AGGREGATION OF MULTIPLE 64 OR 56 kbit/s CHANNELS

(Geneva, 1995)

1 Scope

This Recommendation provides for synchronisation and aggregation of multiple channels of 64 kbit/s or 56 kbit/s, each being with or without octet integrity and relative transmission delay in the range ± 1 second. It is applicable to a wide range of user data transport up to 63 channels using ISO/IEC standard 13871, but special provision is made for audiovisual systems according to Recommendation H.221 [1], up to 24 channels; the aggregation may be network-based or associated with Customer-Premises Equipment. The available operating modes (B1, B2, B3, H2) provide options with/without transmission-management overhead and user-data rates at/less-than the exact multiples of 64/56 kbit/s.

The number of aggregated channels may be varied dynamically during a session. Procedures are given for dealing with faults, including loss of channels and slip.

Call control is not covered in this Recommendation.

2 Normative references

The following 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; all 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.

[1] ITU Recommendation H.221 (1993), *Frame structure for a 64 to 1920 kbit/s channel in audiovisual teleservices.*

[2] ITU Recommendation H.242 (1993), *System for establishing communication between audiovisual terminals using digital channels up to 2 Mbit/s.*

[3] ITU Recommendation H.320 (1993), *Narrow-band visual telephone systems and terminal equipment.*

[4] ISO/IEC CD 13871, *Digital Channel Aggregation.*

[5] ITU Recommendation H.230 (1995), *Frame-synchronous control and indication signals for audiovisual systems.*

3 Definitions and symbols

3.1 Definitions

For the purposes of this Recommendation, the following definitions apply:

3.1.1 H.244 aggregation: Channel aggregation by the process described in clauses 7 and 8.

3.1.2 ISO aggregation: Channel aggregation by the process described in [4].

3.1.3 single channel equipment (SCE): A terminal or other unit (such as a LAN interface) having an interface for a single bidirectional digital connection.

3.1.4 multiple channel equipment (MCE): A terminal or other unit (such as a LAN interface) having interface(s) for multiple bidirectional digital connections at 64 kbit/s each.

3.1.5 channel aggregation unit (CAU): A device having both multiple 64 kbit/s accesses and a single access at a higher bit rate. Reference in this Recommendation to "CAU" or "aggregator" shall mean equipment conforming to this Recommendation.

3.1.6 H.221 frame structure, H.221 framing: Frame structure according to Recommendation H.221, as set out in [1].

3.1.7 Capset: Abbreviation for "Capability set" – see [2].

3.1.8 user information: The application data streams passing (in both directions) between CAU and SCE. (See Note 1.)

3.1.9 calling end: The CAU or MCE which requests the first 64/56-channel connection of the whole session, resulting in the establishment of the "initial channel". If during fault-recovery procedures the intial channel is transferred to another connection, this does not affect the definition. (See Note 2.)

3.1.10 called end: The CAU or MCE which accepts the first 64/56-channel connection request of the whole session, resulting in the establishment of the "initial channel". If during fault-recovery procedures the intial channel is transferred to another connection, this does not affect the definition. (See Note 2.)

3.1.11 TAC case: In-band communication between SCE and CAU takes place using H.221 BAS codes – see clauses 7-8.

3.1.12 NoTAC case: No in-band management communication between SCE and CAU takes place – the single channel is only a clear path for the data which will be wholly transmitted to the remote party; any communication between the terminal and the CAU is by means not specified in this Recommendation.

3.1.13 modes B1, B2, B3: Modes of aggregation by the method of [4] – see 5.2.

3.1.14 mode H2: Modes of aggregation by the method of clauses 7-8.

3.1.15 redundant command: A BAS command which repeats, unchanged, a previously transmitted mode value which is still in force.

3.1.16 compatibility bits: Bit 8 of the first sixteen octets in every time-slot of a single channel except Time-slot 1.

3.1.17 external setting: This term is used to express operations outside the scope of this Recommendation which determine the behaviour of a CAU as to choice of option or timing of its action.

NOTES

1 In the audiovisual cases, the application data stream includes the H.221 frame structure.

2 The significance of "calling" and "called" end-points is mentioned in 8.1.3.

3.2 Symbols

NOTE – For readability, the capability and command values listed in References [1] and [5] are referred to in this Recommendation by their names rather than codepoint byte values; the use of {*name*} for capabilities and [*name*] for commands serves to distinguish between these.

N An integer, applied to 64/56-channels to define a parallel (un-aggregated) bitstream of rate $N \times 64$ kbit/s.

n An integer, applied to 64 kbit/s to define a serial (or otherwise aggregated) bitstream of rate n*64 kbit/s.

N_a The number of active 64/56-channels between CAU and MCE or between two CAUs.

N_m The maximum number of 64/56-channels which can be accepted by a CAU transmitting the value $\{N_m \times B\}$.

N'_m Used to denote the incoming value of N_m from the remote CAU, or equivalent from an MCE.

N_d The number of connections requested by the calling end, the lower of N_m and N'_m.

{N × 64k} Capabilities in the series {1B}, {2B}, {3B}.... corresponding to N = 1, 2, 3 ... (applies to Mode H2 only).

{n*64k} Capabilities in the series {64k}, {128k}, {192k}.... corresponding to n = 1, 2, 3.....

n_m Such that {nm*64k} is the highest transfer-rate capability incoming from the SCE for which the continuous series of rate capabilities {(n_m – 1)*64k}, {(n_m – 2)*64k},.....{2*64k} is also present in the capset.

[N × 64] Multiple-channel commands defined in [1].

[n*64k] Single-channel commands defined in [1].

[capex] Command issued by a CAU (see 7.3.6.3) to an SCE to stimulate a capability exchange.

[AggIN]* A double SBE symbol indicating the number **n** as determined by the process of 7.3.4.2; see the procedure described in clause 8 – see [5].

{null} Capability having no significance other than as a filler; only ever transmitted by a CAU, and therefore it identifies the capset as having last come from, or been forwarded by, a CAU; SCE must ignore any number of these in an incoming capset – see [1].

{SM-comp} Capability to transmit and receive user information without using any compatibility bits, setting these to 1 – see [1].

[SM-comp] User information is not contained in the compatibility bits (and shall not be sent in the compatibility bits in the reverse direction either) – see [1].

S Audible signal (to be defined), which would be recognised by a human user as a call progress tone (he would not hang up).

4 Abbreviations

For the purposes of the Recommendation, the following abbreviations are used:

BAS	Bit-rate Allocation Signal – see [1]
CAU	Channel Aggregation Unit
FAS	Frame Alignment Signal – see [1]
H.221	See 3.1
MC (side)	Multiple Channel (side, of a CAU)
MCE	Multiple-Channel Equipment
NCA, NIA, NIC, NID, NIS	See [5]
NoTAC	No Terminal-Aggregator Communication
SC (side)	Single Channel (side, of a CAU)
SCE	Single-Channel Equipment
SM-comp	Single-Multiple compatibility
TAC	Terminal-Aggregator Communication
UD	Unspecified Data

5 General

5.1 Application of this Recommendation

On the single-channel connections, which may be very short if the terminal and CAU are colocated, or much longer if a telecommunications link is involved, two options are provided for in this Recommendation:

- no in-band management communication on the single channel, this being only a clear path for the data which will be wholly transmitted to the remote party; any communication between the terminal and the CAU is by means not specified in this Recommendation; this is referred to as the "NoTAC" case – No Terminal-Aggregator Communication and applies when "ISO aggregation" is used (see [4]);

- in-band communication as specified in this Recommendation, using the BAS codes defined in [1] and the procedures of [2]; this is referred to as the "TAC" case – Terminal-Aggregator Communication, and applies when "H.244 aggregation" is used (see clauses 7 and 8).

5.1.1 Intercommunication of Audiovisual equipments

For audiovisual terminals conforming to [1] and [2], this Recommendation provides for synchronisation and aggregation of up to 24 channels of 64 kbit/s or 56 kbit/s, each being with or without octet integrity and relative transmission delay in the range ± 1 second.

Provision is made for the following intercommunication Cases A-C.

5.1.1.1 Case A

For interconnection of a single-channel (SCE) and a multiple-channel audiovisual end-point (MCE), both conforming to [1] and [2], only H.244 aggregation is permissible (see Figure 1); this involves only one CAU, which may be within the network or close to the single-channel end-point.

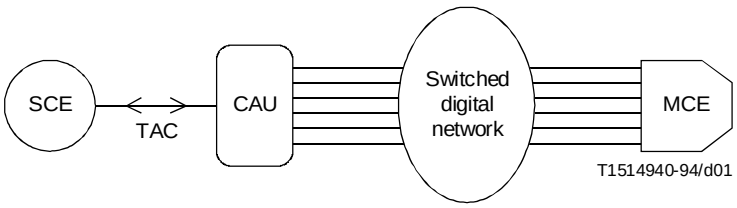


FIGURE 1/H.244

5.1.1.2 Case B

This case provides for interconnection between two single-channel audiovisual end-points which see the aggregated link purely as a clear data channel; each has a CAU associated with it, but there is no in-band control communication between the end-point and its associated CAU (see Figure 2); this is the NoTAC approach. The system is exactly the same as for unspecified data applications (see 5.1.2); the CAU-ISDN-CAU combination provides a clear channel at one of the transfer rates specified in [1], and therefore shall use ISO aggregation, Mode B1 or B3 (see 5.2).

