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Data over Transport – Generic aspects – General

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Internet protocol aspects – Transport

Hitless Adjustment of ODUflex(GFP) (HAO)

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ITU-T Recommendation G.7044/Y.1347

Hitless Adjustment of ODUflex(GFP) (HAO)

Summary

Recommendation ITU-T G.7044/Y.1347 defines hitless adjustment of ODUflex(GFP) (HAO) which provides a control mechanism to hitlessly increase or decrease the bandwidth of an ODUflex(GFP) connection in an OTN network.

ITU-T Recommendation G.7044/Y.1347

Hitless Adjustment of ODUflex(GFP) (HAO)

1 Scope

This Recommendation specifies hitless adjustment of ODUflex(GFP) (HAO) that should be used to hitlessly increase or decrease the bandwidth of an ODUflex(GFP) that is transported in an OTN network. The recommendation is based on the OTN signals specified in Recommendation G.709.

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.

[ITU-T G.798]	Recommendation ITU-T G.798 (2010), <i>Characteristics of optical transport network hierarchy equipment functional block</i> .
[ITU-T G.709]	Recommendation ITU-T G.709 (2009), <i>Interfaces for the Optical Transport Network (OTN)</i> .
[ITU-T Z.100]	Recommendation ITU-T Z.100 (2007), <i>Specification and Description Language (SDL)</i> .

3 Definitions

3.1 Terms defined elsewhere:

This Recommendation uses the following terms defined elsewhere:

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 GMP normal mode: The GMP normal mode is a mode of the GMP process that limits the change of Cn value in a narrow range which is decided by the ODUflex(GFP) bit rate, ODTUk.ts bit rate and their tolerances. The Cn value changes outside this range will be treated as errors and would cause alarm.

3.2.2 GMP special mode: The GMP special mode is a mode of the GMP process that permits the value of Cn change continuously but gradually and does not produce errors during ODUflex(GFP) bandwidth increase or decrease. The change of Cn value is controlled during resize to prevent buffer overflow/underflow.

3.2.3 OPUk multiframe: A number of consecutive frames accordant with the number of tributary slots for each OPUk. That means 8 frames for OPU2, 32 frames for OPU3, and 80 frames for OPU4.

3.2.4 Resize Multiframe (RMF): A number of consecutive frames accordant with the Lowest Common Multiple (LCM) of 256 and the number of tributary slots for each OPUk. That means 256 frames for ODU2/3 and 1280 frames for ODU4.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ACK	Acknowledge
BG	BWR Generator
BR	BWR Receiver
BRG	BWR Relay Generator
BRR	BWR Relay Receiver
BWR	Bandwidth Resize
CC	Consistent Configuration
C_m	number of m-bit client data entities
C_n	number of n-bit client data entities
C_{nD}	difference between C_n and $(m/n \times C_m)$
CRC	Cyclic Redundancy Check
CTRL	Control
CV	Consistent Verification
EMF	Equipment Management Function
FRR	Flex RCOH Receiver
GMP	Generic Mapping Procedure
HAO	Hitless Adjustment of ODUFlex
LC	Link Connection
LCR	Link Connection Resize
LG	LCR Generator
LR	LCR Receiver
MC	Matrix Connection
MSI	Multiplex Structure Identifier
NACK	Negative Acknowledge
NCS	Network Connectivity Status
ODU	Optical channel Data Unit
OH	Overhead
OPU	Optical channel Payload Unit
OTN	Optical Transport Network
PSI	Payload Structure Identifier
RCOH	Resize Control Overhead
RES	Reserved for future international standardization
RG	RCOH Generator
RMF	Resize Multiframe

RP	Resizing Protocol
RR	RCOH Receiver
SDL	Specification and Description Language
TPID	Tributary Port ID
TS	Tributary Slot
TSCC	Tributary Slot Connectivity Check
TSGS	Tributary Slot Group Status
TSOH	Tributary Slot Overhead
xI	CI or MI or AI

5 Conventions

Transmission order: 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 illustrated at the left in all the diagrams.

