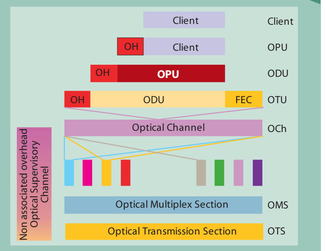
OTN-EfFECtive Networks

Introduction

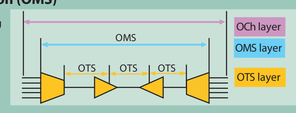
Optical Transport Module (OTM)

- To achieve management functionality, overhead is added to the client signal which together with the FEC form the **Optical channel Transport Unit (OTU)**.
- The OTU is carried by a single wavelength as an **Optical Channel (OCh)**.
- Adding OH via the Optical Supervisory Channel (**OSC**) the **OMS** and the **OTS** are formed.



Optical Multiplex Section (OMS)

- Supports connection monitoring and assists service providers in troubleshooting.
- Describes optical DWDM connection between two network elements (NEs) with multiplex functions e.g. OXC, OADM.



OTN layers	SONET layers	SDH layers
Optical Channel	Path	Path
Optical Multiplex Section	Line	Multiplexer Section
Optical Transmission Section	Section	Regenerator Section

Optical Transmission Section (OTS)

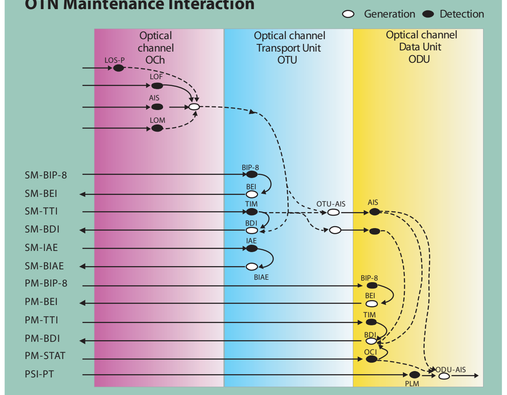
- Describes transport in optical link between two NEs.
- Used for maintenance and operational functions incuding the monitoriing of tasks between NEs.

OTU types and capacity

OTN type	OTU nominal bit rate	Client signal
OTU1	255/238 x 2 488 320 kb/s = 2.666 057 143 Gb/s	STS-48/STM-16
OTU2	255/237 x 9 953 280 kb/s = 10.709 255 316 Gb/s	STS-192/STM-64
OTU3	255/236 x 39 813 120 kb/s = 43.018 413 559 Gb/s	STS-768/STM-256
OTU-LAN no fixed stuff*	255/238 x 10 312 500 kb/s = 11.049 107 Gb/s (overclocked)	10G LAN
OTU-LAN fixed stuff*	255/237 x 10 312 500 kb/s = 11.095 730 Gb/s (overclocked)	10G LAN

* not yet standardized but often used

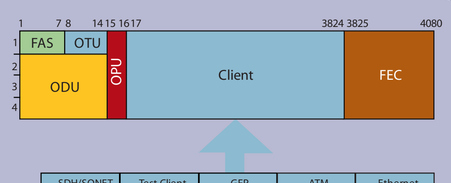
OTN Maintenance Interaction



Description of terms of OTN maintenance interaction

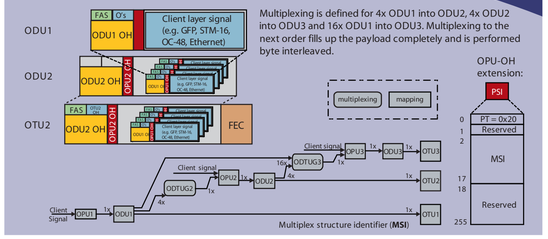
AIS	Alarm Indication Signal	LOS	Loss of Signal
BEI	Backward Error Indication	LOS-P	LOS - Payload
BDI	Backward Defect Indication	OCI	Open Connection Indication
BIAE	Backward Incoming Alignment Error	PLM	Payload Mismatch
DEG	Degraded Defect	PSI	Payload Structure Identifier
IAE	Incoming Alignment Error	PT	Payload Type
LCK	Locked Defect	STAT	Status
LOF	Loss of Frame	TIM	Trace Identifier Mismatch
LOM	Loss of Multiframe	TTI	Trail Trace Identifier

Optical Channel (OCh)



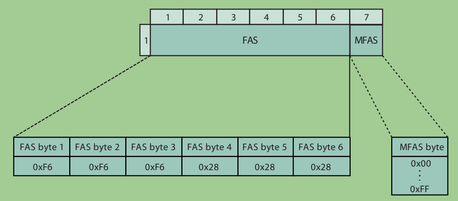
Fully transparent mapping of client signals, e.g. OC-192/STM-64, 10 GbE LAN/WAN

OTN Multiplexing



Multiplexing is defined for 4x ODU1 into ODU2, 4x ODU2 into ODU3 and 16x ODU1 into ODU3. Multiplexing to the next order fills up the payload completely and is performed byte interleaved.