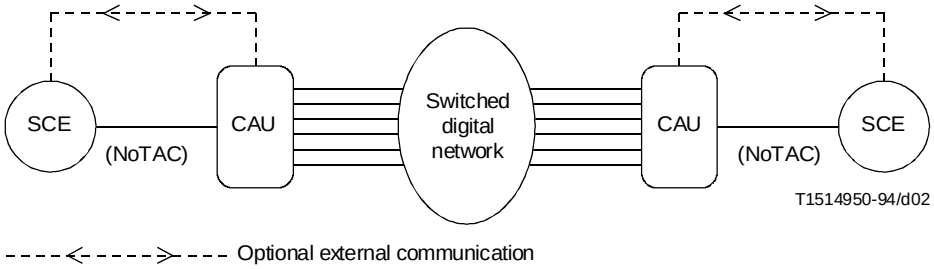


FIGURE 2/H.244

5.1.1.3 Case C

This provides for interconnection of two single-channel end-points both conforming to [1] and [2] and capable of the H.244 agregation operation described in clauses 7-8 (see Figure 3); this involves two CAUs, which may be within the network or close to the single-channel end-points.

NOTE – It is not possible to use TAC at one end and NoTAC at the other – see clause 6.

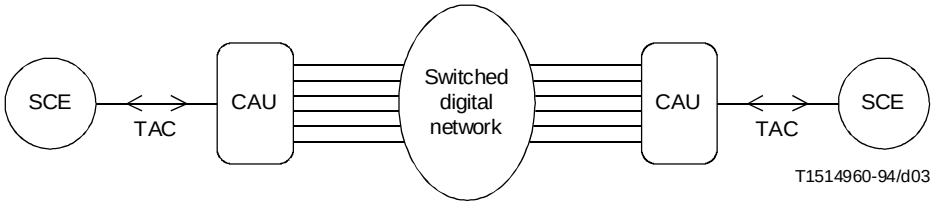


FIGURE 3/H.244

5.1.2 Intercommunication of non-audiovisual equipments – Case D

This Recommendation provides for synchronisation and aggregation of up to 63 channels of 64 kbit/s or 56 kbit/s, each being with or without octet integrity and relative transmission delay in the range ± 1 second. It is applicable to a wide range of user information transport, including LAN-LAN interconnect, private circuit back-up, and other "unspecified data" applications. No in-band control communication takes place on the single-channel side. The equipments see the aggregated link purely as a clear data channel, and the structure or content of the data streams is of no concern to the aggregating equipment.

ISO aggregation is appropriate (see Figure 2); the CAU-ISDN-CAU combination provides a clear channel at one of the transfer rates specified in [4] using Mode B1, B2 or B3 (see 5.2).

5.2 Definition of the Modes of transmission on the MC side

The four modes of transmission are defined below, the accompanying figures being given by way of example for the case of about 192 kbit/s on the SC side.

Mode B1 – The user information occupies an integral number of 64/56k channels (usually the N available and aligned channels); only unframed signals are transmitted (see Figure 4), alignment of the channels has previously been achieved using a framed mode, and it is assumed that no slip or other network fault has occurred since then. There are no management bits multiplexed into the stream on either MC or SC sides, and the total bit rates are equal; the Mode is therefore confined to NoTAC cases, and rate change is not possible.

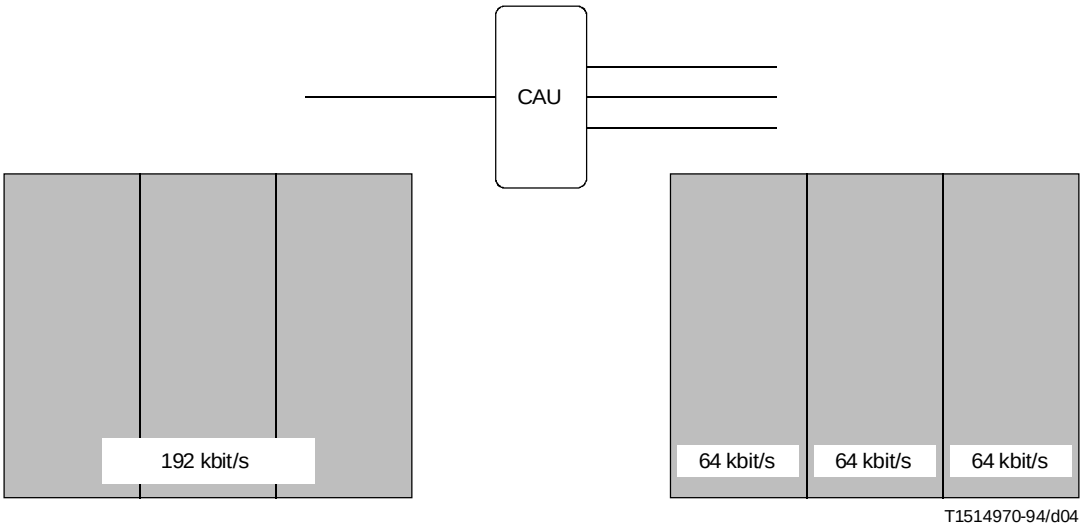


FIGURE 4/H.244

Audiovisual signals according to [1] can be transmitted, but the H.221 framing plays no part in the aggregation process, and will appear at a random position within one of the B-channels as shown in black in Figure 5.

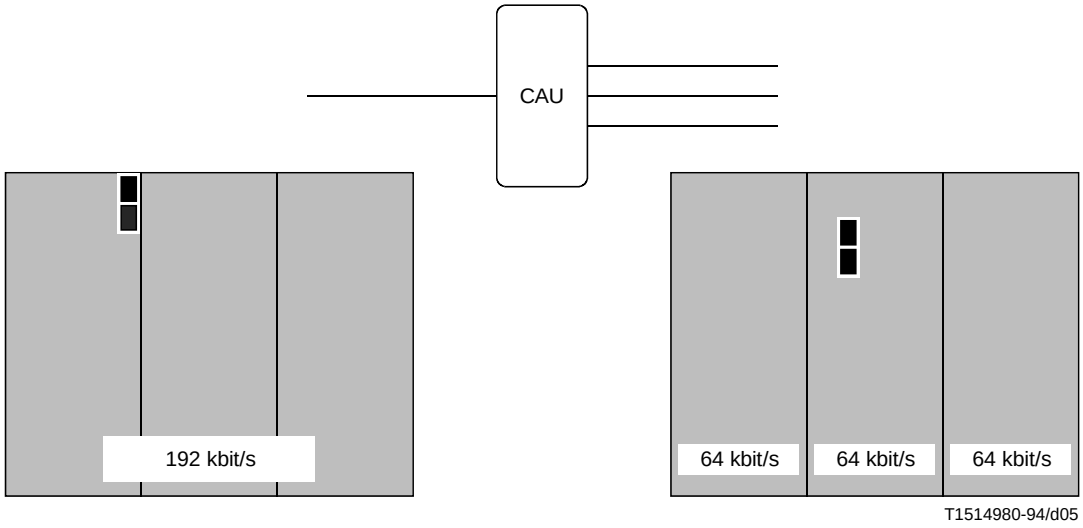


FIGURE 5/H.244

Mode B2 – Signals are transmitted with framing according to [4] (depicted as white in Figure 6), the user information rate being about 1.5% less than an integral multiple of 64/56 kbit/s due to the overhead of the frame structure. There is no provision for management bits on the SC side, so the use of this Mode is confined to the NoTAC case.

