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Transport of IEEE 10GBASE-R in optical transport networks (OTN)

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Supplement 43 to ITU-T G-series Recommendations

Transport of IEEE 10GBASE-R in optical transport networks (OTN)

Summary

Supplement 43 to ITU-T G-series Recommendations describes several approaches for transport of 10G LAN PHY, and one for 10G WAN PHY, over SDH and OTN transport networks. As some of these approaches use rates, formats and mappings that are not defined in ITU-T Recommendations, this supplement analyses various attributes of the different approaches to provide guidance regarding their applicability to different network contexts.

This supplement relates to Recommendations ITU-T G.872, ITU-T G.709/Y.1331, ITU-T G.798, ITU-T G.707/Y.1322, ITU-T G.8010/Y.1306, ITU-T G.8012/Y.1308, ITU-T G.959.1 and ITU-T G.696.1.

Supplement 43 to ITU-T G-series Recommendations

Transport of IEEE 10GBASE-R in optical transport networks (OTN)

1 Scope

This supplement describes different approaches for transport of 10GBASE-R signals, and one for 10GBASE-W signals, in optical transport networks via an ODU2 or non-standard ODU2-like frame format (i.e., rates, formats and mappings that are not defined in ITU-T Recommendations). This supplement includes descriptions related to multiplexing the non-standard ODU2-like structures into ODU3-like signals. Different attributes of the varying solutions are described to help provide guidance on which approaches are appropriate to which network contexts.

Including a currently non-standard mapping in this supplement does not preclude considering that mapping for standardization at a future date.

2 References

- [ITU-T G.694.1] Recommendation ITU-T G.694.1 (2002), *Spectral grids for WDM applications: DWDM frequency grid*.
- [ITU-T G.696.1] Recommendation ITU-T G.696.1 (2005), *Longitudinally compatible intra-domain DWDM applications*.
- [ITU-T G.707] Recommendation ITU-T G.707/Y.1322 (2007), *Network node interface for the synchronous digital hierarchy (SDH)*.
- [ITU-T G.709] Recommendation ITU-T G.709/Y.1331 (2009), *Interfaces for the Optical Transport Network (OTN)*.
- [ITU-T G.798] Recommendation ITU-T G.798 (2006), *Characteristics of optical transport network hierarchy equipment functional blocks*.
- [ITU-T G.870] Recommendation ITU-T G.870/Y.1352 (2004), *Terms and definitions for optical transport networks (OTN)*.
- [ITU-T G.872] Recommendation ITU-T G.872 (2001), *Architecture of optical transport networks*.
- [ITU-T G.959.1] Recommendation ITU-T G.959.1 (2006), *Optical transport network physical layer interfaces*.
- [ITU-T G.7041] Recommendation ITU-T G.7041/Y.1303 (2008), *Generic framing procedure (GFP)*.
- [ITU-T G.8001] Recommendation ITU-T G.8001/Y.1354 (2006), *Terms and definitions for Ethernet frames over Transport (EoT)*.
- [ITU-T G.8010] Recommendation ITU-T G.8010/Y.1306 (2004), *Architecture of Ethernet layer networks*.
- [ITU-T G.8012] Recommendation ITU-T G.8012/Y.1308 (2004), *Ethernet UNI and Ethernet NNI*.

- [ITU-T G.8251] Recommendation ITU-T G.8251 (2001), *The control of jitter and wander within the optical transport network (OTN)*.
- [IEEE 802.3] IEEE 802.3-2008, *Information Technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and physical layer specifications*.

3 Definitions

None.

4 Abbreviations and acronyms

This supplement uses the following abbreviations and acronyms:

CBR10G	Constant Bit Rate signal of 9 953 280 kbit/s ± 20 ppm (see [ITU-T G.870])
CBR2G5	Constant Bit Rate signal of 2 488 320 kbit/s ± 20 ppm (see [ITU-T G.870])
FCS	Frame Check Sequence
FEC	Forward Error Correction
GFP	Generic Framing Procedure
GMP	Generic Mapping Procedure
IaDI	Intra-Domain Interface (see [ITU-T G.870])
IPG	Inter-Packet Gap
IrDI	Inter-Domain Interface (see [ITU-T G.870])
JC	Justification Control
JOH	Justification Overhead
MAC	Media Access Control
MFAS	MultiFrame Alignment Signal
MSI	Multiplex Structure Identifier
NJO	Negative Justification Opportunity
OCC	Optical Channel Carrier with full functionality (see [ITU-T G.870])
OCCr	Optical Channel Carrier with reduced functionality (see [ITU-T G.870])
ODU	Optical Data Unit
OH	Overhead
OPU	Optical Payload Unit
OTU	Optical Transmission Unit
PHY	Physical layer
PJO	Positive Justification Opportunity
PT	Payload Type
SDH	Synchronous Digital Hierarchy