Value of reserved bit(s): The value of an overhead bit, which is reserved or reserved for future international standardization shall be set to "0".

6 Introduction

Hitless Adjustment of ODUflex(GFP) (HAO) is a resizing mechanism within the OTN that allows it to support an increase or decrease of ODUflex(GFP) client data rate across its entire end-to-end path. In many ways, it is similar to VCAT/LCAS. It should be noted that, unlike VCAT where each component of the end-to-end container is an ODUk which can be connected through the OTN independently from all other ODUk components of the same container, an ODUflex signal is carried over a single end-to-end path over a group of tributary slots on each HO OPUk of the path. ODUflex(GFP) resizing has the advantage over VCAT and LCAS that since all the TSs that carry the ODUflex(GFP) client signal follow the same path from the source of the OTN network to the sink, it is not necessary to compensate for the individual TSs having different timing delays. In addition, the ODUflex is a single managed entity rather than containing separate managed entities for each member of a VCAT group. It should also be noted that unlike VCAT/LCAS resizing, which requires participation by only the border NEs, HAO requires the participation of each and every NE along the ODUflex(GFP) path.

6.1 Methodology

HAO functionality in the ODUflex(GFP) to packet source and sink adaptation functions and in HO ODUk to LO ODUflex adaptation source and sink functions provides a control mechanism to hitlessly increase or decrease the capacity of an ODUflex(GFP) connection to meet the bandwidth needs of the application. To accomplish hitless bandwidth adjustment of an ODUflex(GFP) connection, all nodes in the connection must support the HAO protocol, otherwise, the connection requires tear down and rebuilding. The bit rate adjustment of the ODUflex(GFP) occurs simultaneously among all the nodes in the ODUflex(GFP) connection to prevent buffer overflow or underflow.

A resizable ODUflex(GFP) occupies the same number of tributary slots on every link of the server. In cases of bandwidth adjustment (i.e., increase or decrease), the same number of tributary slots (at

least one TS) on each link traversed by the resized ODUflex(GFP) must be involved. Resizable ODUflex(GFP) bit rates are specified in G.709/Table 7-8, illustrated in Figure 6-1, where n is the number of tributary slots that are assigned to the resizable ODUflex(GFP). The HAO application supports ODUflex(GFP) bandwidth increase or decrease from current n range to a different n range if the link of the server permits.

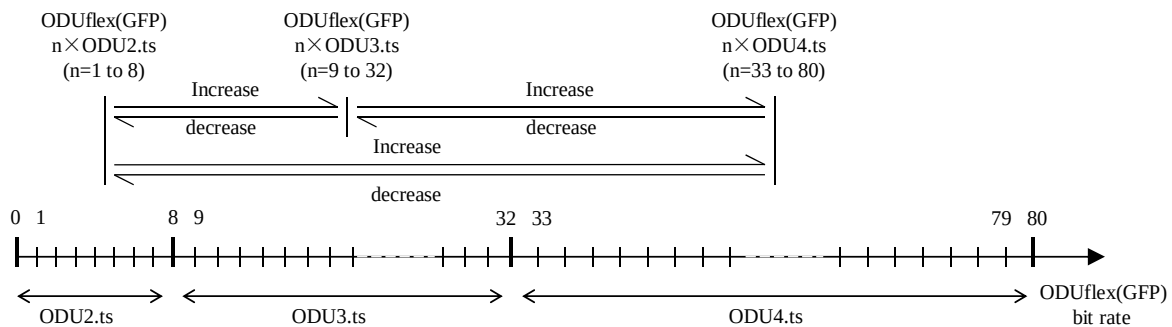


Figure 6-1 – Recommended ODUflex(GFP) bit rate in HAO capability

The modification of the ODUflex(GFP) link and matrix connection configurations are the responsibility of the network management or control plane.

6.2 Control overhead

Synchronization of changes in the capacity of an ODUflex(GFP) connection shall be achieved by Resize Control Overhead (RCOH). The RCOH consists of fields dedicated to a specific function. Changes are sent in advance so that the receiver can switch to the new configuration as soon as it arrives.