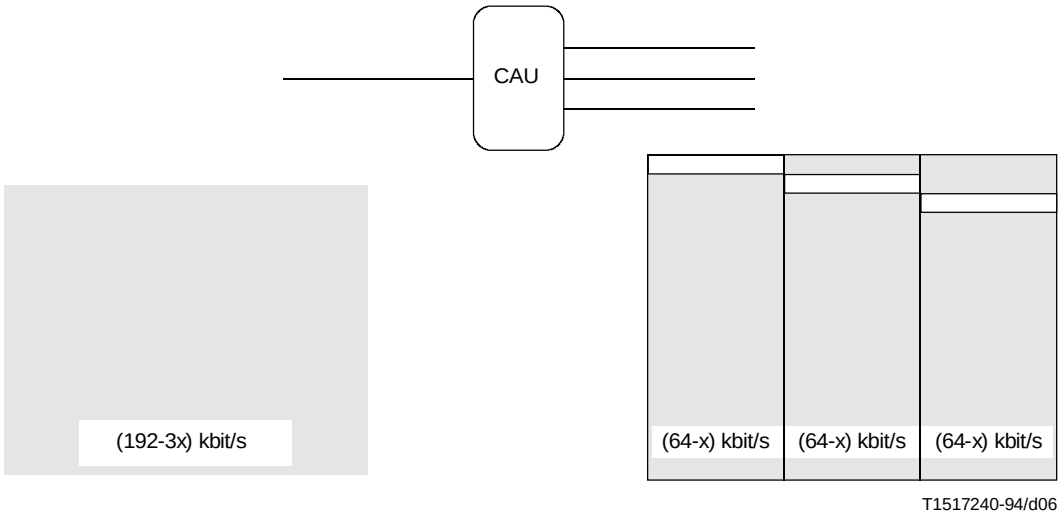


FIGURE 6/H.244

Mode B3 – Signals are transmitted with framing in all N channels according to [4], the user information rate being an integral multiple (such as N – 1) of 64/56 kbit/s; thus there is a management overhead of about 1.5% and generally some unused capacity, as illustrated in Figure 7. The exact bit positions occupied by user information are defined in [4].

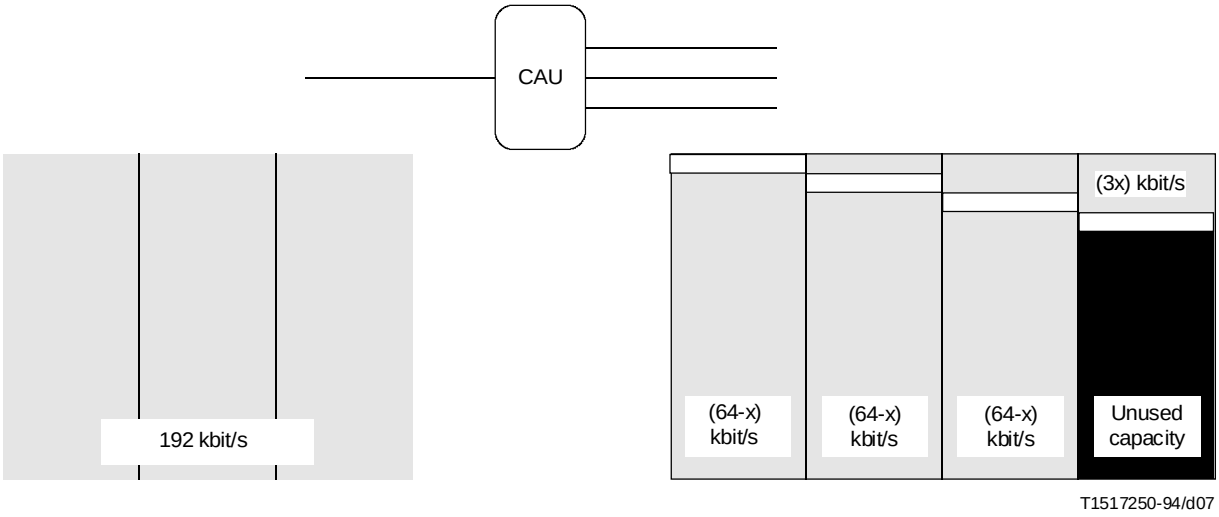


FIGURE 7/H.244

Mode H2 – Only H.221-framed signals are transmitted (framing is shown as white in Figure 8), the user information rate being an integral number of 64/56k channels (usually the N available and aligned channels), including the FAS and BAS within this rate. On the MC side all channels are framed; on the SC side only the I-channel (Time-slot 1) carries H.221 framing, but the corresponding bits (shown with dashed outline) in the other time-slots shall be vacated, so that framing can be inserted at the CAU in the SC-to MC direction (and removed in the other): this is done under the [SM-comp] command.

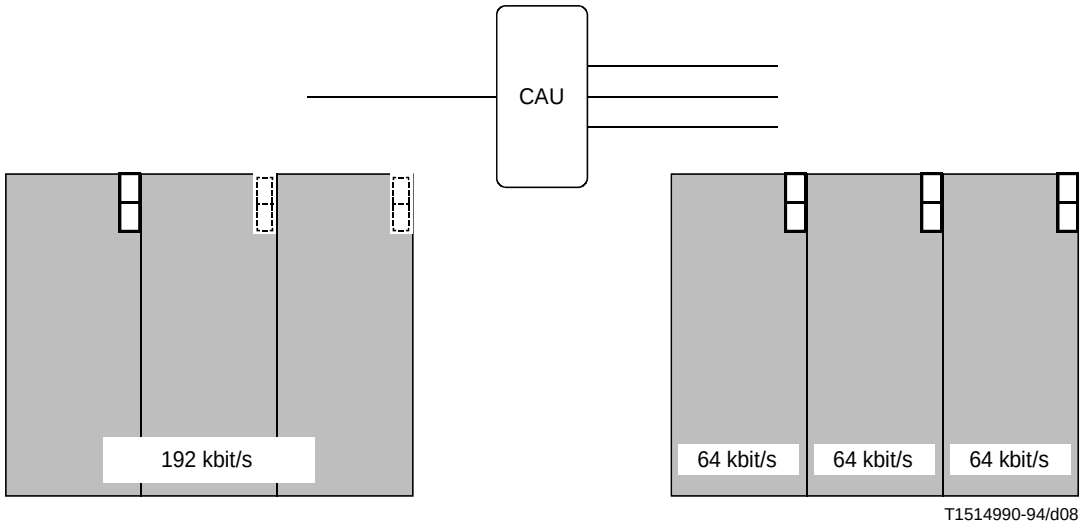


FIGURE 8/H.244

Mode properties

The properties of the four modes are summarised in Table 1. "Dynamic rate change" refers to dynamic variation of the number N of aggregated channels during a session: rate changes within available connection capacity can normally be made in less than 40 ms for Modes H2, B3; when new connections must be added, the response depends on call set-up time; for Mode B1 interruption of the application is inevitable.

TABLE 1/H.244

	Mode B1	Mode H2	Mode B2	Mode B3
Aggregation overhead (% for 64k multiples)	None	2.5% in the additional channels	1.5%	1.5625%
Dynamic rate changes	No	Yes	Yes	Yes
Exact multiples of 64/56 kbit/s	Yes	Yes (H.221-framed only)	No	Yes
Interworking with MCE (audiovisual)	No	Yes	Not applicable	No

The **applicability of the Modes** is summarised in Table 2.

5.3 General description of the aggregation process

The Channel Aggregation Unit (CAU) is a device having on the one side a single-channel port and on the other side a multiplicity of 64/56-channel ports. This Recommendation defines the behaviour of the CAU in respect of the input and output signals at the two sides.

When new multiple channels are active, the CAU buffers the incoming signals in order to synchronise them, and then reads the user information to the SC side. In the reverse direction, the CAU takes the serial input into the SC side and loads it into those parallel channels which it knows to be in synchronism at the remote end. However, according to the two quite different conditions described at the beginning of 5.1, the CAU has two different processes, that is, depending on whether or not it is communicating in-band with the single-channel terminal; selection of the correct process is described in clause 6.

TABLE 2/H.244

Mode	AV/non-AV	Mode applicable when . . . . .
B1	Audiovisual	The remote end is not an MCE, and the remote CAU does not support Mode H2, and Mode B3 is considered too inefficient or is not available; bitstream treated as UD only; NoTAC case, so external means must be used to set bit rate
	Non-audiovisual	Exact multiple of 64/56 kbit/s required, absence of dynamic rate change tolerable, B3 considered too inefficient
B2	Audiovisual	Not applicable – B2 does not provide suitable bit rates
	Non-audiovisual	Exact multiple of 64/56 kbit/s not essential, dynamic rate change desired
B3	Audiovisual	The remote end is not an MCE, and the remote CAU does not support Mode H2; dynamic rate change more important than efficiency; bitstream treated as UD only; NoTAC case, so external means must be used to set bit rate
	Non-audiovisual	Exact multiple of 64/56 kbit/s required, dynamic rate change more important than efficiency
H2	Audiovisual	Remote end is an MCE, or a CAU supporting Mode H2; TAC case, so no external control is needed
	Non-audiovisual	Not applicable (unless conformant to [1])

H.244 aggregation is based on such communication (this applies only to H.320 audiovisual terminals): effectively the SCE communicates with the other terminal at the remote end of the connection in the normal way, by capability sets and commands; the CAU merely moderates this communication in order to assure satisfactory conditions on the multiple 64/56-channel section. The CAU informs the terminal about the upper limit of transmission rate, which depends on the number of channels available, or what the other end can accept, whichever is the lower; it does this by suitably modifying the capability sets exchanged. The synchronisation process is based on [1], which also provides for numbering of the channels. Negotation of appropriate conditions is based on [2]; the capability sets emanating from the CAU define the range of signals that could be sent to it, while commands define the actual signal structure being transmitted from the CAU. See clauses 7-8.

