Transport Ethernet Interfaces 1.5 Mbit/s to 10 Tbit/s

Maarten Vissers

Ethernet in the Transport Network

Introduction of Ethernet in the Transport Network in early 2000

Resulted in 2002 in

- Ethernet OAM development (ITU-T SG13)
- Ethernet over Transport development (ITU-T SG15)

Migrated in 2003 into

- Ethernet Transport Network development

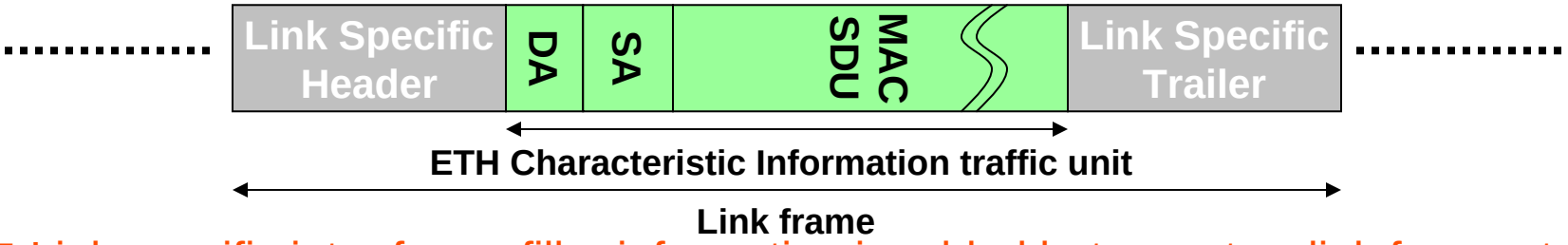
Series of Ethernet Recommendations created

- Services
- Architecture
- ***Interfaces (1.5 Mbit/s up to 10 Tbit/s)***
  - Copper cables and fiber
  - PDH access links, CWDM/DWDM line systems and optical rings
  - SDH and OTN networks
- Equipment & Protection Switching
- Management

What constitutes a full duplex Ethernet interface?

Transport network viewpoint

- A non-continuous flow of Ethernet Characteristic Information (CI) traffic units, where each traffic unit is a DA, SA, MAC_SDU preceded by a LINK SPECIFIC header and followed by a LINK SPECIFIC trailer

