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Supplement on sub 1 Gbit/s services transport over optical transport network

ITU-T G-series Recommendations – Supplement 70

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Supplement 70 to ITU-T G-series Recommendations

Supplement on sub 1 Gbit/s services transport over optical transport network

Summary

Supplement 70 to ITU-T G-series Recommendations describes existing and a synchronous digital hierarchy (SDH) based method to support the transport of sub-1G signals through the optical transport network (OTN). A sub-1G signal is a digital signal whose bit rate is included in a range from nominally 2 Mbit/s to less than nominally 1 Gbit/s.

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Supplement 70 to ITU-T G-series Recommendations

Supplement on sub 1 Gbit/s services transport over optical transport network

1 Scope

This Supplement describes existing methods and a synchronous digital hierarchy (SDH) based method to support the transport of sub-1G signals through the optical transport network (OTN). A sub-1G signal is a digital signal whose bit rate is included in a range from nominally 2 Mbit/s to less than nominally 1 Gbit/s. Sub-1G signals include, for example, E1 and E3 signals according to [ITU-T G.703], VC-12, VC-3 and VC-4 signals according to [ITU-T G.707], STM-1 or STM-4 signals according to [ITU-T G.707] and fast Ethernet 100BASE-TX/FX according to clause 21 of [IEEE 802.3].

Existing methods include, for example, mapping the sub-1G service signal into ODU0 as specified in [ITU-T G.709], mapping the sub-1G service signal into SDH VC-n that are aggregated to STM-N and mapped into ODUk and circuit emulation of the sub-1G service signal and mapping into Ethernet virtual local area network (VLAN) or multiprotocol label switching-transport profile (MPLS-TP) pseudowire (PW) with optional packet aggregation and mapping into ODUk/flex. The SDH-based method is intended to describe OTN frame structures that channelize the payload of an existing ODU0, providing a method of aggregating sub-1G service signals in a bandwidth-efficient manner, and support monitoring and protection of sub-1G services.

2 References

[ITU-T G.703] Recommendation ITU-T G.703 (2016), *Physical/electrical characteristics of hierarchical digital interfaces*.

[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 (2020), *Interfaces for the optical transport network*.

[ITU-T G.7041] Recommendation ITU-T G.7041/Y.1303 (2016), *Generic framing procedure*.

[ITU-T G.8021] Recommendation ITU-T G.8021/Y.1341 (2018), *Characteristics of Ethernet transport network equipment functional blocks.*

[IETF RFC 4553] IETF RFC 4553 (2006), *Structure-Agnostic Time Division Multiplexing (TDM) over Packet (SAToP)*.

[IETF RFC 4842] IETF RFC 4842 (2007), *Synchronous Optical Network/Synchronous Digital Hierarchy (SONET/SDH) Circuit Emulation over Packet (CEP)*.

[IEEE 802.3] IEEE 802.3 – 2018, *IEEE Standard for Ethernet*.

3 Definitions

3.1 Terms defined elsewhere

This Supplement uses the following terms defined elsewhere:

3.1.1 ODUk [ITU-T G.709].

3.1.2 AU-n [ITU-T G.707].

3.1.3 STM-N [ITU-T G.707].

3.1.4 TU-n [ITU-T G.707].

3.1.5 VC-n [ITU-T G.707].

3.1.6 GFP [ITU-T G.7041].

3.2 Terms defined in this Supplement

This Supplement defines the following terms:

3.2.1 micro tributary slot (MTS): The MTS is an increment of bandwidth which when multiplied by a number of micro tributary slots gives the recommended size of an OSDUk optimized to occupy a given number of micro tributary slots of an OPU0.

3.2.2 optical SDH-based data unit (OSDU): The OSDU is an information structure consisting of the information payload (OSPU) and OSDU related overhead. The index k is used to identify the approximate bit rate and different versions.

NOTE – The index "k" is used to represent a supported bit rate and the different versions of OSPUk and OSDUk.

3.2.3 optical SDH-based payload unit (OSPU): The OSPU is the information structure used to adapt client information for transport inside an OPU0. It comprises client information together with any overhead needed to perform rate adaptation between the client signal rate and the OSPU payload rate, and other OSPU overheads supporting the client signal transport. The index k is used to identify the approximate bit rate and different versions.

NOTE – The index "k" is used to represent a supported bit rate and the different versions of OSPUk and OSDUk.

3.2.4 sub-1G signal: A sub-1G signal is a digital signal whose bit rate is included in a range from nominally 2 Mbit/s to less than nominally 1 Gbit/s.

4 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

CBR	Constant Bit Rate
CO	Central Office
DVB-ASI	Digital Video Broadcast – Asynchronous Serial Interface
ELPS	Ethernet Linear Protection Switching
EMFI	Extended Multiframe Indicator
ERPS	Ethernet Ring Protection Switching
GFP	Generic Framing Procedure
GMP	Generic Mapping Procedure
IP	Internet Protocol
LSP	Label Switched Path
MPLS	Multi-Protocol Label Switching
MPLS-TP	Multiprotocol Label Switching-Transport Profile
MSI	Multiplex Structure Identifier
MTS	Micro Tributary Slot
OAM	Operation, Administration and Maintenance

ODU	Optical Data Unit
ODUk	Optical Data Unit-k
OSDU	Optical SDH-based Data Unit
OSDTUG0	Optical SDH-based Data Tributary Unit Group-0
OSDTUk	Optical SDH-based Data Tributary Unit k
OSDUk	Optical SDH-based Data Unit-k
OSPU	Optical SDH-based Payload Unit
OTN	Optical Transport Network
PDH	Plesiochronous Digital Hierarchy
PPP	Point-to-Point Protocol
PT	Payload Type
PW	Pseudowire
SDH	Synchronous Digital Hierarchy
TDM	Time Division Multiplexing
VLAN	Virtual Local Area Network

5 Conventions

k: The index "k" is used to represent a supported bit rate and the different versions of OSPUk and OSDUk.

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 Introduction

Figure 1 below shows the intended network topology of supporting sub-1G signals in OTN. A sub-1G signal is a digital signal whose bit rate is included in a range from nominally 2 Mbit/s to less than nominally 1 Gbit/s. The interface to the OTN network will be via existing ITU-T G.709 OTN interfaces.

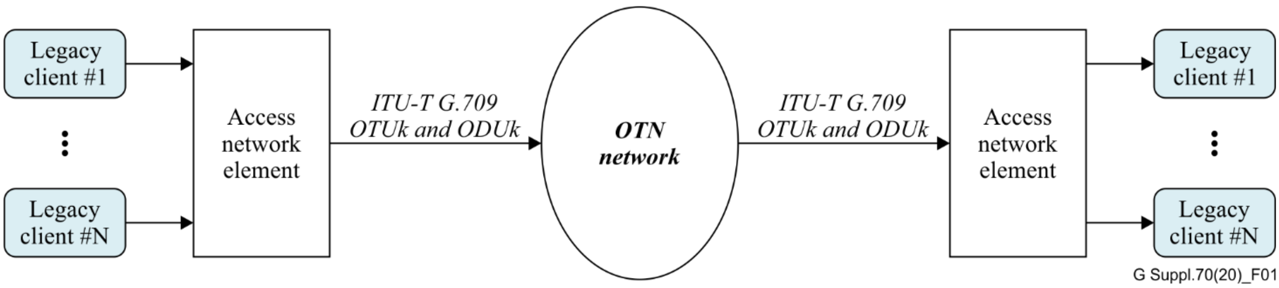


Figure 1 – Model of OTN network supporting sub-1G clients

Transport of sub-1G signals in access domain is mainly used for private line application. Generally, the transport device in access domain is placed at the customer equipment room, or at the edge of the central office (CO) equipment room, and it is directly connected to the customer device. It can provide access for, for example, E1, E3, E4, VC12, VC3, VC4, FE and packet services.

This Supplement first describes methods for mapping sub-1G client signals into the OTN that make use of existing ITU-T Recommendations. Second, this Supplement describes an SDH-based mechanisms for carrying sub-1G signals with greater efficiency than is available using existing methods.