In ISO aggregation there is no in-band communication between the CAU and SCE, the CAU is totally responsible for its communication with the remote CAU, presenting on its SC side a clear digital channel at a specified bit rate, which can be used for any purpose whatsoever (including audiovisual systems). Here again the CAU must control the transmission rate from the terminal – this can be by clocking if the application rate can be varied in this way (and this does not apply to terminals conforming to [3]), or by other external signalling. In this ("NoTAC") case, the synchronisation and communication processes are fully described in [4] – see clause 9.

5.4 CAU functionality

The CAU functionality can be summarised thus:

1) All modes — MC-to-SC direction: Synchronisation and aggregation of N incoming 64/56-channels into one outgoing single channel; SC-to-MC direction: partition of incoming user information onto N outgoing 64/56 kbit/s channels, with framing as appropriate.

   H2 mode — Ignore the compatibility bits incoming on the SC side, putting FAS/BAS into the corresponding outgoing bits on the MC side; remove FAS/BAS in additional channels incoming on the MC side, putting Ones into the corresponding outgoing bits on the SC side.

2) All modes — Control the aggregated bit rate according to application requirements and the available MC capacity.

H2 mode — Modify capability sets and commands to ensure correct operation of the system; detect changes to capacity requirements from incoming capability sets.

3) All modes — Detect fault conditions and take appropriate action.

4) All modes — (Optionally) transfer the call-control signalling between the ISDN and single-channel networks.

The action of the CAU is not completely specified, some matters being left to the choice of the implementer or service provider. For example, requests for channels will not all mature simultaneously, and it is a matter of choice whether each should be added in to the communication as soon as available (increasing the bit rate in a series of many steps), or alternatively held back until all or most are available (increasing the bit rate in one single step).

6 Choice of H.244 or ISO aggregation

The procedure at the start of the call is as depicted in the diagram of Figure 9 and described in the following subclauses. It is mandatory that all CAUs intended for use with audiovisual terminals conforming to [1] be able to operate in Mode H2.

There are two alternatives for the choice between H.244 and ISO aggregation processes at each CAU:

1) the CAU may be preset to perform H.244 or ISO aggregation only, according to the environment for which the CAU is intended;

2) if 1) has not been applied, a decision must be taken on the basis of incoming signals on both SC and MC sides, as described below.

Reference is made to Figure 9. The CAU operation is essentially the same whether it is the originating (calling) end or the destination (called) end (the setting of Flag1 is for possible later use when the additional channels are to be requested, or in the procedure of [4]).

First, three local conditions are tested, and if any of the three are not met then ISO aggregation (clause 9) is used. These conditions are:

Condition 1: There has been no preset to specify ISO aggregation only; note that if the connected SCE is an H.320 terminal, then only modes B1 or B3 may be used – B2 does not provide valid bit rates;

Condition 2: H.221 framing is detected, coming from the SCE; note that a timeout is involved here;

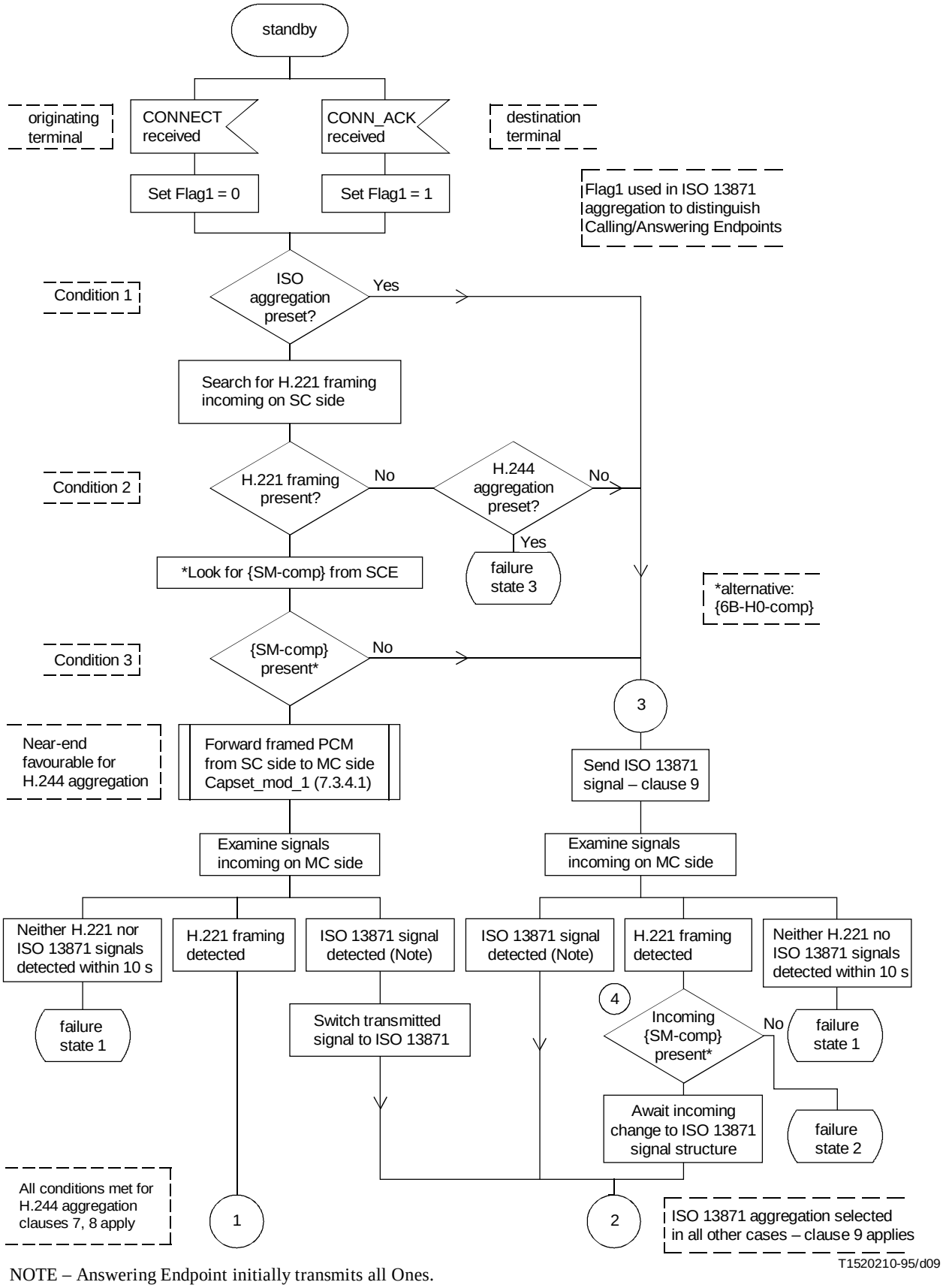
Condition 3: The capset in that H.221 frame contains the value {SM-comp} and/or {6B-H0-comp}.

Only under these three conditions is the H.221-framed signal forwarded from the SCE on the initial channel, otherwise the CAU generates the signal defined in 7.1 of ISO/IEC CD 13871 [4].

Second, the incoming signal is searched for H.221 framing and [4] signal. If a [4] signal is detected (see Note, Figure 9) ISO aggregation clause 9 is used – if previously following clauses 7-8 because the above three conditions were met, this means switching to [4] signals on the outgoing transmission. A timeout of 10 seconds is applied to the detection of [4] to allow for the possibility that clauses 7-8 is initially being followed at the remote end. **Only if the transmissions in both directions are H.221-framed and SCEs transmit the capability value {SM-comp} or {6B-H0-comp} does H.244 aggregation procedure apply.**

Failure states

If no incoming framing, either of H.221 or [4] type, Failure State 1 is reached: it must be presumed that the remote end-point is neither a CAU nor an audiovisual MCE (in some applications, speech communication using PCM according to Recommendation G.711 may still be possible).



NOTE – Answering Endpoint initially transmits all Ones.

FIGURE 9/H.244

If one end is transmitting according to ISO aggregation operation (clause 9), one of the above three conditions not having been fulfilled, and the remote end is sending H.221 framing but without {SM-comp} or {6B-H0-comp}, Failure State 2 is reached, reflecting the technical impossibility of interconnecting to an MCE at the remote end.

Failure State 3 is reached if the CAU is set to operate in the H2 mode but the connected SCE is not sending H.221 framing.

The action to be taken on reaching any of the failure states is an implementation matter. The SBE symbol NII [1], indicating incompatible aggregators, may be used in appropriate fault conditions.

7 H.244 aggregation procedure

7.1 Call control

The signalling for call control is outside the scope of this Recommendation: it is assumed that external signalling is available to set up the appropriate paths between the equipments – for example, the "D-channel" in the case of ISDN. Means are described in 8.1.3 for the in-band transfer of network address information where this is needed for call control.

