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Link capacity adjustment scheme (LCAS) for virtual concatenated signals

ITU-T Recommendation G.7042/Y.1305



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Link capacity adjustment scheme (LCAS) for virtual concatenated signals

Summary

This Recommendation specifies a methodology for dynamically changing (i.e., increasing and decreasing) the capacity of a container that is transported in a generic transport network (e.g., over SDH or OTN network using Virtual Concatenation). In general, this change of capacity does not affect the traffic. In addition, the methodology also provides survivability capabilities, automatically decreasing the capacity if a member experiences a failure in the network, and increasing the capacity when the network fault is repaired.

Source

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Keywords

Link capacity adjustment scheme, optical transport network, synchronous digital hierarchy, virtual concatenation.

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Link capacity adjustment scheme (LCAS) for virtual concatenated signals

1 Scope

This Recommendation specifies a link capacity adjustment scheme that should be used to increase or decrease the capacity of a container that is transported in an SDH/OTN network using Virtual Concatenation. In addition, the scheme will automatically decrease the capacity if a member experiences a failure in the network and increase the capacity when the network fault is repaired. The scheme is applicable to every member of the Virtual Concatenation group.

This Recommendation defines the required states at the source and at the sink side of the link as well as the control information exchanged between both the source and the sink side of the link to enable the flexible resizing of this Virtual Concatenated signal. The actual information fields used to convey the control information through the transport network are defined in their respective Recommendations, ITU-T Recs G.707/Y.1322 [1] and G.783 [3] for SDH and ITU-T Recs G.709/Y.1331 [2] and G.798 [4] for OTN.

2 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 G.707/Y.1322 (2003), *Network node interface for the synchronous digital hierarchy (SDH)*.
- [2] ITU-T Recommendation G.709/Y.1331 (2003), *Interfaces for the Optical Transport Network (OTN)*.
- [3] ITU-T Recommendation G.783 (2006), *Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks*.
- [4] ITU-T Recommendation G.798 (2004), *Characteristics of optical transport network hierarchy equipment functional blocks*.
- [5] ITU-T Recommendation G.806 (2006), *Characteristics of transport equipment – Description methodology and generic functionality*.
- [6] ITU-T Recommendation Z.100 (2002), *Specification and Description Language (SDL)*.

3 Terms and definitions

This Recommendation defines the following terms:

3.1 link: A connection through a network from termination function to termination function. This can be related to the members of a virtual concatenation group as well as the virtual concatenation group itself.

3.2 member: An individual server layer container that belongs to a virtual concatenated group.

3.3 virtual concatenation group (VCG): A group of co-located member trail termination functions that are connected to the same virtual concatenation link.

4 Abbreviations

This Recommendation uses the following abbreviations:

CRC	Cyclic Redundancy Check
CTRL	Control field sent from source to sink
DNU	Do Not Use
EOS	End of Sequence
GID	Group Identification
HO	Hold Off
LCAS	Link Capacity Adjustment Scheme
MFI	MultiFrame Indicator
MI	Management Information
MST	Member Status
MSU	Member Signal Unavailable
MSU_L	Member Signal Unavailable, LCAS-enabled criteria
NORM	Normal Operating Mode
RS-Ack	Re-Sequence Acknowledge
Sk	Sink
So	Source
SQ	Sequence Indicator
TSD	Trail Signal Degrade
VCG	Virtual Concatenation Group
WTR	Wait-To-restore
X_A	Actual number of members of a virtual concatenated group
X_M	Maximum size of a virtual concatenated group
X_P	Number of provisioned members in a virtual concatenated group

5 Conventions

The order of transmission of information in all the diagrams in this Recommendation is first from left to right, and then from top to bottom. Within each byte the most significant bit is transmitted first. The most significant bit (bit 1) is shown at the left in all the diagrams.

6 LCAS for virtual concatenation

6.1 Methodology

LCAS in the virtual concatenation source and sink adaptation functions provides a control mechanism to hitlessly increase or decrease the capacity of a VCG link to meet the bandwidth needs of the application. Hitless bandwidth modification can only be achieved when the transmission of

the active members belonging to the VCG – before and after the bandwidth modification – is error free (see Appendix II for details). It also provides the capability of temporarily removing member links that have experienced a failure. The LCAS assumes that in cases of capacity adjustment (i.e., creation, increase, decrease or deletion), the construction or destruction of the end-to-end path of each individual member is the responsibility of the Network and Element Management Systems. A VCG capacity increase or decrease can be initiated at either end.

6.2 Control packet

Synchronization of changes in the capacity of the transmitter (So) and the receiver (Sk) shall be achieved by a control packet. Each control packet describes the state of the link during the *next* control packet. Changes are sent in advance so that the receiver can switch to the new configuration as soon as it arrives.

The control packet consists of fields dedicated to a specific function. The control packet contains information sent from So to Sk and information sent from Sk to So, see also Figure 1.

Forward direction, So to Sk:

- MultiFrame Indicator (MFI) field;
- Sequence Indicator (SQ) field;
- Control (CTRL) field;
- Group Identification (GID) bit.