The RCOH is carried in the HO OPUk Tributary Slot Overhead (TSOH) and the OPUflex overhead as shown in Figure 6-2. These RCOH (RCOH1, RCOH2 and RCOH3) bytes are located in column 15, row 1, 2 and 3. The HO OPUk RCOH is carried in the tributary slot which is to be added or to be removed. If multiple tributary slots are involved in one resize operation, the protocol is carried in all of these TS RCOHs to be added or to be removed. The RCOHs of these TSs involved in the same resize operation are always the same and transmitted identically.

Note – This recommendation only specifies the RCOH for HAO protocol. For use of these bytes for other applications, refer to Recommendation G.709.

The RCOH is divided into two parts: Link Connection Resize (LCR) protocol overhead and Bandwidth Resize (BWR) protocol overhead.

The LCR protocol overhead includes the Control (CTRL) field, Tributary Port ID (TPID) field and Tributary Slot Group Status (TSGS) bit.

The BWR protocol overhead includes the Network Connectivity Status (NCS) bit, Tributary Slot Connectivity Check (TSCC) bit, Resizing Protocol indicator (RP) bit and Bandwidth Resize Indicator (BWR_IND) bit.

The LCR protocol bits, the RP bit and the TSCC bit in the BWR protocol are carried in HO OPUk (k= 2, 3, 4) Tributary Slot Overhead, and the NCS bit and BWR_IND bit in the BWR protocol are carried in the OPUflex overhead.

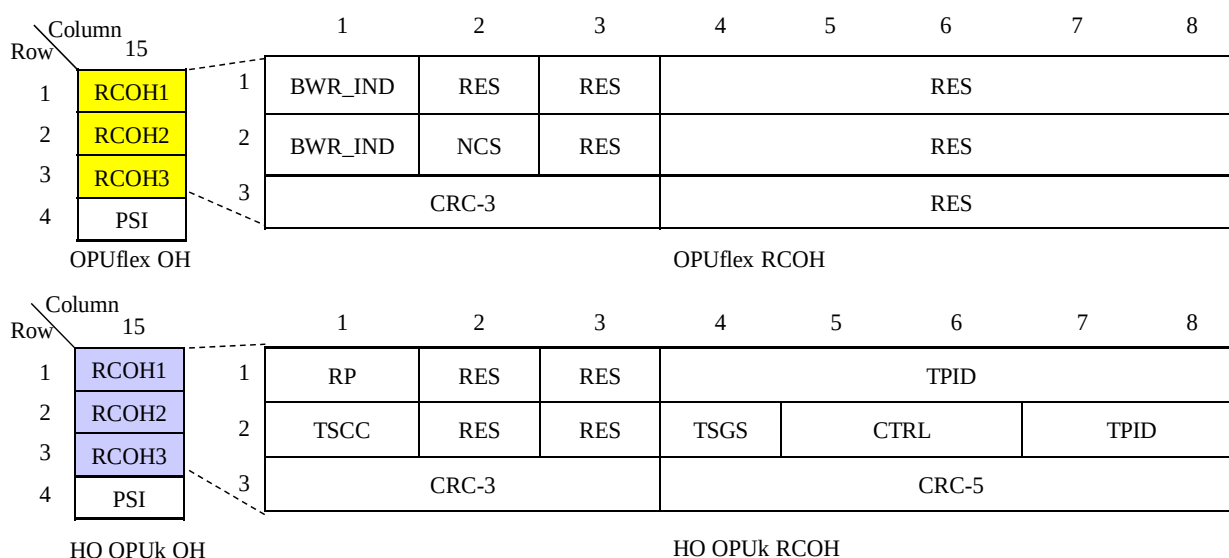


Figure 6-2 – RCOH format

This RCOH supports ODUflex(GFP) LCR control fields and ODUflex(GFP) BWR control fields. The default value of this RCOH is all-0's.