7.1.1 Initial channel

The initial 64/56-channel is requested when communication has been established between the calling-end SCE and its CAU and any necessary checking has been carried out (for example, presence of {SM-comp} if required (see Note); presence of {n*64k} with n > 1....). During establishment of the initial channel, the value of N_m is calculated from the SCE capset (see 7.3.2).

NOTE – SCE terminals conforming to [3] should include the 6B-H0 compatibility mode; if this capability and {SM-comp} are both absent, the CAU shall adopt NoTAC working – see clause 6.

7.1.2 Additional channels

Additional-channel requests are made by a CAU when:

– the total of channels already requested is less than the lower of N_m and N'_m, and (in dial-up cases) the CAU is the calling end.

Additional channels may be dropped by a CAU when the total of channels already requested exceeds the lower of N_m and N'_m.

7.2 Channel synchronisation

On the multiple-channel side, CAUs shall always synchronise all connected channels (in the ISDN case, those for which CONNECT has been sent or received). The value of N_a is determined according to the channels for which:

– the incoming A-bit is set to zero;

– the channel numbers in BAS position (see Appendix I) form a continuous series from 1 to N_a.

7.3 In-band procedure using H.221 BAS codes

In-band signalling shall follow [2] to ensure correct operation between the equipments. H.221 framing is used on all the multiple channels, and also on the single-channel side. All BAS commands are effective from the start of the following submultiframe, and remain in force until countermanded – see [2].

CAUs shall remain responsive to incoming H.221 framing throughout the call, on the MC side on all channels, and on the SC side. This means that when no framing is detected the equipment will nevertheless respond rapidly when the incoming signal is switched to a framed mode, and will also respond quickly (if required) to fault conditions.

7.3.1 Control of transfer rate

The main function of the CAU is to match the effective transfer rates on its two sides. To do this it must be able to control the user information which is sent to it: it does this in-band on the MC side, and in the TAC case on the SC side also. The in-band method is by means of the capability set (see [2]) which it transmits or forwards; this shall always contain transfer-rate capability values no higher than the available rate on the other side of the CAU. See Figure 10.

NOTE – Other in-band signalling between SCE and CAU is possible - this is outside the scope of this Recommendation, and should be treated in the same way as "out-of-band" signalling - see NoTAC case.

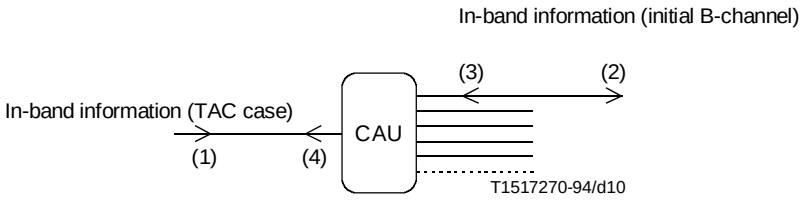


FIGURE 10/H.244

7.3.2 Determination of the transfer-rate capabilities to be transmitted on the MC side

Reference is made to the in-band streams (1) and (2) in Figure 10.

Transfer-rate capabilities transmitted on the MC side (2) are decided on the basis of the capset received from the SCE (1).

If $n_m > 1$, an $\{N \times 64k\}$ type value, with $N = n_m$ shall be sent – this is required for communication with an MCE, and also provides for communication with an SCE with fallback to all lesser multiples of 64/56 kbit/s.

If SCE-transmitted capset contains values of {n*64k} for which n is higher than n_m, these also shall be included (see 7.3.4.2) for potential communication with another SCE, though fallback to lesser rates will be limited.

7.3.3 Determination of the transfer-rate capabilities to be transmitted on the SC side

Reference is made to the in-band streams (3) and (4) in Figure 10.

Transfer-rate capabilities transmitted on the SC side (4) are decided on the basis of the capset received from the MC side (3) and the number of channels currently available, N_a.

The incoming capability set on the MC side contains a single transfer-rate value of $\{N'_m \times 64k\}$ type: this value shall be replaced by a {n*64k}-type transfer-rate value, corresponding either to the incoming value (i.e. such that $n = N'_m$), or to the available number of channels (i.e. such that $n = N_a$), whichever is the lesser. In general, the highest {n*64k}-type transfer-rate capability value transmitted from CAU on the SC side (4) is that which indicates the maximum bit rate that can be accepted, including both user information and management.

7.3.4 Capability sets transmitted from a CAU

Capsets are not generated by the CAU itself; they are generated only in the terminals, and forwarded, in both SC and MC directions, by the CAUs with modifications as described in 7.3.4.1 and 7.3.4.2 below. No changes in the length of a capset are made by a CAU, the value {null} being used to fill any unused positions.

The capsets outgoing from CAUs shall not violate the rules set out in [2]; in particular, all capsets which follow one another in succession without intervening commands shall be identical. Thus when circumstances require that a new modification be made, this shall always be done on a new capset, which shall usually be stimulated by the procedure of 7.3.5.

7.3.4.1 Modification of SCE capset for forwarding towards MC side

The CAU modifies the SCE capset changing the lowest transfer-rate capability value to $\{N_m \times 64k\}$; here N_m is determined from 7.3.2 above, except that if the SCE capset has only one transfer-rate capability value {n*64k} then this is sent unchanged (see Note 2 below).

This may be understood with reference to the following examples:

Original transfer-rate capabilities	External setting	Modified transfer-rate capabilities
512, 384, 320, 256, 192, 128, 64	None	512, 384, 320, 256, 192,128, 6B
384, 256, 192, 128, 64	6B	384, 256, 192, 128, 4B (Note 1)
384, 320, 256, 192, 128	None	384, 320, 256, 192, 6B
384, 320, 256, 192, 128	4B	384, 320, 256, 192, 4B
384	None	384 (Note 2)
NOTES 1 6B cannot be used here since the rate 320 is absent from the list of original capabilities. 2 Refer to Appendix III for further comments on this exceptional provision.		

Modification of the lowest transfer-rate capability guarantees that the transfer-rate capability for just 64 kbit/s, which is the same as 1B, is never present in the same set as a higher rate $\{N \times B\}$-type. The remaining transfer rate and all other Capability codes are left unchanged. A remote MCE will receive the $\{N \times B\}$-type and ignore the {n*64k}-type values. The MCE will use the received A bits to determine the rate at which it can transmit data.

7.3.4.2 Modification of capset incoming from MC side for forwarding towards SCE

The CAU modifies the capset incoming from the MC side according to 7.3.3. All values of transfer rate exceeding the capacity actually available on the multiple-channel link shall be replaced by the {null} value; {null} shall also be used to avoid any repetitions. If only five channels are active, and even though information (3) from the equipment connected at the multiple-channel side is that up to 6B (for example) would be acceptable, then the capset transmitted by the CAU in direction (4) shall contain the transfer rate values no higher than {320k}.

This is best understood with reference to the following examples:

Original transfer-rate capabilities	Available channels	Modified transfer-rate capabilities
512, 384, 320, 256, 192, 128, 6B	6	Null, 384, 320, 256, 192, 128, 6B
384, 256, 192, 128, 4B	3	Null, null, 192, 128, null
384, 256, 192, 128, 5B	5	Null, 256, 192, 128, 320

7.3.5 Notification of change of N_a

When the number of available channels has been changed, this will be made known to the SCE by sending a new value of {n*64k} capability, using the modification of 7.3.4.2. If a sequence of (identical) capsets is already being received on the MC side, then two steps shall be taken:

a) one complete set shall be replaced by redundant commands (since to comply with [2] a capset change may not be made without interposing at least one command);

b) the next capset shall be modified according to 7.3.4.2, using the new value of N_a.

If there are no capsets incoming on the MC side, it is necessary to stimulate a capability exchange.

This procedure is initiated by the CAU by sending [capex] to the SCE (7.3.6.3).

NOTE – A terminal which has sent {6B-H0-comp} rather than {SM-comp} is unlikely to respond to [capex]; in this case the CAU may trigger the capability exchange by repeating the last capset it sent to the SCE.

The SCE shall respond with a new capset, which is passed by the CAU towards the distant terminal with modification according to 7.3.4.1.

If the distant terminal is an MCE, it shall respond with a new capset, which is conveyed to the SCE with modification by the CAU according to 7.3.4.2, reflecting the new value of N_a.

If the distant terminal is a CAU2 and SCE2, then the capset reaching SCE will have been modified by CAU2 according to 7.3.4.2, reflecting the new value of N_a.

SCE2 shall likewise respond with a new capset, which is conveyed to SCE1 with modification by CAU2 according to 7.3.4.1 and by CAU1 according to 7.3.4.2, also reflecting the new value of N_a.

7.3.6 Commands transmitted from a CAU

In the TAC case, commands are not usually generated by the CAU itself, other than that certain substitutions shall be made, as detailed below; the remainder are generated only in the terminals.

7.3.6.1 Substitution of transfer rate commands

When [n*64k] from SCE is detected at the CAU, it is replaced by [N × 64k] with N = n for forwarding on MC side.