7 Mappings based on normative methods

A number of standard mechanisms are available to carry sub-1G clients over an OTN. The mechanisms listed in this clause are not necessarily mutually exclusive; multiples of them may be employed simultaneously to carry sub-1G clients with different needs for monitoring and switching within the same high order ODU.

7.1 CBR mapping to ODU0

Clause 17.7.1 of [ITU-T G.709] provides a mapping of sub-1.238G constant bit rate (CBR) clients into ODU0, and specifically describes its use for STM-1, STM-4, FC-100, SBCON/ESCON, DVB-ASI, SDI, and transcoded 1000BASE-X clients. As the mapping used is the generic mapping procedure (GMP), it can also be used to support other sub-1.238G CBR clients.

Using this mapping, each client occupies an ODU0. Mapping clients in this manner allows each client to be treated individually for operation, administration and maintenance (OAM), protection, and switching purposes, but sacrifices efficiency for clients with bit rates much less than 1 Gbps.

7.2 Using SDH to aggregate low speed CBR clients prior to mapping to OTN

The example in Figure 2 illustrates a deployment scenario using existing SDH to aggregate sub-1G signals and transport the SDH signals over OTN. In this scenario, sub-1G signals are first converged via SDH VC to STM-N, for example STM-16 or STM-64. Then, the STM-N signal is mapped into ODUj (j = 0, 1, 2, 3). The ODUj signal is then transported via ODUk/Cn/FlexO in the traditional OTN metro or backbone networks. SDH cross connect function is embedded in a subset of the OTN equipment and the SDH cross connect function performs the sub-1G switching. SDH SNC protection can be configured to implement end-to-end protection for sub-1G service. It requires that working and protection SDH entities should be transported over different OTN paths.

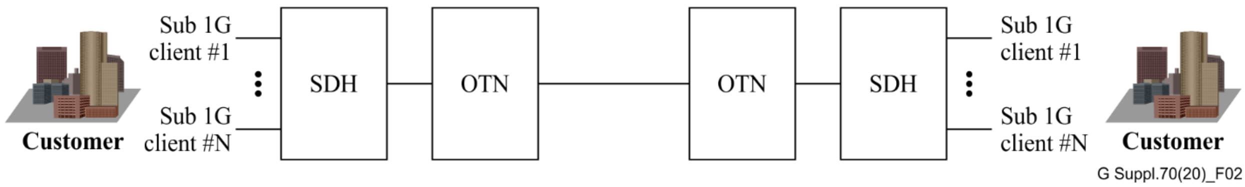


Figure 2 – Example of sub-1G signals transport over OTN via SDH for aggregation

Clause 17.7.1 of [ITU-T G.709] describes mapping of STM-1 and STM-4 to ODU0; clause 17.2 of [ITU-T G.709] describes mapping of STM-16 into ODU1 and STM-64 into ODU2. Clause 10 of [ITU-T G.707] describes mapping a variety of clients into SDH virtual containers, including plesiochronous digital hierarchy (PDH) traffic (clause 10.1) and GFP frames (clause 10.6). Clauses 7 and 8 of [ITU-T G.7041] describe mapping a variety of packet-based or 8B/10B-encoded clients into GFP-F or GFP-T frames, including Ethernet, fibre channel, point-to-point protocol (PPP), multi-protocol label switching (MPLS), Internet protocol (IP), and digital video broadcast – asynchronous serial interface (DVB-ASI). Collectively, these Recommendations provide a standard mechanism for using SDH to channelize an ODU0, ODU1, or ODU2 into VC-n tributary slots that can be used to carry sub-1G clients across an OTN.

In the absence of an SDH network to which the client signals must be connected, the use of SDH for the purpose of channelizing an ODUk in an OTN network does not require a complex synchronization distribution network or management of all the SDH layers. All the SDH layers are point to point in this application, and as such the VC-n can be viewed as if they are tributary slots of the ODUk. The granularity of OAM, switching, and protection within the OTN is at the ODUk layer. If individual client level OAM, switching, and protection is necessary, a VC-n connection function is required. Such a function may not be necessary in all nodes in the OTN; a few centralized locations could provide VC-n groom-and-fill functions.

7.3 Aggregating packet clients and mapping via GFP-F with linear extension

Sub-1G traffic that is packet-based can be aggregated into a larger OTN container by mapping the traffic into GFP as described in clauses 7 and 8 of [ITU-T G.7041] and using the linear extension of GFP, as described in clause 6.1.2.1.3 of [ITU-T G.7041], to enable mapping multiple client flows into the same ODU with the mapping described in clause 17.10 of [ITU-T G.709]. The linear extension header provides separation of individual client streams within the ODU server layer.

The granularity of OAM, switching, and protection is at the ODUk layer. Individual client OAM, switching, and protection cannot be supported with this mechanism without demultiplexing back to the client layers.

7.4 Aggregating packet clients at layer 2 and mapping to OTN via GFP-F

Sub-1G traffic that is carried via Ethernet can be aggregated at the Ethernet MAC layer (optionally using VLAN tags to separate individual flows) as described in [ITU-T G.8021]. The aggregated stream can then be mapped via GFP into an ODU as described in clause 17.10 of [ITU-T G.709].

The granularity of OAM, switching, and protection is at the ODUk layer. Individual client OAM, switching, and protection can be supported via layer 2 functions in nodes. Such functions may not be necessary in all nodes in the OTN; a few centralized locations could provide Ethernet switching functions.

This concept can be generalized to the case of any other packet-based transport of the client traffic; aggregation of multiple flows can occur in the packet domain, with the aggregate stream being mapped into an ODU of the appropriate size.

7.5 Aggregating packet clients at layer 2 and mapping to OTN

The example in Figure 3 illustrates a deployment scenario of using existing L2 (Ethernet VLAN or MPLS-TP PW) technologies to aggregate sub-1G signals and transport L2 traffic over OTN. In this scenario, sub-1G signals are first converged via L2 to Ethernet, for example 1GE or 10GE. And then Ethernet is mapped into ODUj (j = 0, 2, 2e...). The ODUj signal is then transported via ODUk/Cn/FlexO in the traditional OTN metro or backbone networks. Ethernet/MPLS-TP switching function is embedded in a subset of the OTN equipment and the Ethernet/MPLS-TP switching function performs the sub-1G switching. Label switched path (LSP) SNC protection can be configured to implement end-to-end protection for sub-1G service. It requires that working and protection LSP entities should be transported in different OTN paths.

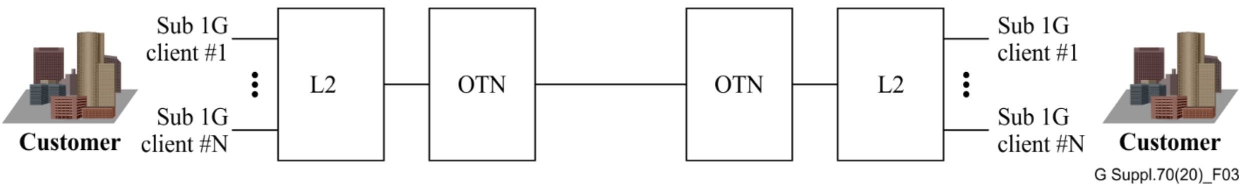


Figure 3 – Example of sub-1G signals transport over OTN via L2 aggregation

7.6 Aggregating packet clients at layer 2, over SDH and mapping to OTN

The example in Figure 4 illustrates a deployment scenario of using existing L2 technologies to aggregate sub-1G signals, transport L2 traffic over SDH, and finally mapping the SDH signals into

OTN. In this scenario, sub-1G signals are first converged via L2 to Ethernet, for example 1GE or 10GE. And then Ethernet is mapped into SDH, then SDH is further mapped into ODUj (j = 0, 2, 2e...). Finally, the ODUj signal is transported via ODUk/Cn/FlexO in the traditional OTN metro or backbone networks. SDH cross connect or Ethernet/MPLS-TP switching functions are embedded in a subset of the OTN equipment and these SDH cross connect or Ethernet/MPLS-TP switching functions perform the sub-1G switching. Ethernet ring protection switching/Ethernet linear protection switching (ERPS/ELPS) protection or SDH SNC protection can be configured to implement end-to-end protection for sub-1G service. It requires that working and protection VLAN or SDH entities should be transported in a different OTN path.