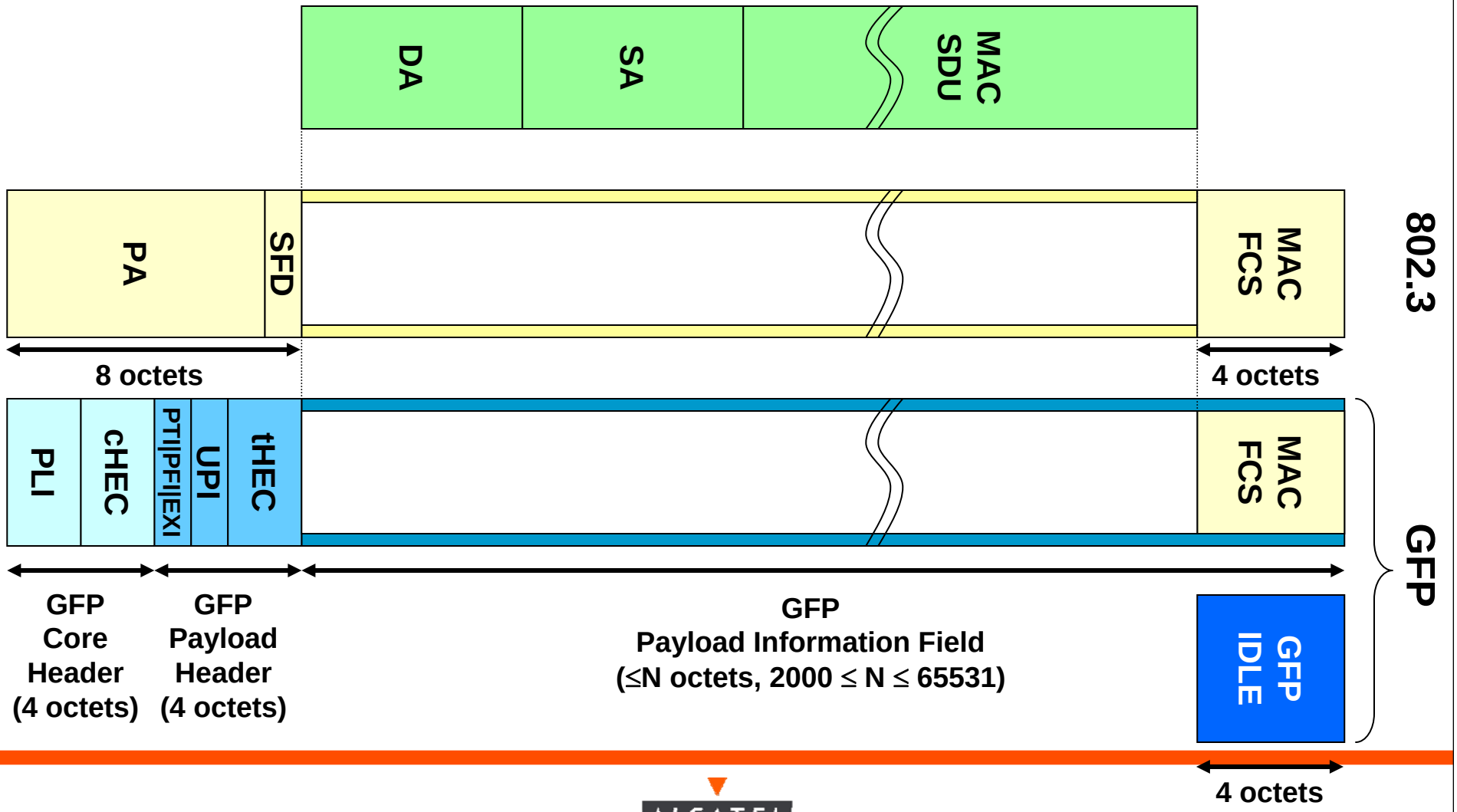


- Link specific inter frame filler information is added between two link frames to create a bitstream

Ethernet Interface	Link specific header	Link specific trailer	Inter frame filler
802.3 Ethernet	Preamble/SFD	MAC FCS	IFG
Ethernet transport	GFP Core/Payload Header	MAC FCS	GFP Idle

- Specific links will encode and/or wrap this bitstream to carry it over the medium or through a transport network