6.2.1 Control (CTRL) field

The control field is used to transfer LCR protocol status information from source to sink. It shall be used to provide the operation indication of the individual tributary slot that belongs to a specified ODUflex(GFP) connection. The CTRL field is carried in the LCR protocol overhead in HO OPUk (k=2, 3, 4) overhead row 2, column 15, bit 5 and bit 6.

Table 6-1 – HAO CTRL words

Value	Command	Remarks
00	IDLE	Indication that the node has completed LCR and there is no new LCR operation. IDLE may also be transmitted for a short time at operation start before transmission of the ADD/REMOVE command.
01	ADD	Indication that the tributary slot is to be added to the ODUflex(GFP) connection
10	REMOVE	Indication that the tributary slot is to be removed to the ODUflex(GFP) connection
11	NORM	Indication that LCR will be started at the next resize multiframe boundary when sending out NORM command after ADD or REMOVE command at the resize multiframe boundary

6.2.2 Tributary Port ID (TPID) field

The TPID field is used to identify the tributary port ID. The TPID field carries the tributary port number to which the tributary slot is to be added or to be removed. The TPID field is carried in the LCR protocol overhead in HO OPUk (k=2, 3, 4) overhead row 1, column 15, bits 4 to 8, and row 2, column 15, bit 7 and bit 8.

Figure 6-3 – TPID field coding

Row 1					Row 2	
4	5	6	7	8	7	8

000 0000: Tributary Port 1
000 0001: Tributary Port 2
000 0010: Tributary Port 3
000 0011: Tributary Port 4
:
10 01111: Tributary Port 80

6.2.3 Tributary Slot Group Status (TSGS) bit

The TSGS bit is used for link connection acknowledgement indication.

In the bandwidth increase case, the TSGS bit is generated by the HO OPU sink to acknowledge to the HO OPU source there is a match between the tributary slots indicated by the received CTRL and TPID as being added, and the provisioning for those tributary slots (by the management plane or control plane) at the sink end. It furthermore acknowledges that the HO OPU sink end is ready to receive the increase of the ODTUk.M into the ODTUk.M+N.

In the bandwidth decrease case, the TSGS bit is generated by the HO OPU sink to acknowledge to the HO OPU source that the ODUflex(GFP) bandwidth has been decreased and that it has exited GMP special mode after receiving TSCC=0 in So to Sk direction. It furthermore acknowledges that the HO OPU sink end is ready to receive the decrease of the ODTUk.M into the ODTUk.M-N.

The TSGS bit reports link connection acknowledgement with two values: ACK(1) and NACK (0). The TSGS bit is carried in the LCR protocol overhead in HO OPUk (k=2, 3, 4) overhead row 2, column 15, bit 4.

6.2.4 Tributary Slot Connectivity Check (TSCC) bit

The TSCC bit is used to check the connectivity of the link connection and ODUflex(GFP) connection. It carries signaling information associated with a TS being added or removed and is propagated hop by hop from the So to the Sk. Initially, the value of TSCC is set to 0.

During the resize period, TSCC =1 confirms GMP special mode at intermediate nodes and signals to the sink that all NEs in the source to sink direction are ready to support the bandwidth resizing operation.

After the ODUflex(GFP) resize operation is complete, TSCC=0 is used by the source to indicate the bandwidth resize completion and its exit from GMP special mode in the source to sink direction. It triggers exit from GMP special mode at the intermediate nodes and sink, and is only forwarded by intermediate nodes when they have exited GMP special mode.

The TSCC bit is defined as a BWR protocol overhead in HO OPUk (k=2, 3, 4) overhead row 2, column 15, bit 1.

6.2.5 Network Connectivity Status (NCS) bit

The NCS bit is used for a network connection acknowledgement indication. It is defined as an end-to-end acknowledgment indication in the OPUflex overhead. It is used by the ODUflex(GFP) sink to acknowledge to the ODUflex(GFP) source directly when the sink receives the correct TSCC value. The intermediate nodes do not need to process this signal since it is transparent to them.