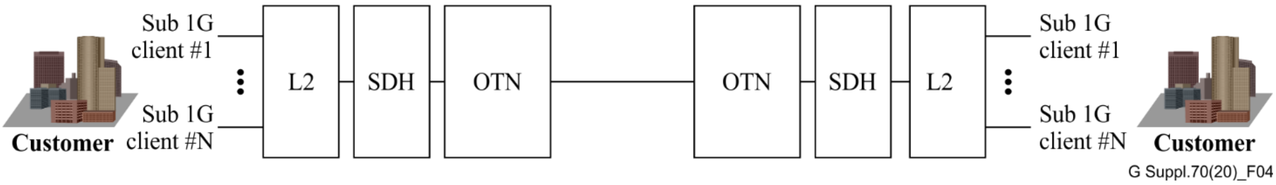


Figure 4 – Example of sub-1G signals transport over SDH over OTN via L2 aggregation

7.7 Circuit emulation of CBR clients over MPLS

CBR clients can be circuit-emulated over an MPLS network, allowing the mechanisms described in clauses 6.3 or 6.4 to be used for carrying the CBR traffic along with other sub-1G packet traffic over an OTN. [IETF RFC 4553] describes circuit emulation of PDH traffic. [IETF RFC 4842] describes circuit emulation of SDH traffic.

The use of circuit emulation for CBR streams enables individual monitoring, switching, and protection of CBR client streams in nodes that are MPLS-aware.

8 Mappings based on new methods

8.1 Method based on modified SDH constructs

The example in Figure 5 illustrates a deployment scenario of using an SDH-based method to support the transport of sub-1G signal directly into OTN. In this scenario, sub-1G signals are directly mapped into ODU0 via the OSDTUG0 that is based on SDH constructs with fine grained tributary slots. The ODU0 signal is then transported via ODUk/Cn/FlexO in the traditional OTN metro or backbone networks. The OSDUk layer should be switchable in the access OTN equipment. OSDUk SNC protection can be configured to implement end-to-end protection for sub-1G service. It requires that working and protection OSDUk entities should be transported in different OTN paths.

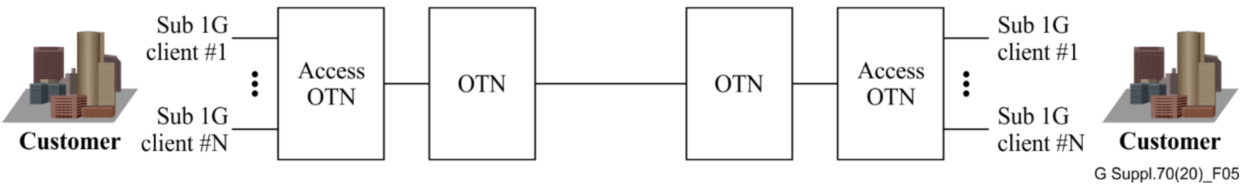


Figure 5 – Example of sub-1G signals transport over end-to-end OTN

8.1.1 Motivation

There is currently a large installed base of SDH equipment in the network. However, a number of vendors are announcing end of sale/end of support of their SDH equipment. However, in many countries, E1 services belong to a regulated, highly profitable market. The SDH-based sub-1G methodology described in this clause addresses these network events.

An important observation to note is networks are never migrated in a single step but progressively in several phases, spaced over time:

– Figure 6 shows an example to explain the rationale (real cases might be different) and implies the end-to-end extension of the circuits between an "Access new OTN area" and legacy SDH islands. The interworking of the circuits between different areas, possibly provided by different vendors, is guaranteed by keeping end-to-end SDH VC networking during the migration phase.

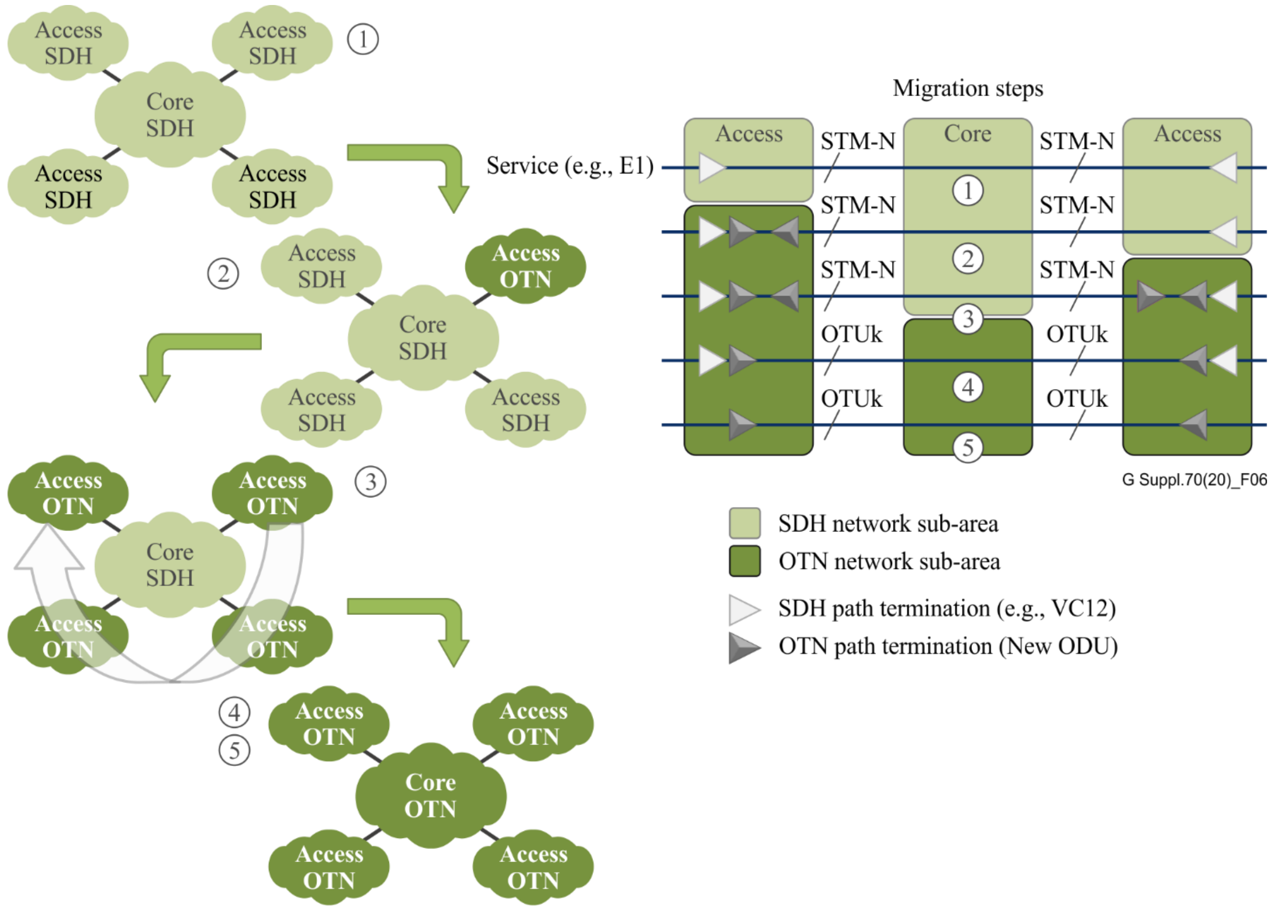


Figure 6 – Progression of network evolution away from SDH to OTN

– As a consequence, the SDH VC management should be maintained until the migration of the entire network is completed, then the SDH can finally be removed. This implies that the addressed technology should map both clients and corresponding SDH containers, and allow for moving from a mapping to the other one in a seamless way.

– Maximum similarity should be kept with SDH from the point of view of networking performance (BER detection capability, alignment times, jitter and wander, etc.).