Frame Alignment Signal (FAS)

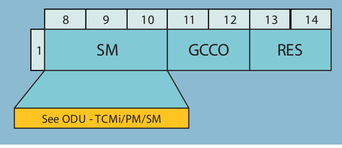


Optical channel Transport Unit (OTU)

Allows the user to support Section Monitoring (SM).

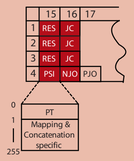
General communication channels (GCCO)
These two fields allow communication between section end points

For further description please refer to the optical channel data unit (ODU).



Optical channel Payload Unit (OPU)

The **OPU OH** regulates the mapping and concatenation of the client signals and provides information on the type of signal transported.
Payload Structure Identifier (PSI) a 256 byte multi-frame signal. The PSI[0] contains the **Payload Type (PT)**.
Justification bits (J0, NJ0, PJ0) they are required for asynchronous mappings.
For synchronous mappings all JCs are 0 and the PJ0 is a data byte.
Mapping and concatenation PSI[1] to PSI[255] are mapping and concatenation specific.



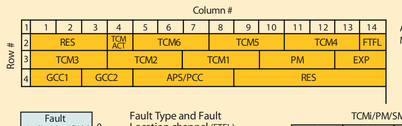
JC, NJO and PJO generation by asynchronous mapping process

JC [7, 8]	NJO	PJO
00	Justification byte	Data byte
01	Data byte	Data byte
10	Not generated	Not generated
11	Justification byte	Justification byte

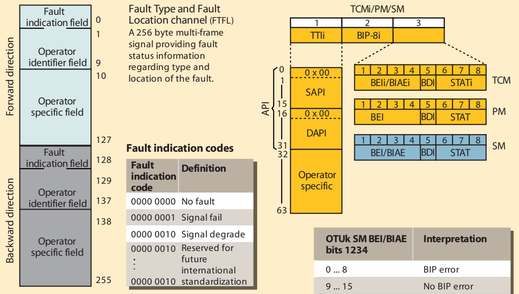
Payload type code points

Hex code	Interpretation
01	Experimental mapping
02	Asynchronous STM-N mapping
03	Bit synchronous STM-N mapping
04	ATM mapping
05	GFP mapping
06	Virtual concatenated signal
10	Bit stream with octet timing mapping
11	Bit stream without octet timing mapping
20	ODU mulitplex structure
55	Not available
66	Not available
80 - 8F	Reserved codes for proprietary use
FD	NULL test signal mapping
FE	PRBS test signal mapping
FF	Not available

Optical channel Data Unit (ODU)



Allows the user to support Path Monitoring (PM), Tandem Connection Monitoring (TCM) and Automatic Protection Switching (APS).



Fault Type and Fault Location channel (FTFL)
A 256 byte multi-frame signal providing fault status information regarding type and location of the fault.

Fault indication codes

Fault indication code	Definition
0000 0000	No fault
0000 0001	Signal fail
0000 0010	Signal degrade
0000 0010 : 0000 0010	Reserved for future international standardization

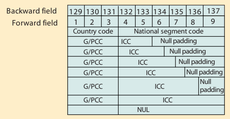
OTUk SM BEI/BIAE bits 1234	Interpretation
0 ... 8	BIP error
9 ... 15	No BIP error
11	BIAE, no BIP error

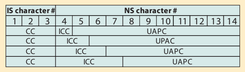
Operator Identifier Field Structure

G/PCC	Geographic/Political country code
ICC	ITU carrier code

Access Point Identifier (API) structure

CC	Country Code
ICC	ITU Carrier Code
IS	International Segment
NS	National Segment
UAPC	Unique Acces Point Code





Trail Trace Identifier (TTI)
The 64 byte multi-frame TTI signal is similar to the J0 byte in SONET/SDH.

Bit Interleaved Parity (BIP-8)
The BIP-8 (8 bit) is computed over the whole OPU and payload and is inserted into the BIP-8 SM byte two frames later.

Backward Defect Indication (BDI)
BDI = 1 indicates OTUk backward defect
BDI = 0 otherwise

Backward Error Indication (BEI) and Backward Incoming Alignment Error (BIAE) for TCM
These signals carry information on interleaved-bit blocks detected in error in the upstream direction.

Status (STAT)
Three bits indicate the presence of maintenance signals.

RES
Reserved for future international standardization. All bytes are set to 0's.

TCM/ACT
Byte field is used for the activation and deactivation of the TCM fields. For future standardization.

EXP
Reserved for further experimental use.

General communication channels (GCC1, GCC2)
Fields allow communication between two NEs.