When [N × 64k] from the MC side is detected at the CAU, it is replaced by [n*64k] with N = n for forwarding to SCE.

7.3.6.2 Insertion and removal of [SM-comp] and [6B-H0-comp]

When [SM-comp] or [6B-H0-comp] from SCE is detected at the CAU, it is replaced by repeating the latest command received from SCE, for forwarding on MC side.

A redundant command from the MC side shall be replaced by the same value, [SM-comp] or [6B-H0-comp], for forwarding to SCE. For security, this process should be repeated from time to time during the communication, when convenient.

7.3.6.3 Insertion of [capex]

When it is necessary to stimulate a capability exchange between two terminals, a redundant command from the MC side shall be replaced by [capex] for forwarding to the SCE; on receipt, a terminal which is able to recognise [capex] shall:

1) if it is transmitting a capset, complete that capset, followed by cap-mark and a valid command (see [2]);

2) start a new capability exchange according to [2].

7.3.6.4 Insertion of [AggIN]*

When it is necessary rapidly to notify the SCE of an unexpected drop in available capacity, four successive commands from the MC side shall be replaced by [AggIN]* for forwarding to SCE. A terminal which is able to recognise [AggIN]* shall make a mode switch to a lower transfer rate, consistent with the available multiple channels. (See Note 1 of 8.1.3.)

7.4 Transmission of user information by a CAU

Transmissions in both directions are governed by commands generated by the two terminals, except that on the MC side of a CAU the outgoing transfer rate is modified from the incoming value on the SC side according to 7.3.6, and on the SC side of a CAU the outgoing transfer rate is modified from the incoming value on the MC side, also according to 7.3.6.

While a CAU has no connection made on one side, it transmits its locally-generated frame structure on the other side, in Mode 0F with audio S and any relevant command (such as [Recommendation G.711-A-law]) in the BAS position.

As soon as both sides are connected, the signal from each side is routed directly through to the other with two modifications:

- BAS values are modified according to 7.3.4 and 7.3.6;
- (optional) a fractional-frame buffer may be inserted to avoid the discontinuity arising when the locally-generated frame structure is replaced by that coming in on the other side.

NOTE – Because of the dependent H.221 framing on the two sides of the CAU, there may be a need to interrupt the framing while doing the synchronisation of an additional channel.

8 Initialisation, Mode/Rate changing and Fault recovery

8.1 Initialisation

The in-band procedures are the same for any CAU, whether it originates the request for the initial channel (calling end-point) or is the destination (called end-point). An additional example description of initialisation, with SDL figure, is given in Appendix II.

Summary (see also examples in Appendix I):

Step	
1.	SCE connected to CAU: CAU detects framing and {SM-comp} or {6B-H0-comp}, determines desired rate from transfer-rate capabilities from SCE
2.	CAU makes/receives initial connection (which can be to/from another CAU or an MCE)
3.	Seeks and finds H.221 framing on connected initial channel
4.	Capability exchange takes place between the SCE and the remote equipment, the transfer rate values being modified by the CAU in both directions; audio from SCE is sent; audio incoming from MC side is passed on
5.	Requests additional network addresses if necessary; then requests additional connections (see Note 1 in 8.1.3)
6.	Synchronises additional channels when connected
7.	The command [SM-comp] is sent to the SCE, to ensure voiding of “compatibility bits” later
8.	The command [capex] is sent to the SCE, to stimulate another capability exchange
9.	New cap-exchange, CAU now modifies to reflect the available multi-channel capacity
10.	SCE performs a mode switch to the desired higher rate

8.1.1 Single-channel Side

Incoming signal

The CAU searches the incoming signal from the SCE for frame and multiframe alignment. If H.221 framing is absent, it is presumed that a non-audiovisual equipment is connected, and transmission of Mode 0F is discontinued (see clause 6). In the case of Outcome I (see [2]), the incoming capset is examined. The CAU derives the target number of B-channels N_m from n_m. If the capset does not also contain {SM-comp} or {6B-H0-comp}, then the call cannot proceed as a TAC case, but should be treated as NoTAC (see clause 6).

Outgoing signal

Until a suitable signal is available incoming on the MC side, the CAU may optionally transmit towards SCE an audible signal S in Mode 0F (local audio coding law) and any relevant command (such as [Recommendation G.711-A-law]) in the BAS position. When H.221-framed signals are received on the MC side, the whole signal from the MC side is forwarded towards SCE, the capsets being modified according to 7.3.4.2. At this stage the transfer rate is just 64 kbit/s.

8.1.2 Multi-channel Side, initial channel

The following process begins when the CAU is notified, by external signalling, that the first connection on the MC side is completed.

Incoming signal

The incoming signal is searched for H.221 framing; if H.221 framing is not found, the process continues as in clause 6.

Outgoing signal

Transmission shall be in H.221-framed Mode 0F with the signal from SCE, as follows.

Receiving an H.221-framed signal from the SC side, the CAU forwards this same signal outwards from the MC side. If the signal contains (repeated) capsets, it modifies these according to 7.3.4.1; if it does not, then it sends [capex] towards the SCE to stimulate a capability exchange initiated by the SCE.

Transmission continues to follow the initialisation procedure according to [2]. When Outcome I is reached, mode switching may take place, if desired, before the establishment of additional channels; however, such action is the responsibility of the terminals alone – the CAU merely modifies the commands according to 7.3.6.

8.1.3 Multi-channel Side, additional channels

A CAU (Note 1) may dial more channels after having detected framing on the initial channel and a capset incoming on the MC side. The total number N_d of connections to be dialled is selected as follows.

The capset incoming on the MC side contains a single value of type {N × 64k}, where $N = N'_m$; there may also be values of type {n*64k} (indicating the presence of another CAU – such values are not transmitted by an MCE), the maximum value being $n = n'_{max}$.

The capset incoming on the SC side contains values of type {n*64k}, the maximum value being $n = n_{max}$; the value of N_m is also calculated (see 7.3.2).

N_d is the greater of {(the lesser of N_m, N'_m),(the lesser of n_{max}, n'_{max})}.

NOTE 1 – It is assumed in this Recommendation that additional connections may only be requested by the same unit that has obtained the initial connection; likewise the dropping of unwanted connections; however, since the in-band behaviour is not affected, there is no problem if some or all calls are made/dropped from the other endpoint.

NOTE 2 – According to the properties of the network accessed, it may be necessary to insert a delay of up to 1 second between successive additional connection requests.

Methods of obtaining network address information for additional channels are described in [2].

NOTE 3 – The use of SBE rather than MBE messages is preferred here, since the substitution of an MBE message into the BAS command stream from a terminal is much more difficult than substitution of an SBE. In general, the use of same or consecutive network addresses is strongly recommended.

When the CAU is notified, by external signalling, that an additional connection is completed, it carries out framing and synchronisation according to [1], and assigns the channel a number (see Appendix I). Transmission of user information may be expanded onto the additional channels either:

a) one by one as they become synchronised and numbered;

b) the target number of channels is reached (as determined from the incoming capset or external control); or

c) an allowed time limit for reaching this target has expired.

NOTE 4 – The choice of time limit is an implementation matter.

At this point the CAU shall notify the SCE of the increased available capacity on the MC side; this it does by the procedure of 7.3.5. Subsequent mode switching is a matter for the terminals alone – the CAU merely modifies the commands according to 7.3.6.

8.2 Change of transmission rate during a session

Either terminal may switch its transmission to another mode within the ranges declared by the capability set received from the CAU, which is itself dependent on N_a. If having made such a mode change, one or more channels are no longer required, the calling CAU may release them.

An increase of N_a may be necessary to accommodate the desired transmission; if the called CAU is not permitted to request additional channels, and so shall await that action by the calling CAU (see Note 1 of 8.1.3), this need shall first be communicated to the calling CAU in the same way as for the initial session set-up (see 7.3.2), and the calling CAU then requests the additional channels. The change of available capacity is notified to both terminals by the procedure of 7.3.5, and they then make the desired mode change(s).

8.3 Recovery from fault conditions

The onset of a fault may be recognised in a number of ways: by loss of frame synchronisation on an incoming channel; by an incoming A-bit set to 1; errored connections, from CRC4 checks; a high number of temporary loss-of-synchronisation events; others. The currently effective value of N_a is determined from the incoming A-bits and channel numbers according to 7.2 (this may be delayed a short time to allow for the possibility of rapid restoration of normal conditions).

The change of available capacity is notified rapidly by each CAU to its local SCE by sending the double SBE symbol [AggIN]*, enabling them to switch immediately to a lower rate and enable the application to recover.

NOTE – A terminal which has sent {6B-H0-comp} rather than {SM-comp} is unlikely to respond to [AggIN]*; in this case the CAU shall repeat the last capset it sent to the SCE, except that the modification according to 7.3.4.2 now reflects the lower value of N_a.