– Moreover, the solution must also be cost effective at network boundaries, for example between the core and access networks shown in the figure. This is because at network boundaries, circuits under migration are all bundled in high speed interfaces (STM16 and/or STM64) and the complexity of "transforming" all those circuits from SDH to a completely different technology may be very high.

8.1.2 Introduction

Figure 7 shows the relationship between the OSDUk layer and the existing OTN ODUk layers. OSDUk is a client of the ODU0.

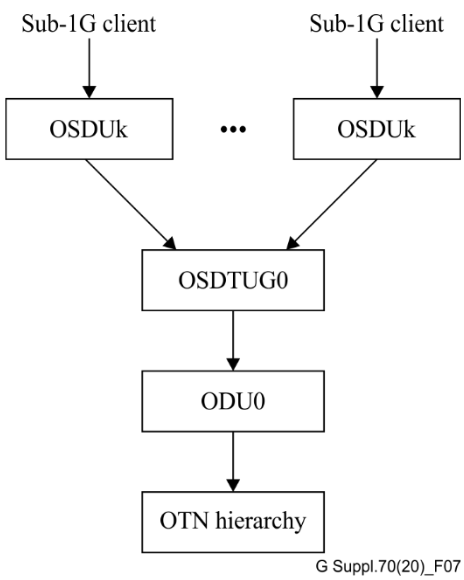


Figure 7 – Relationship between OSDUk and OTN Hierarchy

Currently, three OSDUk frame formats are defined, k = 4, k = 3 and k = 12, which are related to SDH virtual containers VC-4, VC-3 and VC = 12, respectively, with OTN overhead added.

The method based on modified SDH constructs uses time division multiplexing (TDM) to multiplex OSDUk streams into an OPU0 carrier stream. Figure 8 shows how various signals are multiplexed using the OSDTUG0 (PT = X) multiplexing elements. An OSDUk signal is extended with a pointer to form an OSDTUk. Multiple OSDTUk frames can be multiplexed into an OSDTUG0 Group. The OSDTUG0 is an 8 kHz SDH-like structure, with roughly "STM-8" granularity and is BMP mapped into the payload area of the OPU0 carrier. The OSDU mapping specific OPU0 overhead is the OPU0 overhead and stuff bytes specific to mapping of OSDU clients into the OPU0. It is shown as OPU0 Map OH in Figure 8.

The value of payload type (PT) should be chosen from the proprietary use range (0x80-0x8F) in Table 15-8 of [ITU-T G.709]. A PT value of X = 0x85 is suggested.

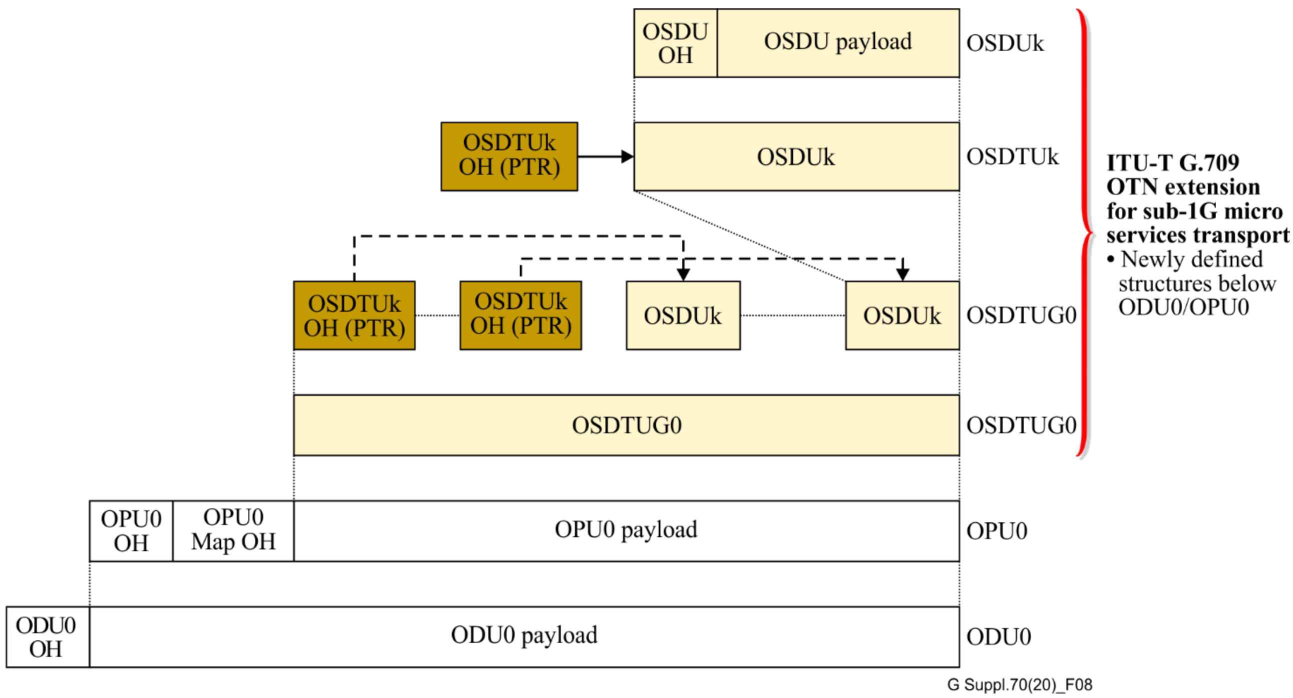


Figure 8 – Cascaded SDH and OSDUk functional model

8.1.3 OSDTUG0 frame structure

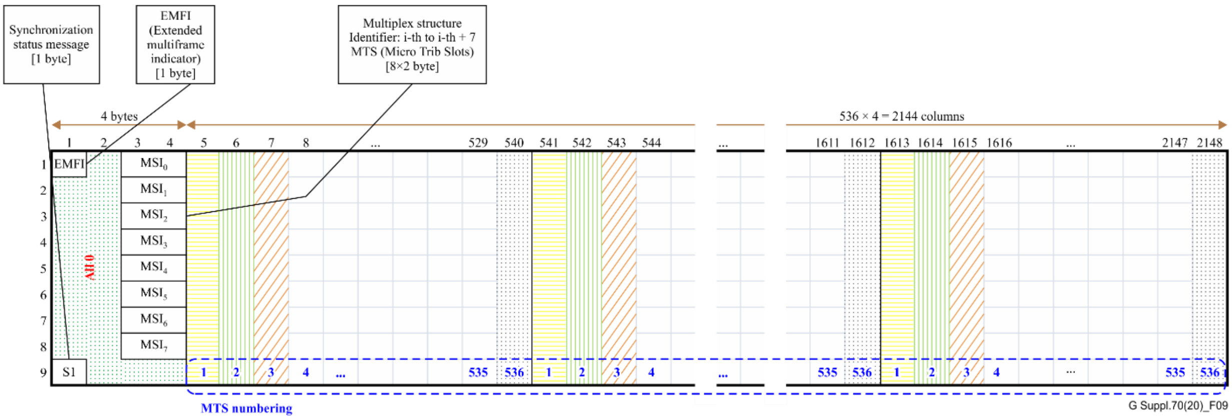
The OSDTUG0 group is defined in the following way:

– The OSDTUG0 is structured as a shortened form of an "STM-8" frame that can be synchronously (BMP) mapped in the payload area of an OPU0.

– An OSDTUG0 is partitioned in an integer number of nominally 2 Mb/s micro tributary slots (MTS).

– Each OSDUk is assigned one (k = 12) or multiple (k = 3, 4) MTS.

Figure 9 shows the frame format of an OSDTUG0. It is a byte-organized structure of 9 rows and 2184 columns. Each MTS byte in the frame has a nominal bandwidth of 64 kb/s (as with SDH). The nominal period of an OSDTUG0 frame is 125 µs, and the nominal bitrate of the OSDTUG0 is (2148*9*8)/125 µs = 1 237 248 kbit/s.