Return direction, Sk to So:

- Member Status (MST) field;
- Re-Sequence Acknowledge (RS-Ack) bit.

NOTE 1 – MST and RS-Ack are identical in the control packets of all members of the VCG.

Both directions:

- CRC field;
- Unused bits are reserved and shall be set to "0".

NOTE 2 – To allow consistent timing relationships, it is assumed that the LCAS control packets are processed at the Sk after differential delay compensation.

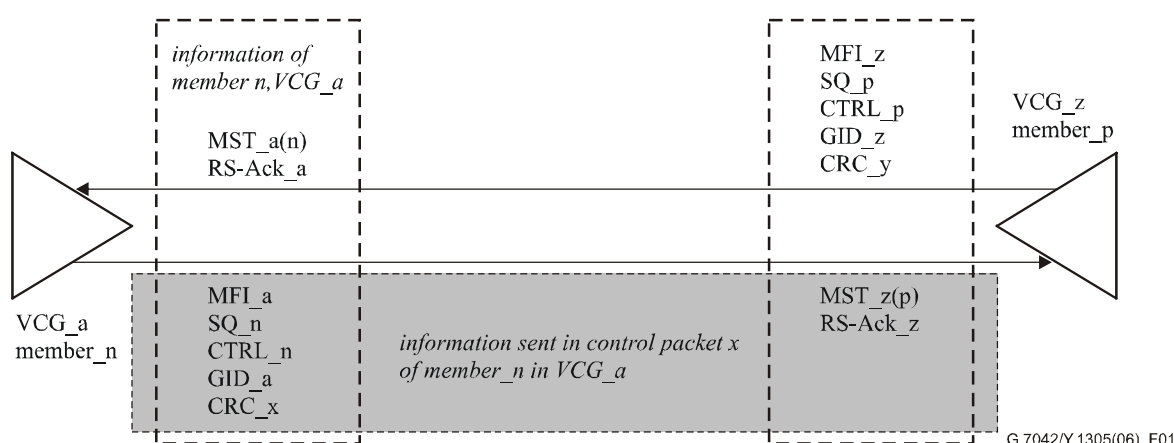


Figure 1/G.7042/Y.1305 – Allocation of information in a control packet

6.2.1 MultiFrame Indicator (MFI) field

At the So side, the MFI is equal for all members of the VCG. At the Sk side, the MFI shall be used to realign the payload for all the members in the group. The MFI is used to determine the differential delay between members of the same VCG. See ITU-T Rec. G.806 for more details.

6.2.2 Sequence Indicator (SQ) field

Contains the sequence number assigned to a specific member. Each member of the same VCG is assigned a unique sequence number, starting at 0, similar to the Recommendations for Virtual Concatenation in ITU-T Recs G.707/Y.1322 [1] and G.709/Y.1331 [2].

The SQ is ignored at the Sk end for members sending IDLE in the control field.

The SQ of a member of the VCG sending IDLE in the control field shall be set to the highest possible value.

6.2.3 Control (CTRL) field

The control field is used to transfer information from So to Sk. It shall be used to synchronize the Sk with the So and provide the status of the individual member of the group.

Table 1/G.7042/Y.1305 – LCAS CTRL words

Value msb...lsb	Command	Remarks
0000	FIXED	This is an indication that this end uses fixed bandwidth (non-LCAS mode)
0001	ADD	This member is about to be added to the group
0010	NORM	Normal transmission
0011	EOS	End of Sequence indication and Normal transmission
0101	IDLE	This member is not part of the group or about to be removed
1111	DNU	Do Not Use (the payload) the Sk side reported FAIL status

At initiation of a VCG source, all members shall send CTRL = IDLE until they are added to the VCG (and send CTRL = ADD).

6.2.4 Group Identification (GID) bit

Used for identification of the VCG. The GID bit of all members of the same VCG has the same value in the control packets with the same MFI.

The GID provides the receiver with a means of verifying that all the arriving members originated from one transmitter. The contents are pseudo-random, but the receiver is not required to synchronize with the incoming stream. The pseudo-random pattern used is $2^{15} - 1$.

6.2.5 CRC field

To simplify the validation of the changes in the virtual concatenation overhead, a CRC is used to protect each control packet. The CRC check is performed on every control packet after it has been received, and the contents rejected if the test fails. If the control packet passes the CRC test, then its contents are used immediately. To simplify MFI multi-framing, it is allowed to disregard the result of the control packet CRC check for the MFI element checked by the CRC so that the multi-framing process may use the MFI element equivalently with the non-LCAS virtual concatenation processing case.

6.2.5.1 CRC multiplication/division process

The bits of the control packet can be regarded as the coefficients of a polynomial where the first bit of the control packet to be transmitted is the most significant bit. A particular CRC-n block is the remainder after multiplication of all bits in a control packet by x^n and then division (modulo 2) by the application specific generator polynomial. The remainder is a polynomial of at most degree $(n - 1)$.

When representing the contents of the block as a polynomial, the first bit in the block, bit 1, should be taken as being the most significant bit. Consequently, C_1 is defined to be the most significant bit of the remainder and C_n the least significant bit of the remainder.