Encapsulating Ethernet Frames in 802.3 & GFP



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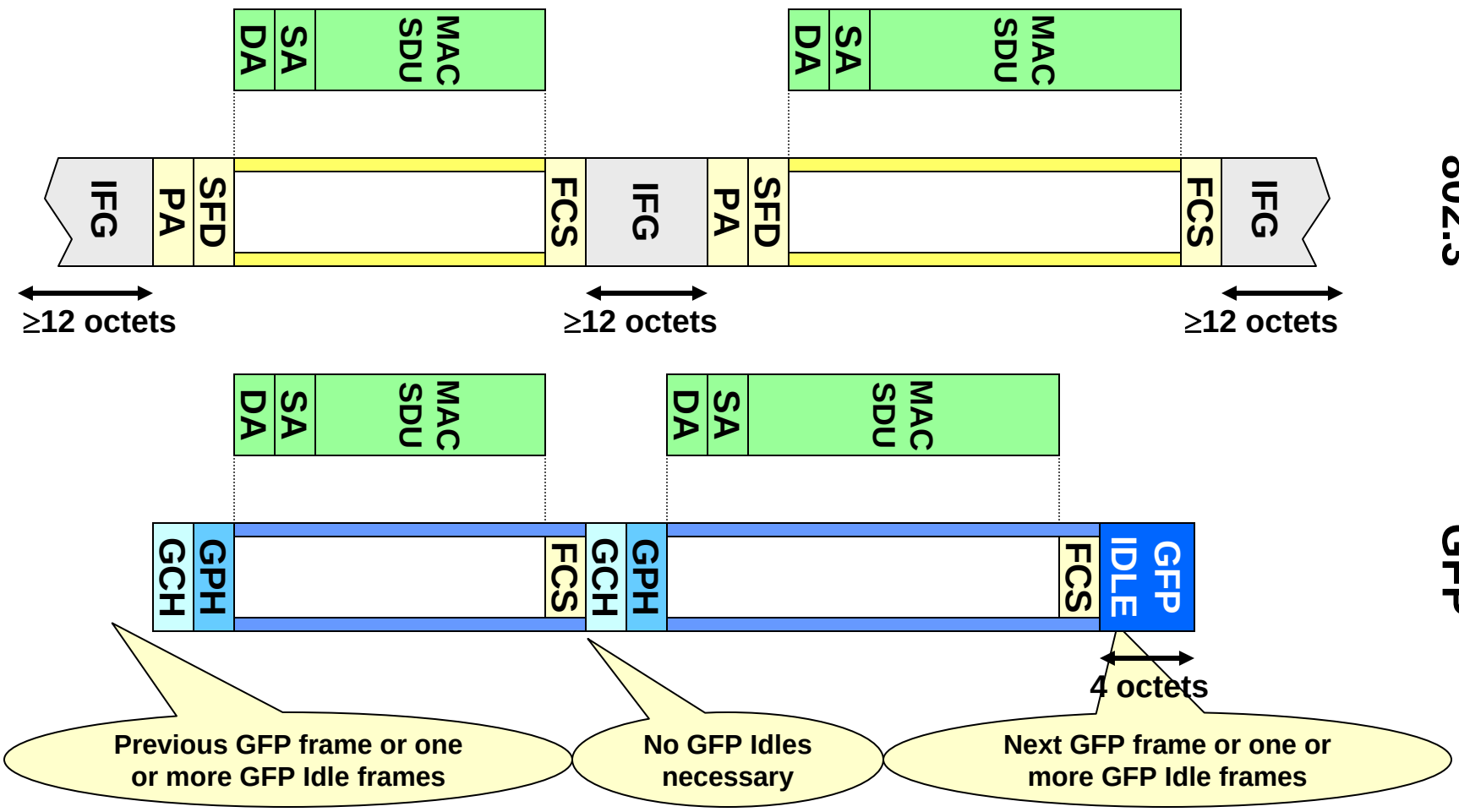
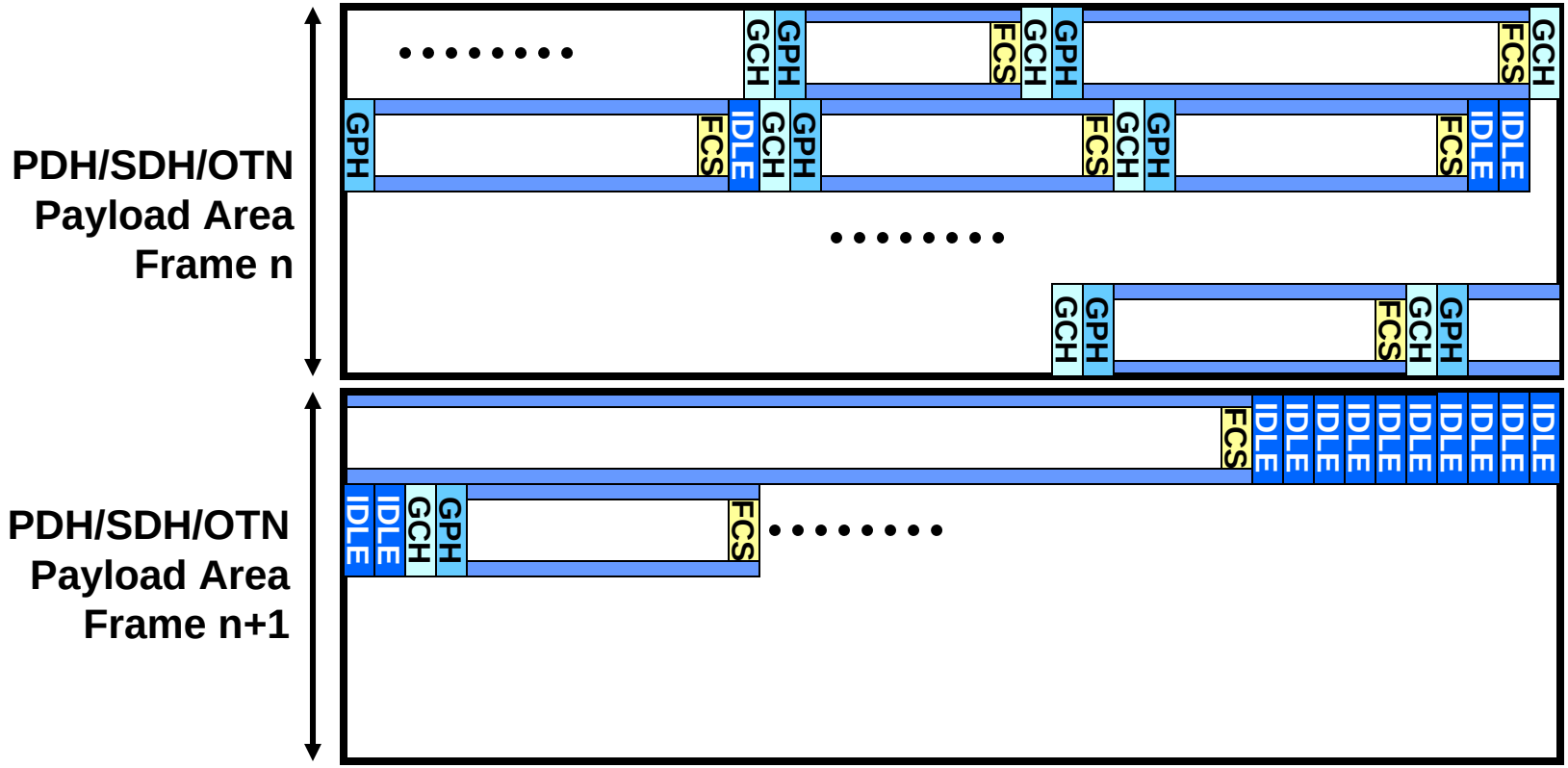
802.3 & GFP Bitstreams