Legend:
EMFI (extended multiframe indicator – 1 byte) – 1st byte used as "meta-frame" counter to address MTSs and specify the multiplex structure.
S1 (Synchronization status – 1 byte) – Allocated for synchronization status messages.
MSI (multiplex structure identifier – 16 bytes) – MSI definition is derived from [ITU-T G.709] and consists in one 2-tuple per MTS.

Figure 9 – OSDTUG0 Frame with Overhead and MTS Structure

8.1.4 Mapping of OSDTUG0 into an OPU0

An OSDTUG0 is mapped into the payload area of an OPU0 using BMP, as shown in Figure 11. The OSDTUG0 is phase locked to the OPU0 and the ratio between the two frame periods is 19440:15296 = 1215:956 i.e., the period of 1215 ODU0 frames equals the period of 956 OSDTUG0 frames. The number of bytes in 956 OSDTUG0 frames (956×9×2148 = 18,481,392) and the payload bytes in 1215 OPU0 frames (1215×4×3808 = 18,506,880) differs by 18,506,880–18,481,392 = 25488 = 27×(44×21+1×20) bytes. Hence for bit rate matching, 20 payload bytes are "stuffed out" once every 45 ODU0 frames and 21 bytes from each of the remaining 44 frames. The 21st stuff byte is located at row 1 column 22 of the OPU0, as shown in Figure 11. A multi-frame counter (MF) is used to indicate OPU0 frames with 20 and 21 stuff byes using the following equation:

If (MF Mod 45 = 0) then Payload_stuff = 20 bytes
else Payload_stuff = 21 bytes

At MF = 0, the OSDTUG0 is aligned to row 1, column 22 of the OPU0 frame. The alignment returns to this location every 1215 frames. It is, therefore, possible to locate the boundaries of OSDTUG0 using the MF value. MF has a range of 0 to 1214.

The MF field is located in row 1 of the OSDU mapping specific OPU0 overhead region (OPU0 columns 17 to 18). The format of MF is shown in Figure 10.

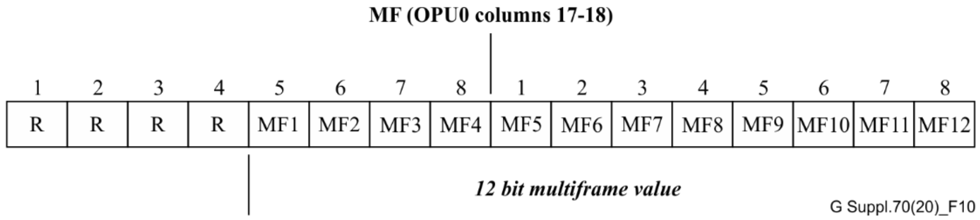


Figure 10 – MF byte format

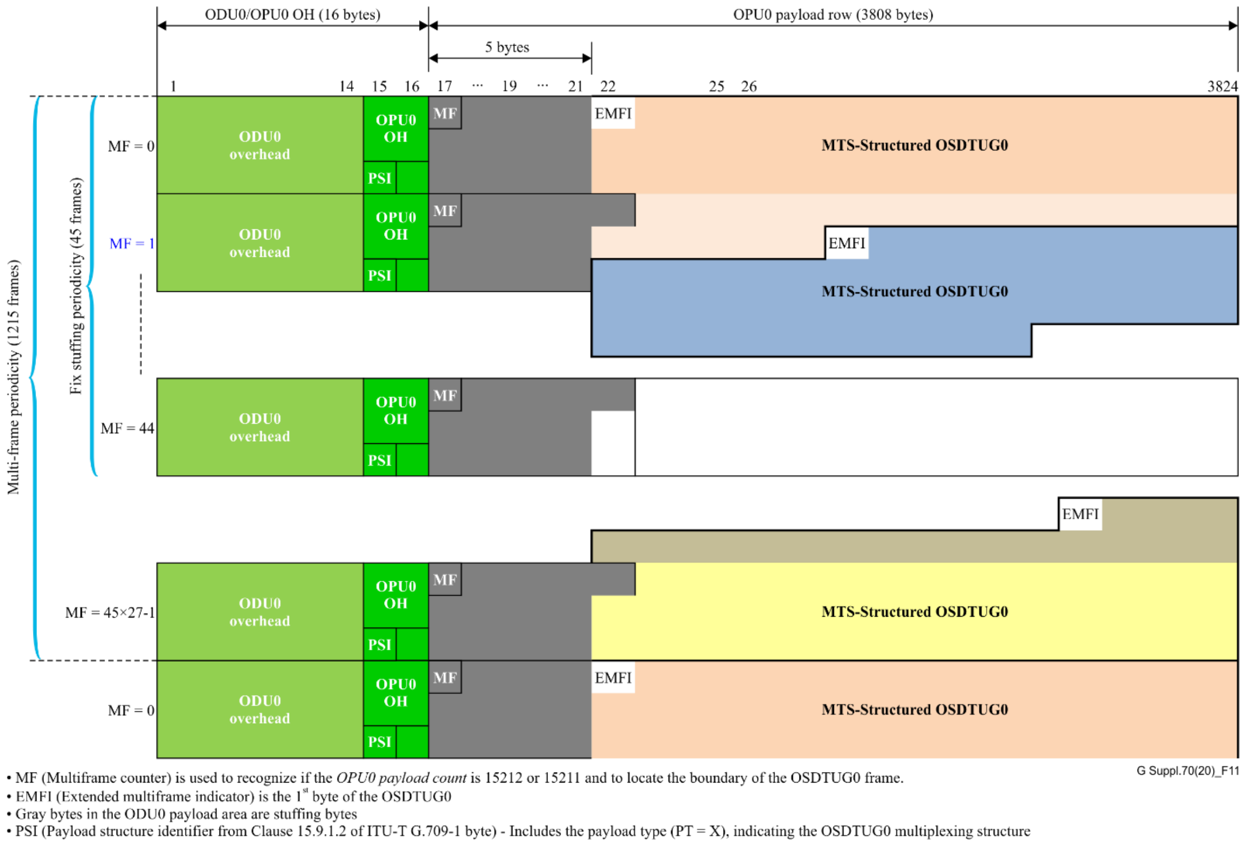


Figure 11 – Mapping OSDTUG0 into OPU0 frames

8.1.5 OSDUk and OSDTUk frame format

8.1.5.1 OSDU4 and OSDTU4 frames

The OSDU4 and OSDTU4 frame structures (designed to transport VC4 clients) are shown in Figure 12 and are organized as an octet-based block frame with a nominal period of 125 µs.