6.2.5.2 CRC encoding procedure

The control packet is considered to be static. This means that the CRC-n checksum can be calculated *a priori* over the control packet.

The encoding procedure is as follows:

- i) The CRC-n bits in the control packet are replaced by binary 0s.
- ii) The control packet is then acted upon by the multiplication/division process referred to in 6.2.5.1.
- iii) The remainder resulting from the multiplication/division process is inserted into the CRC-n location in the control packet.

The CRC-n bits generated do not affect the result of the multiplication/division process because, as indicated in i) above, the CRC-n bit positions are initially set to 0 during the multiplication/division process.

6.2.5.3 CRC decoding procedure

The decoding procedure is as follows:

- i) A received control packet is acted upon by the division process referred to in 6.2.5.1.
- ii) If the remainder calculated in the decoder is zero, it is assumed that the checked control packet is error free.

6.2.6 Member Status (MST) field

Information about the status of all members of the same VCG is conveyed from Sk to So in the MST by member signals with control word ADD, NORM, EOS or DNU.

It reports the member status from Sk to So with two states: OK or FAIL (1 status bit per member). OK = 0, FAIL = 1. Since each control packet contains only a limited number of bits for communicating the MST field, this information is spread across multiple control packets, an MST multiframe.

The quantity of members in the VCG can be any number in the allocated range (e.g., 0-255 for High Order in SDH), and can be changed. For each member, the Sk uses the SQ number it receives from the So as the MST number for its response to the So. In this manner, the MST values received by the So will always correspond directly to the SQ values that it assigned.

NOTE – In the non-LCAS mode, the receiver function is provisioned to expect a fixed number of members.

To allow the receiver to determine the number of members in the VCG, the following should be noted. The highest non-failed active member will be indicating end of sequence (EOS) in the control field. The VCG may have other members with a higher SQ value in the do-not-use (DNU) state.

At initiation of a VCG sink all members shall report MST = FAIL. A transition to MST = OK occurs when a control packet is received for that member with a control field of ADD (or NORM or EOS after it has been added, or DNU after recovery from a network failure). All unused MST and members that have a control field of IDLE shall be set to FAIL.

6.2.7 Re-Sequence Acknowledge (RS-Ack) bit

When a renumbering of the sequence numbers of the members sending in CTRL field NORM, DNU, EOS, or when a change of the number of these members is detected at the Sk, a notification to the So per VCG has to be performed by toggling (i.e., change from '0' to '1' or from '1' to '0') the RS-Ack bit. In particular, the causes that trigger the toggling of RS-Ack bit can be listed as follows (see also SDL diagrams for a detailed description of RS-Ack use):

- SQ change for any VC of the VCG (SQ change detected by Sk for members in DNU/NORM/EOS);
- CTRL = "ADD" → CTRL = "EOS" and/or CTRL = "ADD" → CTRL = "NORM" (Addition of one or more members);
- CTRL = "NORM" (or "EOS") → CTRL = "IDLE" (Decrease bandwidth);
- CTRL = "DNU" → CTRL = "IDLE".

NOTE 1 – Following an ADD command from management interface (i.e., when a transition CTRL = IDLE → CTRL = ADD occurs), no RS-Ack has to be transmitted. In fact, RS-Ack should be toggled only when a change in sequence of the members belonging to the VCG is detected at the Sink. During the first phase of the addition of new members (IDLE to ADD state transition), even if a SQ assignment may happen, it does not yet affect the VCG, therefore no RS-Ack is needed.

The RS-Ack bit can only be toggled after the status of all members of the VCG has been evaluated and the sequence change has taken place. In case the RS-Ack is not sent to the So, the synchronization between Sk and So is achieved with the activation (during operations requiring a resequence or variation of the member's number in a VCG) of a RS-Ack time-out. The expiration of the time-out is equivalent to the detection of a toggled RS-Ack bit at So (refer to SDL protocol description, shown in Figures A.1 and A.7, for details). The toggling of the RS-Ack bit or the expiration of the RS-Ack time-out indicates that a new MST value can be considered. This means that MST values received in the control packet that contains the RS-Ack, and MST values received in subsequent control packets, correspond to the new sequence. The So can use this toggling as an indication that the change initiated by the So has been accepted and completed, and will start accepting new MST information.

NOTE 2 – No new change in the VCG should be executed, i.e., no member should be added or removed from the VCG, until the RS-Ack is received or the RS-Ack timeout has expired for the currently active change request.

6.3 VCG capacity increase (Addition of member(s))

When a member is added, it shall always be assigned a sequence number one larger than the currently highest sequence number that has EOS or DNU in the CTRL code. When multiple members are added, they must each use a unique sequence number so there will be a unique MST response for each additional member.

Following an ADD command, the first member to respond with MST = OK shall be allocated the next highest sequence number and shall change its CTRL code to EOS coinciding with the currently highest member changing its CTRL code to NORM (or remains DNU).

NOTE – When the CTRL = ADD is sent to initiate the addition of a new member, it shall be sent continuously until the MST = OK is received.