Mapping GFP bitstream in Link Specific Payload Area



Continuous mapping of GFP frames into payload area of PDH, SDH or OTN frames.
When no GFP frames available, GFP Idle frames are inserted.

Mapping bitstreams into interface signals

Final step in the process to send the non-contiguous flow of Ethernet CI over a medium or through a network is the encoding and/or wrapping into the interface signal

10GBASE-R	64B/66B encoding
10GBASE-W	64B/66B encoding, wrapping into STM-64/CCAT frame
PDH, SDH	scrambling, wrapping into PDH/VCAT, SDH/CCAT or SDH/VCAT frame for multiplexing with other transport services and service independent management
WDM	scrambling, wrapping into SDH/CCAT frame, optional addition of Forward Error Correction for longer reach
OTN	scrambling, wrapping into OTUk or OTUk/VCAT frame, optional addition of Forward Error Correction for longer reach

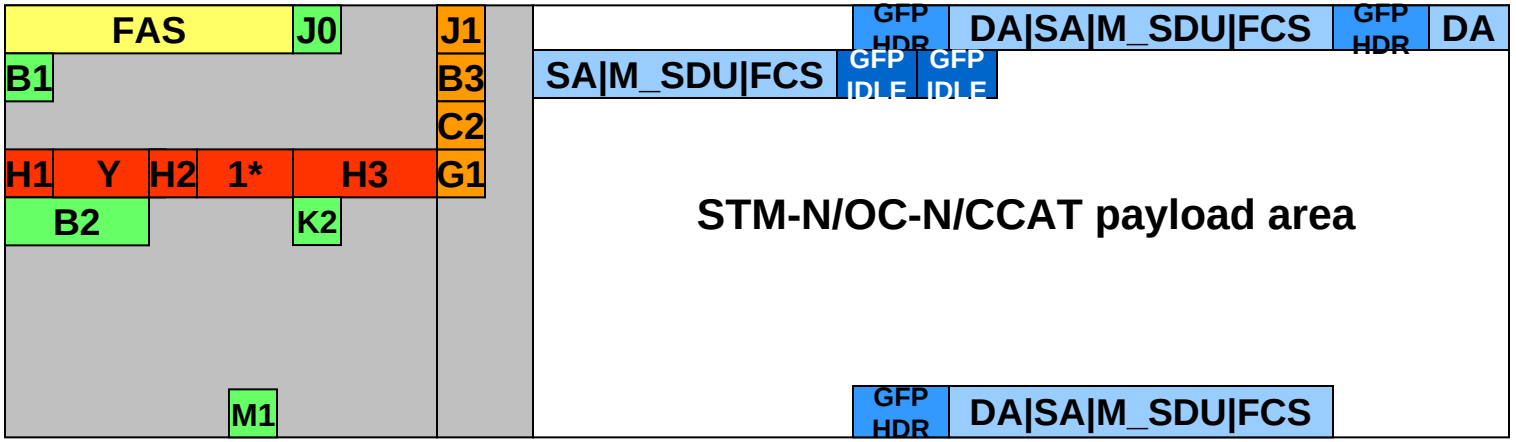
Examples of such wrapping in slides hereafter

- Refer to “Considerations for multi-lane implementations of higher rate Ethernet Interfaces” for more information on Virtual Concatenation (VCAT)

Mapping Payload Area into STM-N/OC-N frame

STM-N/OC-N frame with contiguous concatenation (CCAT)