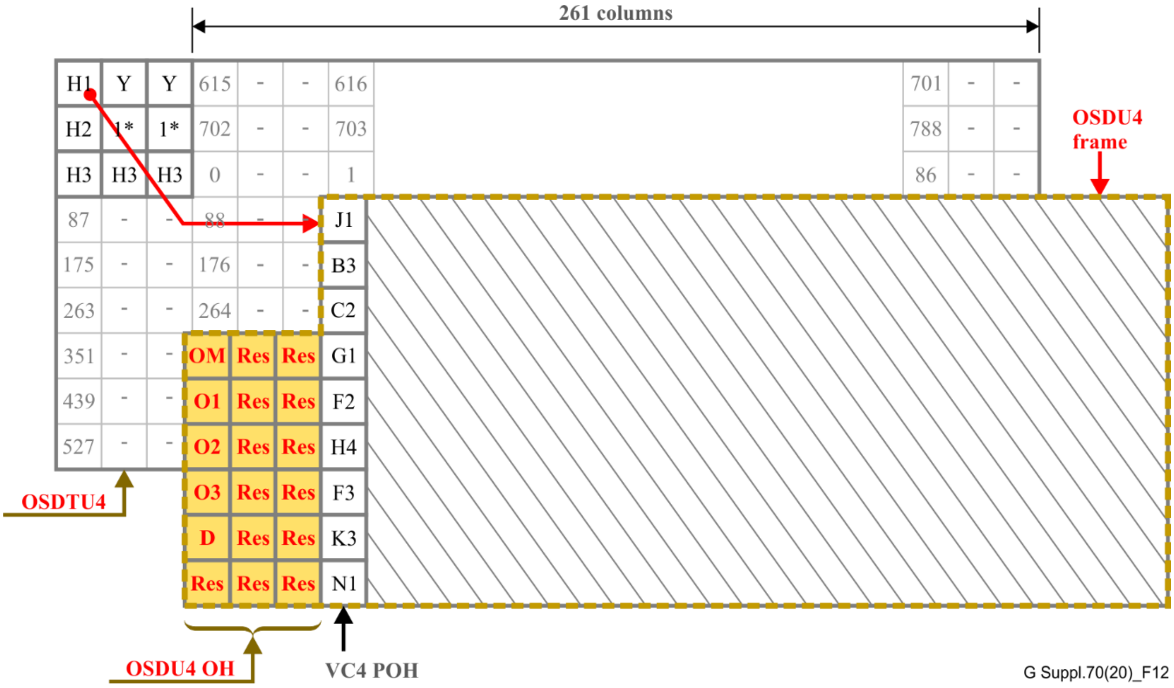


Figure 12 – OSDU4 and OSDTU4 frame structure

OSDU4 is mapped in a framed tributary unit OSDTU4 including the OSDTU4 pointer (H1, H2, H3) which is modelled after the AU-4 pointer in clause 8.1 of [ITU-T G.707]. The pointer allows the OSDU4 to "float" within the OSDTU4 frame. Thus, it is able to accommodate differences, not only in the phases of the OSDU4 and the OSDTU4 frame boundary, but also in the frame rates. The OSDTU4 pointer is identical to the AU-4 pointer except for having a valid range of 0 to 788. The OSDTU4 pointer offset numbering is shown in Figure 12.

– OSDTU4 = 264 x 9 = 2376 bytes.

– OSDU4 = 2367 bytes where the bandwidth dedicated to the OSDU4 OH is 1152 kbit/s.

The OSDU4 OH is defined in similarity with ODUk OH, that is

– 1 byte (OM) acting as multiframe counter MOD 256.

– 3 bytes (O1, O2, O3) providing TTI, BIP-8 and remote indication (RI) as well as maintenance signals support.

– 1 byte (D) for various uses such as delay measurement (DM) and payload structure identification (PSI).

– Up to 13 bytes (RES) left for future enhancement (e.g., APS/PCC, GCC, etc.).

8.1.5.2 OSDU3 and OSDTU3 frames

The OSDU3 and OSDTU3 frame structures (sized to transport VC3/E3 clients) are shown in Figure 13 and are organized as an octet-based block frame with a nominal period of 125 µs.

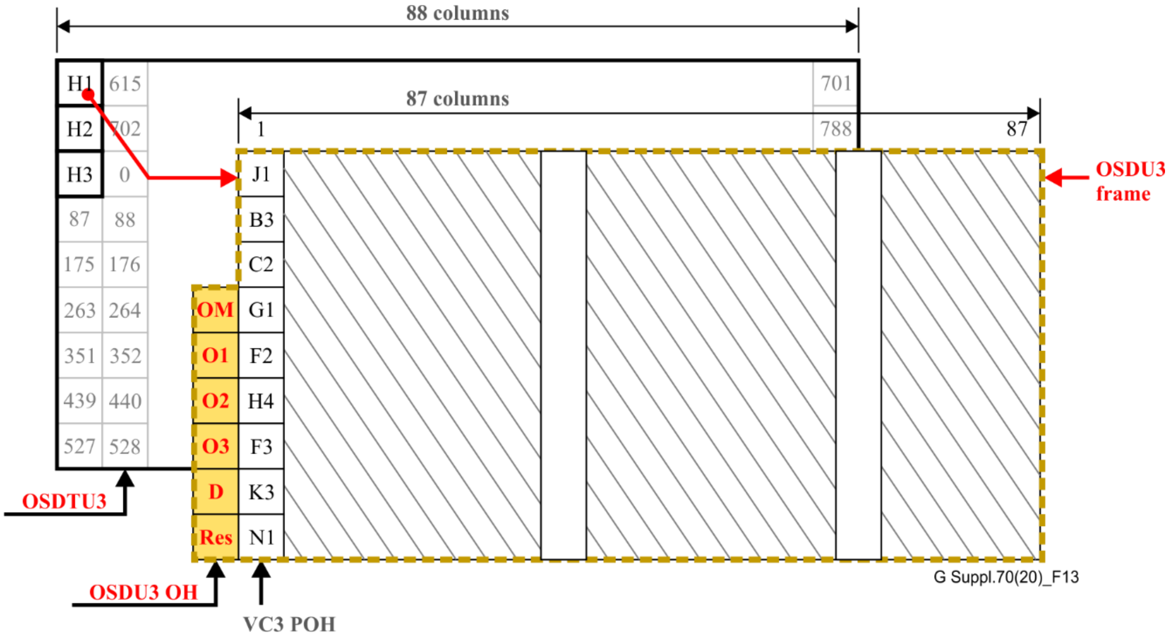


Figure 13 – OSDU3 and OSDTU3 frame structure (AU3 and TU3 compatible)

OSDU3 is mapped in a framed tributary unit OSDTU3 including the OSDTU3 pointer (H1, H2, H3) which is modelled after the TU-3 pointer in clause 8.2 of [ITU-T G.707]. The pointer allows the OSDU3 to "float" within the OSDTU3 frame. Thus, it is able to accommodate differences, not only in the phases of the OSDU3 and the OSDTU3 frame boundary, but also in the frame rates. The OSDTU3 pointer is identical to the TU-3 pointer except for having a valid range 0 to 788. The OSDTU3 pointer offset numbering is shown in Figure 13.

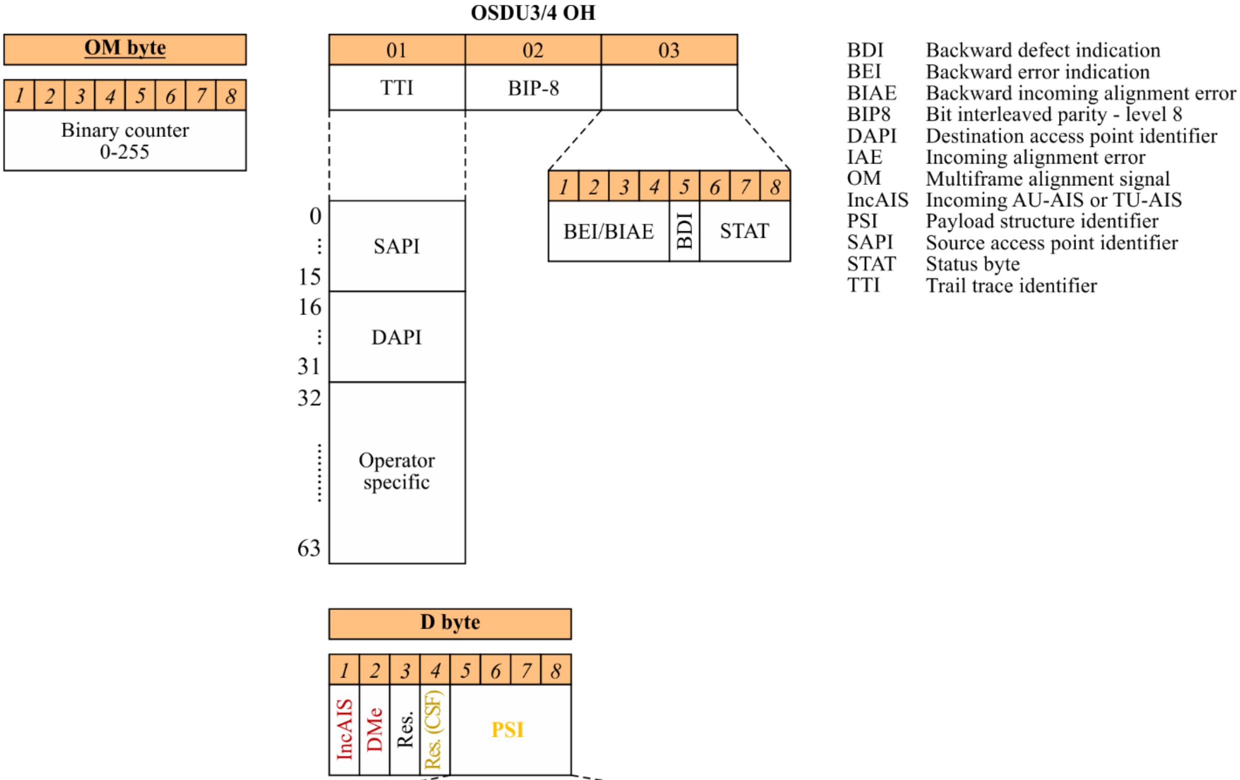
– OSDTU3 = 88 x 9 = 792 bytes.
– OSDU3 = 789 bytes where the bandwidth dedicated to the OSDU3 OH is 384 kbit/s.