SFD	Start-of-Frame Delimiter
SONET	Synchronous Optical Network
TS	Tributary Slot
TSOH	Tributary Slot Overhead
WAN	Wide Area Network

5 Conventions

Transmission order: The order of transmission of information in all the figures in this supplement 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 figures.

6 Standard mappings

6.1 10GBASE-W (WAN PHY) via STM-64

[IEEE 802.3] has defined a WAN interface for compatibility with SDH/SONET transport. In the Ethernet domain, this interface is supported via a WAN interface sub-layer (clause 50 of [IEEE 802.3]). For this interface the MAC reduces that limits the effective data rate of the XGMII from 10 Gbit/s to 9.95328 Gbit/s 9.29419 Gbit/s by inserting sufficient Idle characters (i.e., pads the effective 9.29419 Gbit/s data rate to the 10 Gbit/s XGMII bit rate). The physical coding sub-layer then deletes the extra Idles prior to 64B/66B coding (increasing the bit rate from 9.29419 Gbit/s to 9.58464 Gbit/s). The WAN interface sub-layer then performs the mapping into an SDH STM-64 (VC-4-64c), as illustrated in Annex F of [ITU-T G.707], (further increasing the bit rate to 9.95328 Gbit/s). ~~prior to 64B/66B coding and insertion in an SDH/SONET format frame. The mapping of this data into the frame of an SDH STM-64 (VC-4-64c) is illustrated in Annex F of [ITU-T G.707].~~

Even if the interface provides only the ± 20 ppm clock accuracy required by clause 50 of [IEEE 802.3], rather than SDH clock tolerances (± 4.6 ppm), this can be transported via ODU2 according to the mapping specified in clause 17.2.2 of [ITU-T G.709].

6.2 GFP-F mapping of 10GBASE-R (LAN PHY) payload only into OPU2

A payload information transparent mapping can be performed according to clause 17.4 of [ITU-T G.709] using the following process:

- Terminate (sink) the 64B/66B line code, preamble, SFD and IPG as per [IEEE 802.3].
- Apply GFP-F framing.
 - Encode into an OPU2 according to clause 7.3 ~~17.4~~ of [ITU-T G.709].

On the assumption that MAC frames do not on average exceed the maximum size specified by [IEEE 802.3] (~~1518~~ 2000 octets excluding the preamble, SFD and IPG), the bit rate required is for a signal that is $+100$ ppm from the nominal bit rate, approximately ~~9'922'968.791~~ 9'988'548.039 kbit/s.

If maximum size jumbo frames are used, the bit rate required for a signal that is $+100$ ppm from the nominal bit rate is approximately ~~9'995'002.399~~ 9'988'548.039 kbit/s.

Note that in the mapping of GFP frames into OPUk specified in clause 7.3 ~~17.4~~ of [ITU-T G.709], the entire OPU2 payload area of ~~9'995'277~~ 9'988'548.039 kbit/s is available (i.e., the fixed stuff bytes of the CBR10G mapping are not present). For an OPU2 that is running at the minimum rate of -20 ppm from the nominal value, this is reduced to ~~9'995'077.058~~ 9'988'548.039 kbit/s.

With standard IEEE 802.3 termination, this mapping can fully transport every ETH_CI traffic unit from a 10GBASE-R signal over an OPU2. Refer to Table V.4 of [ITU-T G.7041], where a characterization is given of the MAC rate throughput (not counting overhead) of 10GBASE-R signals versus GFP mappings. The MAC rate throughput of a 10GBASE-R interface, assuming a worst case situation of 9618-byte jumbo-frames is 9'986'502 bit/s. The MAC rate throughput of GFP mapping of the same MAC frames into ODU2 is 9'986'970 bit/s, which is greater than what is required to carry the entire MAC payload from a 10GBASE-R signal.