8.4 Further mode changes

When it is desired to switch on video and/or data transmission, the procedures of [2] are followed. No action is required by the CAU as long as no change of transfer rate is involved. Symmetry of transmission is, as always, a matter for terminal procedures, neither terminal being obliged by in-band management signals to conform to a transmission mode adopted by the other. The transfer rate is essentially under the control of the calling party.

9 ISO aggregation procedure

The ISO Aggregation Procedure is described in [4]. The frame structure is detailed in 5.2 of this Recommendation, and the initialisation in 7.1.

Appendix I

Examples of procedures

(This appendix does not form an integral part of this Recommendation)

Case 1: Interconnection of two H.320 SCE-type terminals via two CAUs using Mode H2; the last additional connection is tardy in maturing; during the call, a reduction of capacity is requested.

NOTE – The values 13, 9, 7, 3 in the following are purely for example.

SCE1 is the calling end, and the desired number of channels is specified as that giving the same capacity as the highest transfer rate in the SCE1 capset; the time limit for awaiting that number in the intial set-up phase is set at TIM. It is also specified that the SC side is to be active for user information as much as possible, including the period when only one channel is active.

1. CAU1 makes the initial channel request when the connection from SCE1 to CAU1 is complete and H.221 framing from SCE1 is detected, or upon an external stimulus which also resets the "Sequence A" timer in the SCE. It transmits tone S in Mode 0U towards SCE1.

   NOTE – If CAU1 does not detect H.221 framing from SCE2 within {1 s?}, then it sends [4] framing to CAU2, and tone S is omitted.

2. CAU2 receives SETUP from CAU1, and establishes contact with SCE2 (this may be a permanently active link, or require "waking up"); it then returns CONNECT to CAU1, and commences transmission of the framed signal from SCE2. It transmits tone S in Mode 0U towards SCE2.

   NOTE – If CAU2 does not detect H.221 framing from SCE2 within {1 s?}, then it sends [4] framing to CAU1.

3. On receipt of CONNECT, CAU1 sends towards MC side the incoming signal from SC side, including capsets (repeated continuously) from SCE with modification according to 7.3.4.1 – in this case the {13*64k} is modified to {13B}.

4. CAU1 detects H.221 framing from CAU2; the incoming capset is that from SCE2, repeated; this contains {9B}, which is lower than the {13B}; passes the incoming signal from the MC side on towards the SCE1, modifying the {9B} to {1B}, since only one channel is yet available. Likewise CAU2 detects H.221 framing from CAU1; the incoming capset is that from SCE1, repeated; it passes the incoming signal from the MC side on towards the SCE1, modifying the {13B} to {1B}.

5. Comparing the incoming {13*64k} and {9B}, CAU1 calculates N_d as "9", and requests 8 additional connections, obtaining the remote addresses if necessary using the NCA-a procedure of [2].

6. By expiry of TIM, CONNECT has been received from CAU2 in respect of 7 more channels; CAU1 adds buffering and numbering to these to achieve synchronism and returns A = 0 according to Recommendation H.221. CAU2 does likewise. CAU1 and CAU2 both look for a redundant command, and replace this with [SM-comp].

7. When CAU1 receives A = 0 on initial and the seven available additional channels, it must stimulate another capability exchange, in order to be able to indicate the increase channel availability; therefore it sends [capex] to SCE1, which returns one capset + cap-mark.

   NOTE – An H.320 terminal which transmits {6B-H0-comp} rather than {SM-comp} may not recognise [capex]; in this case the CAU may send the previously transmitted capset from CAU2, which it would have stored for the purpose; however, such situations would be better avoided.

8. CAU1 passes this on to CAU2 with usual modification (7.3.4.1), namely {13*64k} >> {13B}.

9. CAU2 passes the capset on to SCE2, modifying the capset again according to 7.3.4.2, namely replacing one of the transfer-rate values with {512k}, the n*64k value corresponding to the multiple-channel capacity actually now available.

10. SCE2 itself responds with its normal capset + cap-mark; CAU2 passes this back with modification as in 7.3.4.1.

11. CAU1 passes the capset on to SCE1, modifying the capset again according to 7.3.4.2, namely replacing one of the transfer-rate values with {512k}, the n*64k value corresponding to the multiple-channel capacity actually now available.

12. Both SCEs are now in a position to mode switch to any framed rate up to [512k]. The CAUs must watch out for [SM-comp] coming from SCEs and replace it with a redundant command, and also for [n*64k] commands, replacing them with [N × 64k].

13. CONNECT is belatedly received by CAU1 from CAU2 in respect of last requested channel; it adds buffering and numbering to this to achieve synchronism and returns A = 0 according to Recommendation H.221.

14. Receives A = 0 on this last channel; same process as in 7-12 above, with 512k replaced by 576k.

15. At user request, SCE1 is instructed to drop three channels – namely down to 384k; SCE1 sends new capset containing {.....128k, 192k, 256k, 320k, 384k} + cap-mark; the process continues from step 8. above.

Case 2: Interconnection of two H.320 terminals, one an MCE type, the other SCE working via a CAU; the number of desired connections, etc., is as for Case 1. **The SCE is the calling end.**

1. CAU makes the initial channel request when the connection from SCE to CAU is complete and H.221 framing from SCE is detected, or upon an external stimulus which also resets the “Sequence A” timer in the SCE. It transmits tone S in Mode 0U towards SCE.

   NOTE – If CAU does not detect H.221 framing from SCE2 within {1 s?}, then it sends [4] framing to MCE, and tone S is omitted; on later receipt of H.221 framing from MCE and this does not itself change to [4] framing within 2 s, a terminal-incompatibility fault condition is identified.

2. MCE receives SETUP from CAU; it then returns CONNECT to CAU, and commences transmission of the framed signal.

3. On receipt of CONNECT, CAU sends towards MC side the incoming signal from SC side, including capsets (repeated continuously) from SCE with modification according to 7.3.4.1 – in this case the {13*64k} is modified to {13B}.

4. CAU detects H.221 framing and capset is that from MCE, repeated; this contains {9B}, which is lower than the {13B}; passes the incoming signal from the MC side on towards the SCE, modifying the {9B} to {64k}, since only one channel is yet available. Likewise MCE detects H.221 framing from CAU; the incoming capset is that from SCE, repeated.

5. Comparing the incoming {13*64k} and {9B}, CAU calculates N_d as “9”, and requests 8 additional connections, obtaining the remote addresses if necessary using the NCA-a procedure of [2].

6. By expiry of TIM, CONNECT has been received from CAU2 in respect of 7 more channels; CAU adds buffering and numbering to these to achieve synchronism and returns A = 0 according to Recommendation H.221. CAU2 does likewise. CAU looks for a redundant command, and replaces this with [SM-comp].

7. When CAU receives A = 0 on initial and the seven available additional channels, it must stimulate another capability exchange, in order to be able to indicate the increase channel availability; therefore it sends [capex] to SCE, which returns one capset + cap-mark.

NOTE – An H.320 terminal which transmits {6B-H0-comp} rather than {SM-comp} may not recognise [capex]; in this case the CAU may send the previously transmitted capset from CAU2, which it would have stored for the purpose; however, such situations would be better avoided.

8. CAU passes this on to MCE with usual modification (7.3.4.1), namely {13*64k} >> {13B}.

9. (Deleted).

10. MCE itself responds with its normal capset + cap-mark.

11. CAU passes the capset on to SCE, modifying the capset again according to 7.3.4.2, namely replacing one of the transfer-rate values with {512k}, the n*64k value corresponding to the multiple-channel capacity actually now available.

12. Both SCE and MCE are now in a position to mode switch to any framed rate up to [512k]. The CAUs must watch out for [SM-comp] coming from SCEs and replace it with a redundant command, and also for [n*64k] commands, replacing them with [N × 64k].

13. CONNECT is belatedly received by CAU from MCE in respect of last requested channel; it adds buffering and numbering to this to achieve synchronism and returns A = 0 according to Recommendation H.221.

14. Receives A = 0 on this last channel; same process as in 7-12 above, with 512k replaced by 576k.

15. At user request, SCE is instructed to drop three channels – namely down to 384k; SCE sends new capset containing {.....128k, 192k, 256k, 320k, 384k} + cap-mark; the process continues from step 8. above.

Case 3: Interconnection of two H.320 terminals, one an MCE type, the other SCE working via a CAU; the number of desired connections, etc., is as for Case 1. **MCE is the calling end.**

1. CAU sends the initial channel CONNECT when the connection from SCE to CAU is complete and H.221 framing from SCE is detected, or upon an external stimulus which also resets the "Sequence A" timer in the SCE. It transmits tone S in Mode 0U towards SCE.

NOTE – If CAU does not detect H.221 framing from SCE2 within {1 s?}, then it sends [4] framing to MCE, and tone S is omitted; on later receipt of H.221 framing from MCE and this does not itself change to [4] framing within 2 s, a terminal-incompatibility fault condition is identified.