The OSDU3 OH is defined in similarity with ITU-T G.709 OH, that is

– 1 byte (OM) acting as multiframe counter MOD 256.
– 3 bytes (O1, O2, O3) providing TTI, BIP-8 and RI (Remote Indication) as well as maintenance signals support.
– 1 byte (D) for various uses such as delay measurement (DM) and payload structure identification (PSI).
– 1 byte (RES) left for future enhancement (e.g., APS/PCC, etc.).

8.1.5.3 OSDU3 and OSDU4 overhead

The meaning of the OSDUk (k = 3, 4) overhead bytes is described in Figure 14.



Bits 5, 6, 7, 8	Hex code	Interpretation
0 0 0 0	0	Reserved
0 0 0 1	1	Asynchronous E3/T3 mapping in OSDU 3
0 0 1 0	2	Asynchronous E4 mapping in OSDU 4
0 0 1 1	3	VC3 synchronous mapping
0 1 0 0	4	VC4 synchronous mapping
0 1 0 1	5	Not available (Note 1)
0 1 1 0	6	Not available (Note 1)
0 1 1 1	7	100BASE-X into OSU4 transparent mapping
1 0 0 0	8	GFP-F mapping
1 0 0 1	9	Experimental mapping (Note 2)
1 0 1 0	A	Experimental mapping (Note 2)
1 0 1 1	B	Reserved
1 1 0 0	C	Reserved
1 1 0 1	D	Reserved
1 1 1 0	E	Reserved
1 1 1 1	F	Not available (Note 1)

NOTE 1 – These values are excluded from the set of available code points. These bit patterns are present in ODUk maintenance signals (or were used to represent client types that are no longer supported).
NOTE 2 – Values "9" and "A" are only to be used for experimental activities in cases where a mapping code is not defined.

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Figure 14 – OSDUk (k = 3, 4) overhead

The bit interleaved parity byte (BIP-8) is computed over the entire OSDUk (k = 3, 4) payload area. BIP processing for OSDU4 is shown in Figure 15, while that of OSDU3 is shown in Figure 16.

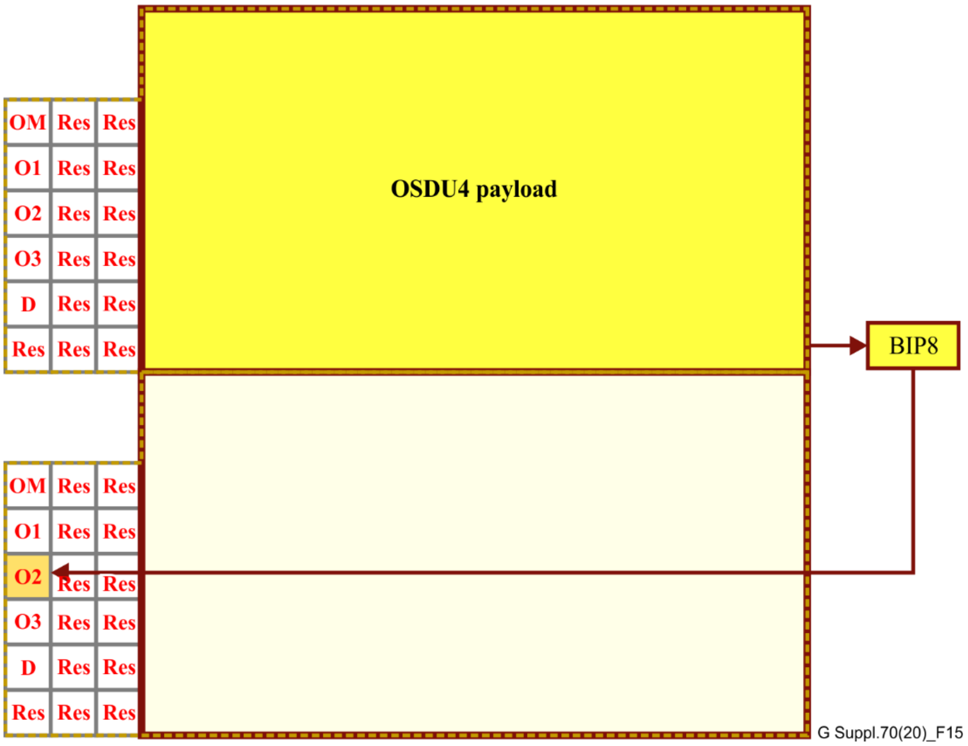

Figure 15 – OSDU4 BIP process

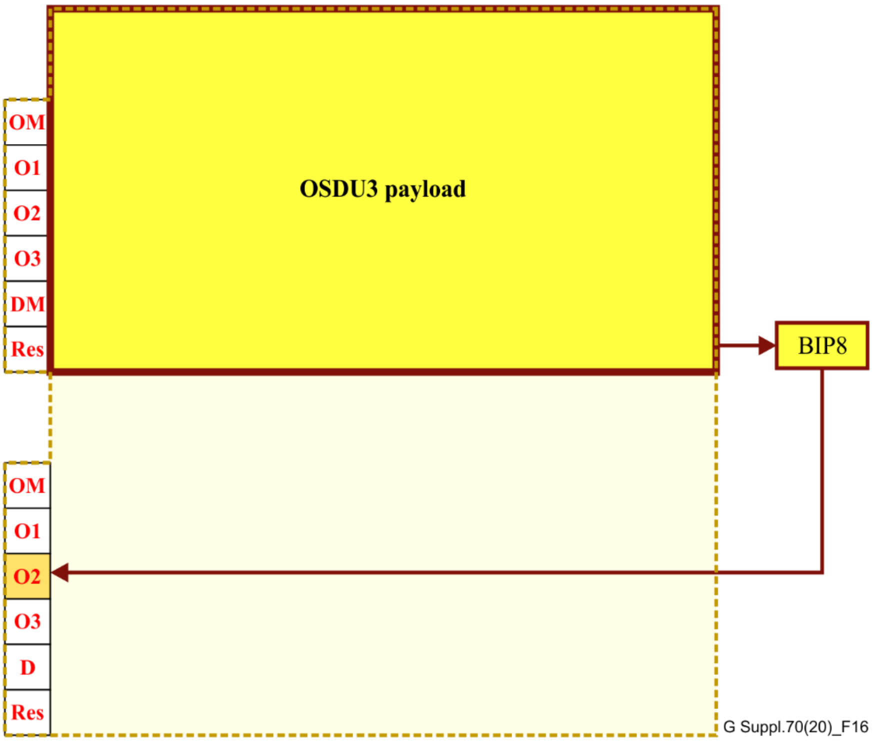

Figure 16 – OSDU3 BIP process

8.1.5.4 OSDU12 and OSDTU12 frames

OSDU12 is mapped in a framed tributary unit OSDTU12 including the OSDTU12 pointer (V1, V2, V3) which is modelled after the TU-12 pointer in clause 8.3 of [ITU-T G.707]. The pointer allows the OSDU12 to "float" within the OSDTU12 frame. Thus, it is able to accommodate differences, not only in the phases of the OSDU12 and the OSDTU12 frame boundary, but also in the frame rates. The OSDTU12 pointer is identical to TU-12 pointer except for the absence of the V4 bytes and having a valid range of is 0 to 140. The OSDTU12 pointer offset numbering is shown in Figure 17.