7 Non-standard mappings

This means rates, formats and mappings that are not fully defined in ITU-T Recommendations.

7.1 Bit transparent mapping of 10GBASE-R signal into OPU2e

This mapping has been moved to clause 17.2.4 of [ITU-T G.709].

With this mapping, the resulting OTU-like OTU2e signal must be clocked at a nominal bit rate of 11.0957 Gbit/s, as opposed to the standard OTU2 nominal bit rate of 10.709225316 Gbit/s.

7.2 Bit transparent mapping of 10GBASE-R signal into OPU1e

This mapping uses the mapping of a CBR2G5 signal into OPU1, defined in clause 17.2.1 of [ITU-T G.709]. It has the same attributes as the clause 7.2.4 7.4 mapping above, but since the fixed stuff bytes of the CBR10G mapping are not left free, the overall data rate is somewhat less (11.0491 Gbit/s rather than 11.0957 Gbit/s). As with the clause 7.2.4 7.4 option, the clock tolerance of the underlying Ethernet signal (± 100 ppm) rather than that of a standard OTU2 signal (± 20 ppm), standard methods for control of jitter and wander according to [ITU-T G.8251] do not apply.

A unique payload type (PT) shall be specified in the payload structure identifier (PSI). For example, code "0x80" (reserved code for proprietary use per Table 15-8 of [ITU-T G.709] – Payload type code points) is to be used.

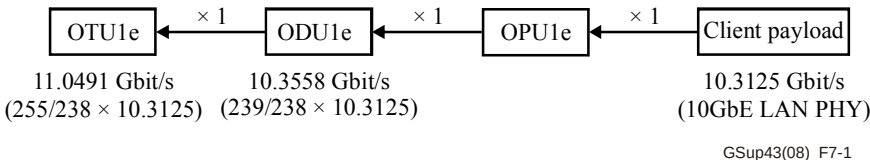


Figure 7-1 – Mapping structure without fixed stuffing

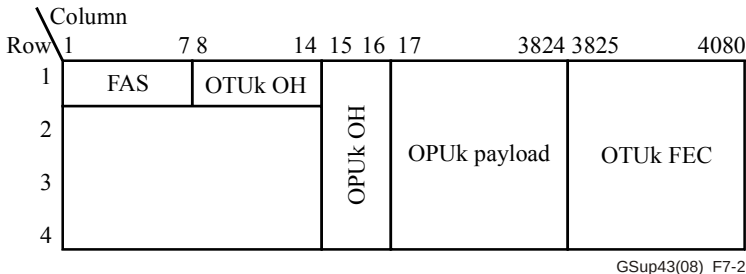


Figure 7-2 – Mapping frame without fixed stuff bytes

7.3 ITU-T G.709 bit-rate compliant information transparent transport of payload and preamble

This mapping has been moved to clause 17.4.1 of [ITU-T G.709] and clause 7.9 of [ITU-T G.7041].

8 Characteristics of alternative mappings

Table 8-1 provides a summary of the characteristics and applicability of each of the different mappings. Further discussion of each of these characteristics is provided in the indicated clauses.

Table 8-1 – Characteristics of alternative mappings

Mapping	Clause 6.1	Clause 6.2	Clause 7.1	Clause 7.2	Clause 7.3
ITU-T G.709 bit-rate compliant (clause 8.1)	Yes	Yes	<u>Yes</u> ~~No~~	No	Yes
IrDI/IaDI (clause 8.2)	Both	Both	IaDI only	IaDI only	Both
Clock tolerance of client Ethernet signal (clause 8.3)	±20 ppm (Note 1)	±100 ppm	±100 ppm	±100 ppm	±100 ppm
Clock tolerance of ODUxx signal (clause 8.3)	±20 ppm	±20 ppm	±100 ppm	±100 ppm	±20 ppm
Jitter/wander according to [ITU-T G.8251] (clause 8.3)	Yes	Yes	No	No	Yes
ITU-T G.959.1 optical tributary class (clause 8.4)	NRZ/RZ 10G	NRZ/RZ 10G	NRZ/RZ 40G	NRZ/RZ 40G	NRZ/RZ 10G
ITU-T G.696.1 client class (clause 8.4)	10G	10G	40G	40G	10G
Multiplex to 40G according to [ITU-T G.709] (clause 8.5)	Yes	Yes	<u>Yes</u> ~~No~~ (Note 4)	No	Yes
Transport full rate payload (clause 8.6)	No	Yes	Yes	Yes	Yes
Transport ordered sets (clause 8.6)	Yes	No	Yes	Yes	Yes (Note 3)
Transport full rate preamble and payload (clause 8.6)	Yes	No	Yes	Yes	Yes
Transport IPG (clause 8.6)	Yes	No	Yes	Yes	No
Full bit transparency (clause 8.6)	Yes	No	Yes	Yes	No
Support undisclosed proprietary usage of MAC or PCS sublayer (clause 8.6)	Yes	No	Yes	Yes	Yes (Note 2)
BER monitoring based on PCS (clause 8.7)	Yes	No	Yes	Yes	No