Automatic Protection Switching and Protection Communication Channel (APS/PCC)
Up to eight levels of nested APS/PCC signals may be present in this field.

The **Access Point Identifiers (API)** specify the **Source Access Point Identifier (SAPI)** and **Destination Access Point Identifier (DAPI)** Contain information regarding the country of origin, network operator and administrative details.

Operator specific
For operator specific use.

Incoming Alignment Error (IAE)
IAE = 1 indicates frame alignment error
IAE = 0 otherwise

Tandem Connection Monitoring (TCM), enables signal management across multiple networks.

ODUk TCM status interpretation

TCM byte 3, bits 678	Status
000	no source TC
001	in use without IAE
010	in use with IAE
011	reserved for future international standardization
100	reserved for future international standardization
101	maintenance signal: ODUk-LCK
110	maintenance signal: ODUk-OCI
111	maintenance signal: ODUk-AIS

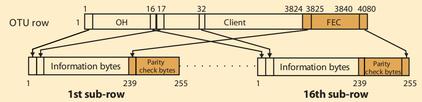
Path Monitoring (PM) enables the monitoring of particular sections within the network and fault location.

ODUk PM status interpretation

PM byte 3, bits 678	Status
000	reserved for future international standardization
001	normal path signal
010	reserved for future international standardization
011	reserved for future international standardization
100	reserved for future international standardization
101	maintenance signal: ODUk-LCK
110	maintenance signal: ODUk-OCI
111	maintenance signal: ODUk-AIS

Forward Error Correction (FEC)

The FEC enables the correction and detection of errors in an optical link.



239 bytes of the sub-row are used to calculate the FEC parity check, the result of which is transmiitted in bytes (symbols) 240 to 255 of the same sub-row.

The Reed-Solomon Code (RS)
An OTU row is split into 16 sub-rows each consisting of 255 bytes. The sub-rows are formed byte interleaved.

RS can correct up to 8 symbol errors and detect up to 16 symbol errors per sub-row.
==> RS can correct up to 512 symbol errors and detect up to 1024 symbol errors per OTU frame.

Detection Criteria (according to ITU-T G.709/G.798)

Abbreviation	Alarm/Error	Detection criteria
OOF	Out of Frame	FAS (bytes 3, 4 and 5) are errored for ≥ 5 frames
LOF	Loss of Frame	If OOF persists ≥ 3 ms
OOM	Out of Multiframe	MFAS numbers errored for ≥ 5 frames
LOM	Loss of Multiframe	If OOM persists ≥ 3 ms
OTU		
SM-BIP-8	SM BIP Error	Mismatch of the recovered and computed BIP-8 covers the OPU and Payload
SM-BEI	SM Backward Error Indication	SM byte 3, bits 1 to 4: value 0 to 8: BIP error count value 9 to 15: No BIP errors value 11: BIAE active
OTU-AIS	OTU AIS	PN-11 sequence covers complete OCh
SM-BDI	SM Backward Defect Indication	SM byte 3, bit 5 = 1 ≥ 5 frames
SM-IAE	SM Incoming Alignment Error	SM byte 3, bit 6 = 1 ≥ 5 frames
SM-BIAE	SM Backward Incoming Alignment Error	SM byte 3, bits 1 to 4 = '1011' ≥ 3 frames

Abbreviation	Alarm/Error	Detection criteria
ODU-PM		
PM-BIP-8	PM BIP Error	Mismatch of the recovered and computed BIP-8 covers the OPU and Payload
PM-BEI	PM Backward Error Indication	PM byte 3, bits 1 to 4: value 0 to 8: BIP error count value 9 to 15: No BIP errors
ODU-AIS	ODU AIS	PM byte 3, bits 6 to 8 = '111' ≥ 3 frames and ODU except FTFL filled with All-1s
ODU-OCI	ODU Open Connection Indication	PM byte 3, bits 6 to 8 = '110' ≥ 3 frames and ODU filled with '0110 0110 ODU
ODU-LCK	ODU Locked Defect	PM byte 3, bits 6 to 8 = '101' ≥ 3 frames and ODU filled with '0101 0101'
PM-BDI	PM Backward Defect Indication	PM byte 3, bit 5 = 1 ≥ 5 frames
ODU-TCM		
TCMi-BIP-8	TCM BIP Error	Mismatch of the recovered and computed BIP-8 covers the OPU and Payload
TCMi-BEI	TCM Backward Error Indication	TCM byte 3, bits 1 to 4: value 0 to 8: BIP error count value 9 to 15: No BIP errors value 11: BIAE active
TCMi-BDI	TCM Backward Defect Indication	TCM byte 3, bit 5 = 1 ≥ 5 frames
TCMi-BIAE	TCM Backward Incoming Alignment Error	TCM byte 3, bits 1 to 4 = '1011' ≥ 3 frames

To learn more, visit www.jdsu.com/ont

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