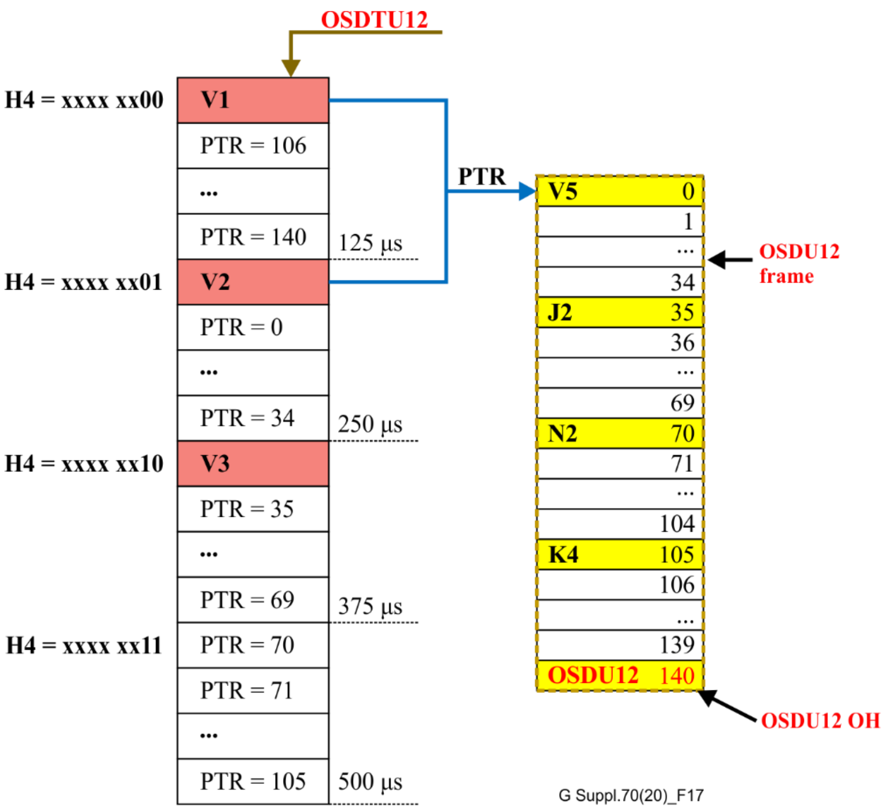

Figure 17 – OSDU12 and OSDTU12 frame structure

8.1.5.5 OSDUk (k = 12) overhead

The details of the OSDU12 overhead can be seen in Figure 18.

b1	b2	b3	b4	b5	b6	b7	b8
BIP-2		"I"	IncAIS	REI	IAE	API, RDI, PSI, BIAE, reserved	

Frame #	b7 - b8 definition
1-8	Frame alignment signal: 1111 1111 1111 1110
9-12	API byte #1 [0 C_1 C_2 C_3 C_4 C_5 C_6 C_7]
13-16	API byte #2 [0 X X X X X X X]
17-20	API byte #3 [0 X X X X X X X]
:	:
:	:
:	:
65-68	API byte #15 [0 X X X X X X X]
69-72	API byte #16 [0 X X X X X X X]
73-76	API, RDI, BIAE, PSI and reserved

Bits 7-8 operate in a 76 multiframe as
– OSDU12 API is a 16-bytes string format (OTN SAPI and DAPI cannot be supported at the same time)
– OSDU12 BDI indicates to the Far-End that defects have been detected within the ODU domain at the NE sink
– Bit [74] [7] is used as BIAE
– Bit [75] [7] and [75] [8] are reserved to the PSI signal

RDI, BIAE and reserved capacity		
Frame	b7 definition	b8 definition
73	Reserved (default = "0")	RDI
74	BIAE	Reserved (default = "0")
75	Reserved (default = "0")	Reserved (default = "0")
76	Reserved (default = "0")	Reserved (default = "0")

Bin code	Interpretation
00	Reserved
01	E1 Asynchronous mapping
10	VC12 Synchrounous mapping
11	Reserved

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Figure 18 – OSDU12 overhead

8.1.6 Mapping of OSDTUk into an OSDTUG0

In ITU-T G.709, the ODU0 is not structured. Thus, the OSDTUk signals are first mapped an OSDTUG0 which is partitioned into 504 micro tributary slots (MTS); each OSDTUk takes one MTS or multiple MTSs, as needed.

An MTS is sized to carry a single OSDTU12. The OSDTU12 consists of 36 bytes in 4 columns of 9 bytes, following the usual SDH LO structure. For other clients, such as VC3/E3 in an OSDTU3, takes up a group of MTSs. The first MTS holds the justification OH bytes.

An OSDUk signal is asynchronously mapped and aligned in an OSDTUk using a pointer mechanism that is inherited from the SDH AU and TU pointer. The OSDTUk signals are time-division multiplexed within an optical data tributary unit group fitting in the OSDTUG0.

The required number of MTS used to carry an OSDTUk can be freely picked arbitrarily from the pool of the unused MTSs (flexible assignment between trib port and micro tributary slots) within the OSDTUG0. This offers the same level of flexibility allowed in standard OTN, e.g., OPU4.

The example illustrated in Figure 19 shows an interesting specific sub-case of the just stated general criterion, where the assignment of MTSs for OSDTUk mapping is not completely arbitrary, but obeys the assignment the TribSlot assignment rules in SDH. With the application of these constraints, the characteristics of the generated signal in terms of jitter/wander performances will be, by design, definitely close to SDH (use of an SDH-like justification mechanism and of an SDH-like tributary distribution within the frame).

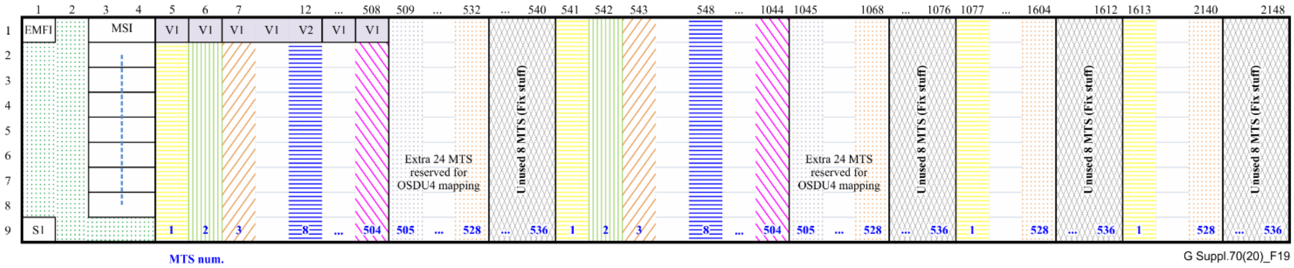

Figure 19 – Example of MTS allocation to OSDTU12 using SDH rules

The signal resulting from the multiplexing of OSDUk signals into the OPU0 via the OSDTUG0 will be characterized by a payload type indicating the multiplexing structure (PT = X).

It is important to note that differently from SDH there is no intention to introduce a hierarchy, i.e., OSDUk does not provide a separation between HO and LO containers but there will be just one "flat" OSDUk layer for all types of containers mapped within an OPU0.

8.1.7 Client mapping into OSDUk

In the SDH to OTN transition phase, the VC-n signals from terminated STM-N client interfaces are synchronously (BMP) mapped in the OSPU the appropriate low rate OSDUk (k = 12, 3, 4). Low-rate services (e.g., PDH) are asynchronously (AMP) mapped into in the corresponding SDH VC, as specified in ITU-T G.707. The resulting VC-n is then mapped in a corresponding OSDUk.

– During the intermediate transition phases the end-to-end service management continuity (e.g., between a legacy SDH device and the OSDU based OTN one) is guaranteed by the SDH VC that has to be maintained.

– After the whole network is migrated, the end-to-end service can be managed by the OSDUk OH alone.

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