Table 8-1 – Characteristics of alternative mappings

Mapping	Clause 6.1	Clause 6.2	Clause 7.1	Clause 7.2	Clause 7.3
NOTE 1 – [IEEE 802.3] specifies ± 20 ppm for the clock tolerance for a 10GBASE-W interface. [ITU-T G.707] indicates that 10GBASE-W signals that meet the stricter clock tolerance of ± 4.6 ppm may be transported as STM64 in an SDH network. However, the mapping into ODU2 supports any CBR10G signal including STM64 and 10GBASE-W that has a clock tolerance of ± 20 ppm. NOTE 2 – Proprietary usage of the preamble is supported. Proprietary usage of the IPG is not. NOTE 3 – While ordered sets are transported, if the ordered sets are close together there is no guarantee that all will be transported or that their original transmitted sequence will be preserved. See [ITU-T G.709] and [ITU-T G.7041]. NOTE 4 – <u>Three of these signals can be multiplexed into an OPU3 it is structured to use GMP into 1.25Gbit/s Tributary Slots</u>					

8.1 ITU-T G.709 bit-rate compliant

The ITU-T G.709 bit rate that is generally used to transport signals of approximately 10 Gbit/s is OPU2. The nominal bit rate for an OPU2 payload is 9'995'276.962 kbit/s. This may transport signals directly via mappings such as GFP-F or via STM-64 using the CBR10G mapping specified in clause 17.2.2 of [ITU-T G.709]. Mappings that comply with the [ITU-T G.709] bit rate are networkable signals according to the OTN architecture specified in [ITU-T G.872].

8.2 Inter-domain/intra-domain interfaces

[ITU-T G.872] specifies two different types of interfaces to be used in the optical transport network. Inter-domain interfaces (IrDI) are standardized interfaces that may be used at handoff points between operators or between equipment from different vendors within an operator's environment. Intra-domain interfaces (IaDI) are generally applicable only within a single-vendor island within an operator's network to enable the use of unique optical technology, dispersion management, etc., in the context of long-haul optical line systems.

The mappings of 10GBASE-R signals via OPU2e and OPU1e according to clauses 7.1 and 7.2 are inherently intra-domain interfaces except where OPU2e is mapped into an OTU3 or OTU4. They are not standard ITU-T G.709 bit-rate signals. They do not interwork with standard mappings of Ethernet, e.g., using GFP-F. The two over-clocked mechanisms do not interwork with each other. As a result, such signals are generally only deployed in a point-to-point configuration between equipment that implements the same mapping.

8.3 Timing and synchronization

The timing tolerance for ITU-T G.709 signals is ± 20 ppm. The timing tolerance for 10GBASE-R Ethernet signals is ± 100 ppm. Mappings that simply wrap the Ethernet signal in an ITU-T G.709-like frame (e.g., those described in clauses 7.1 and 7.2) derive their timing from the Ethernet signal, and hence have a timing accuracy of ± 100 ppm.

The control of jitter and wander for ITU-T G.709 signals having a timing accuracy of ± 20 ppm has been extensively analysed in [ITU-T G.8251]. No such analysis has been done for Ethernet-based signals with a timing accuracy of ± 100 ppm. Signals with a timing accuracy of ± 100 ppm should generally only be deployed in point-to-point situations where jitter and wander accumulation is not an issue.