2. MCE sends SETUP to CAU; when it then receives CONNECT from CAU, and commences transmission of the framed signal.

3. Having sent CONNECT, CAU sends towards MC side the incoming signal from SC side, including capsets (repeated continuously) from SCE with modification according to 7.3.4.1 – in this case the {13*64k} is modified to {13B}.

4. CAU detects H.221 framing and capset is that from MCE, repeated; this contains {9B}, which is lower than the {13B}; passes the incoming signal from the MC side on towards the SCE, modifying the {9B} to {64k}, since only one channel is yet available. Likewise MCE detects H.221 framing from CAU; the incoming capset is that from SCE, repeated.

5. Comparing the incoming {13B} and its own {9B}, MCE calculates N_d as "9", and requests 8 additional connections, obtaining the remote addresses if necessary using the NCA-a procedure of [2].

6. By expiry of TIM, CONNECT has been sent to MCE in respect of 7 more channels; CAU adds buffering and numbering to these to achieve synchronism and returns A = 0 according to Recommendation H.221. CAU2 does likewise. CAU looks for a redundant command, and replaces this with [SM-comp].

7. When CAU receives A = 0 on initial and the seven available additional channels, it must stimulate another capability exchange, in order to be able to indicate the increase channel availability; therefore it sends [capex] to SCE, which returns one capset + cap-mark.

NOTE – An H.320 terminal which transmits {6B-H0-comp} rather than {SM-comp} may not recognise [capex]; in this case the CAU may send the previously transmitted capset from CAU2, which it would have stored for the purpose; however, such situations would be better avoided.

8. CAU passes this on to MCE with usual modification (7.3.4.1), namely {13*64k} >> {13B}.

9. (No action in Case 2).

10. MCE itself responds with its normal capset + cap-mark.

11. CAU passes the capset on to SCE, modifying the capset again according to 7.3.4.2, namely replacing one of the transfer-rate values with {512k}, the n*64k value corresponding to the multiple-channel capacity actually now available.

12. Both SCE and MCE are now in a position to mode switch to any framed rate up to [512k]. The CAUs must watch out for [SM-comp] coming from SCEs and replace it with a redundant command, and also for [n*64k] commands, replacing them with [N × 64k].

13. CONNECT is belatedly received by CAU from MCE in respect of last requested channel; it adds buffering and numbering to this to achieve synchronism and returns A = 0 according to Recommendation H.221.

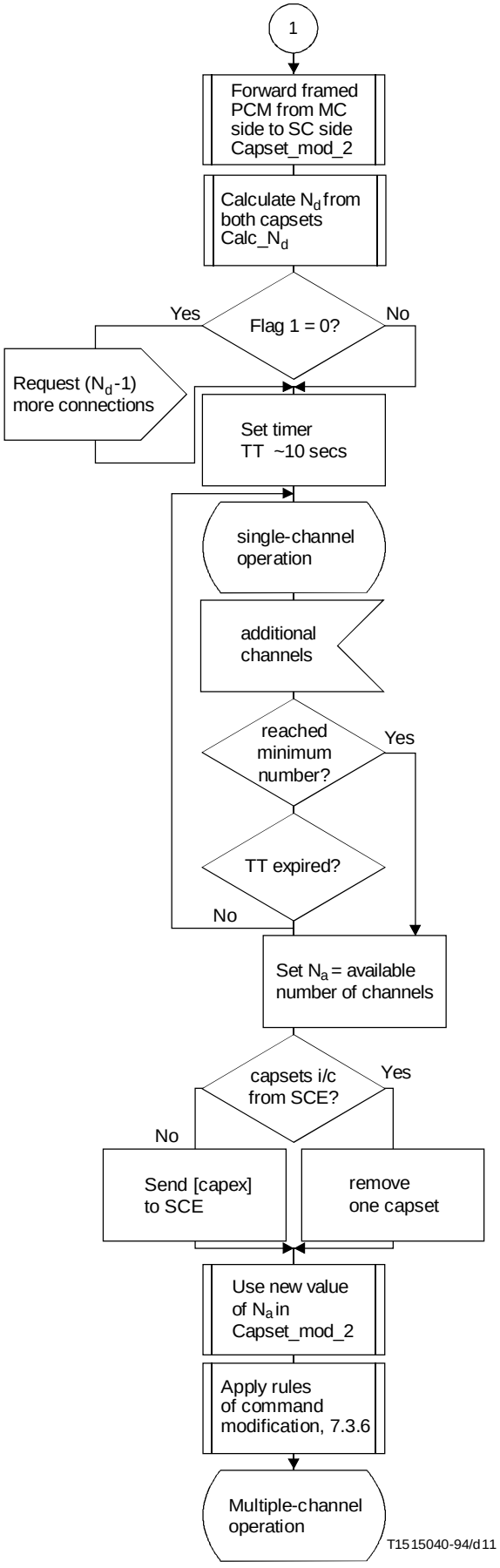
14. Receives A = 0 on this last channel; same process as in 7-12 above, with 512k replaced by 576k.

15. At user request, SCE is instructed to drop three channels – namely down to 384k; SCE sends new capset containing {.....128k, 192k, 256k, 320k, 384k} + cap-mark; the process continues from step 8 above.

Appendix II

Example of SDL diagram for TAC initialisation

(This appendix does not form an integral part of this Recommendation)



TAC operation selected

The incoming signal on the MC side is forwarded, with modification of its Capset according to the procedure Capset_mod_2 (see main text: N_a is set at 1). At this point, only one 64 kbit/s connection is available, so all higher incoming transfer-rate capabilities must be replaced by {null}.

If the CAU is sending a highest transfer-rate capability of $\{N_m \times B\}$, resulting from Capset_mod_1, and is receiving $\{N'_m \times B\}$ from the remote end, then calc_N_d gives the lower of N_m and N'_m.

In Recommendation H.320 all the connections must be requested from the same end. If the network addresses are unknown, they may be obtained as described in the text (not shown here).

When the additional connections have been made, they are synchronised (H.221 procedure) and when incoming A = 0 on each it is made available to the process defined here.

However, it may not be desirable to increase the bit rate used for the H.320 application in many steps of 64 kbit/s, but rather wait in single-channel operation until a chosen minimum number of channels is available – for example, if 5 additional channels have been requested, it would be sensible to wait until at least 4 of these are available, but in any case not wait more than, say, 10 seconds. Such waiting is not mandatory – the "minimum" could be just 1.

From this point, N_a, hitherto set at 1, is increased to reflect the true number of available channels connected and synchronised. The rules for Capset_mod_2 still apply (see main text): essentially, the transfer rates passed to the SCE must be a continuous series 128, 192, 256....n*64, where $n = N_a$ is equal to the number of 64k connections available. Since the capset must not be changed in length, the {null} value is used to fill gaps left by incoming values not passed on.

Of course Capset_mod_2 needs capsets to operate on. If there is already a stream of (identical) capsets coming in on the MC side, then a complete set must be removed, replacing the BAS codes with valid commands (this is because, according to [2] concatenated capsets must be identical); then the next capset is modified using the changed value of N_a. If there are currently no capsets, they must be stimulated by sending [capex] to the SCE (replacing a redundant command). The SCE will then send a capset, and the remote end must respond even if it is an MCE.

The actual increase in operating bit rate is carried out by the two terminals – the CAU need do nothing about this, though it must apply the modification rules to the commands – see 7.3.6 in the main text.

Appendix III

Comments on the modification of capsets and commands

(This appendix does not form an integral part of this Recommendation)

Whereas the capset sent by a CAU on the MC side normally contains a single value from the series {1B, 2B, 3B....}, in the case where only one transfer rate capability {n*64} has been received from the SCE then this value alone is forwarded; this exception provides for the case that two similar SCEs be connected via two CAUs.

It should be noted that an SCE declaring only {384} will not interwork with a {6B} MCE via a CAU according to this Recommendation; if the CAU were to forward {6B} towards the MCE, this would falsely imply that the SCE had declared {384, 320, 256, 192, 128, 64}. An SCE which is intended for interworking with an MCE should possess all the transfer-rate caps in the {n*64} series up to the maximum intended operating rate, as well as {SM-comp} and the ability to recognise and act upon [capex] and [AggIN]*.

NOTE – If a CAU is provided in a situation where its only use is to interconnect a {384 only} SCE with {6B}-type MCEs, then it could be programmed to modify {384} to {6B}, and to deal appropriately with the situation when 5 or fewer channels are available. It is clear that connection to another CAU may cause misoperation if the CAU is programmed in this way.

There may be cases where the modification involves substitution by a two-byte capability or command. For example, the CAU modifies {512, H0, 320, 256, 192, 128, 1B} from the SCE to include {7 × 64}; this can be done by replacing the {512} value rather than {1B}.

The CAU must (= "shall") conform to Recommendation H.242 at all times: in particular, it must not cause a change (in content or even in order) in forwarded capsets without the insertion of a command – this may require the omission of a complete capset.