When the sink receives TSCC=1, the NCS=1 is used by sink as an ACK for the source to the sink path resize preparation completion. When the sink receives TSCC=0, the NCS=0 is used by the sink to acknowledge the BWR completion. The NCS transparently passes through each intermediate node going back to source.

The NCS bit is defined as a BWR protocol overhead carried in the OPUflex overhead row 2, column 15, bit 2.

6.2.6 Resizing Protocol indicator (RP) bit

The RP bit is used to indicate whether the resizing protocol is carried in the RCOH. RP=1 indicates that the RCOH is carrying resizing protocol. When RP=0, these bytes carry overhead associated with the mapping specific information, such as GMP overhead (C_nD), as defined in Recommendation G.709. At the beginning of the resize operation, the RP bit should be set to 1 by the management plane or control plane. The RP bit is reset to 0 by the source as indicated below in order to indicate that it has exited all resizing protocol processing. The RP = 0 terminates the TSCC information relay and all other resizing processing operations in that direction at intermediate nodes. When an intermediate node receives RP = 0, it forwards it after confirming that it has exited GMP special mode and terminated LCR protocol processing in that direction. When the sink receives RP = 0, it confirms the exit from resizing processing by the source and all intermediate nodes. The sink can then report the resizing completion to network management or control plane.

The RP bit is defined as a BWR protocol overhead carried in the HO OPU_k (k=2, 3, 4) overhead row 1, column 15, bit 1.

6.2.7 Bandwidth Resize Indicator (BWR_IND) bit

The BWR_IND bit is used to indicate that the ODUflex(GFP) source is adjusting the ODUflex(GFP) signal's bit rate. It is set to "0" before ODUflex(GFP) signal's bit rate adjustment starts. Once it transitions from "0" to "1", the ODUflex(GFP) source shall start ramping $x \mu s$ later. When the BWR_IND will transition from "1" to "0", the ODUflex(GFP) source shall stop ramping $y \mu s$ later. x is almost equal to y and shall be in the range of 125 to 250 μs .

The BWR_IND is used to trigger the start of the ramp at the downstream nodes, and to signal the end of the ramp. Refer to 7.1.1 and 7.2.1.

The BWR_IND signal is encoded into bit 1 of both the ODUflex(GFP) RCOH1 and RCOH2 bytes, as illustrated in Figure 6-2. When BWR_IND is set, both bits are '1', and when it is reset both bits are '0'. The receiver determines a transition in the BWR_IND state after examining RCOH3. The CRC-3 values allow detection of an error affecting the BWR_IND bit in RCOH1 or RCOH2, and can be used to determine the correct value. The receiver rules are as follows:

The receiver determines that BWR_IND is set after examining RCOH1-RCOH3 when:

- The BWR_IND bits in both RCOH1 and RCOH2 are set to '1', or
- The BWR_IND bit in either RCOH1 or RCOH2 is set to '1' and the received CRC-3 has a value corresponding to the source sending BWR_IND set to '1' (and NCS set to '1').

The receiver determines that BWR_IND is reset after examining RCOH1-RCOH3 when:

- The BWR_IND bits in both RCOH1 and RCOH2 are set to '0', or
- The BWR_IND bit in either RCOH1 or RCOH2 is set to '0' and the received CRC-3 has a value corresponding to the source sending BWR_IND set to '0' (and NCS set to '1').

Otherwise, the receiver maintains its current value for the received BWR_IND.

Note: If the second and third bits of RCOH1 and the third bit of RCOH2 are '0' and the NCS bit is '1', the corresponding CRC-3 values are 110 when BWR_IND = 1 and 111 when BWR_IND = 0.

6.2.8 CRC field

To simplify the validation of the changes in the RCOH, a CRC field is used to protect the resizing protocol overhead. The RCOH is divided into two parts as shown in Figure 6-2. The CRC3 monitors the RP bit together with BWR protocol in HO OPU Overhead area and ODUflex(GFP) Overhead area. The CRC5 monitors the LCR protocol. Since the unused bits are 0 and the CRC