- STM-N/OC-N/CCAT payload area (2.5G, 10G, 40G)
- STM-N/OC-N Overhead (3.9%)
  - Frame Alignment (FAS)
  - Regenerator & Multiplex Section Overhead (J0,B1,B2,M1,K2)
  - AU-4-Nc Pointer (H1,Y,H2,1*,H3)
  - VC-4-Nc Path Overhead (J1,B3,C2,G1)
  - Optional STM-N Forward Error Correction (FEC, not illustrated)

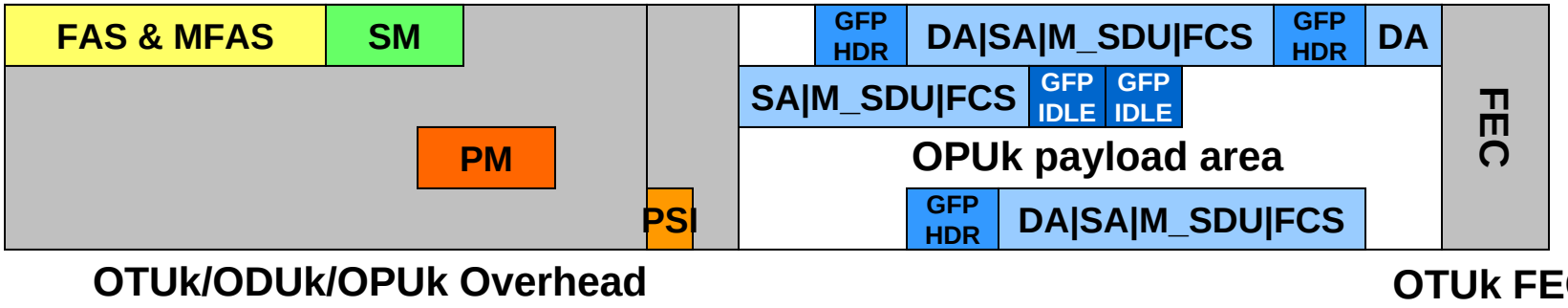


STM-N/OC-N Overhead

Mapping Payload Area into OTUk frame

OTUk frame

- OPUk Payload Area (2.5G, 10G, 40G)
- OTUk/ODUk/OPUk Overhead (0.4%)
  - Frame Alignment (FAS, MFAS)
  - OTUk Section Monitoring (SM)
  - ODUk Path Monitoring (PM)
  - OPUk Payload Structure Identifier (PSI)
- OTUk Forward Error Correction (FEC, optional) (6.7%)

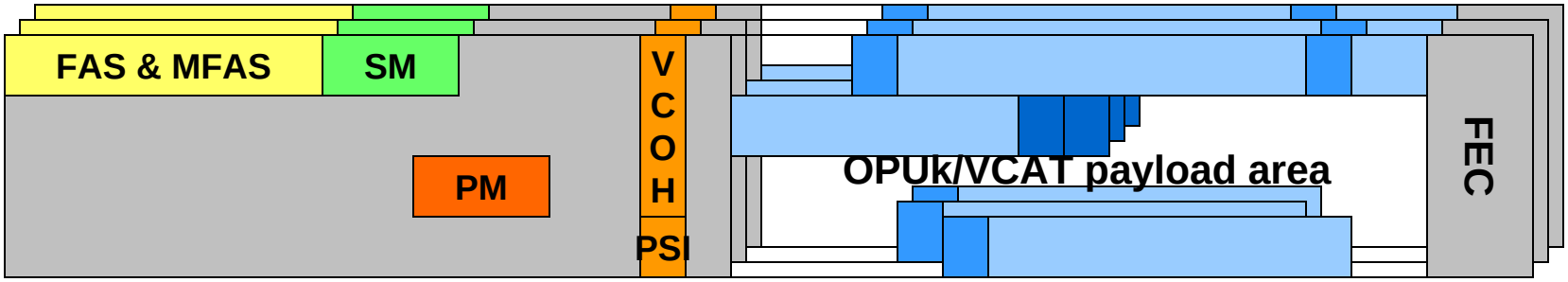


Mapping Payload Area into OTUk/VCAT frame

Multi-lane or multi-wavelength interface (X = 1..256)

OTUk/VCAT frame

- OPUk/VCAT Payload Area (X x 2.5G, X x 10G, X x 40G)
- OTUk/ODUk/OPUk/VCAT Overhead (0.4%)
  - Frame Alignment (FAS, MFAS)
  - OTUk Section Monitoring (SM)
  - ODUk Path Monitoring (PM)
  - OPUk Payload Structure Identifier (PSI)
  - OPUk VCAT Overhead (VCOH)
- OTUk Forward Error Correction (FEC, optional) (6.7%)

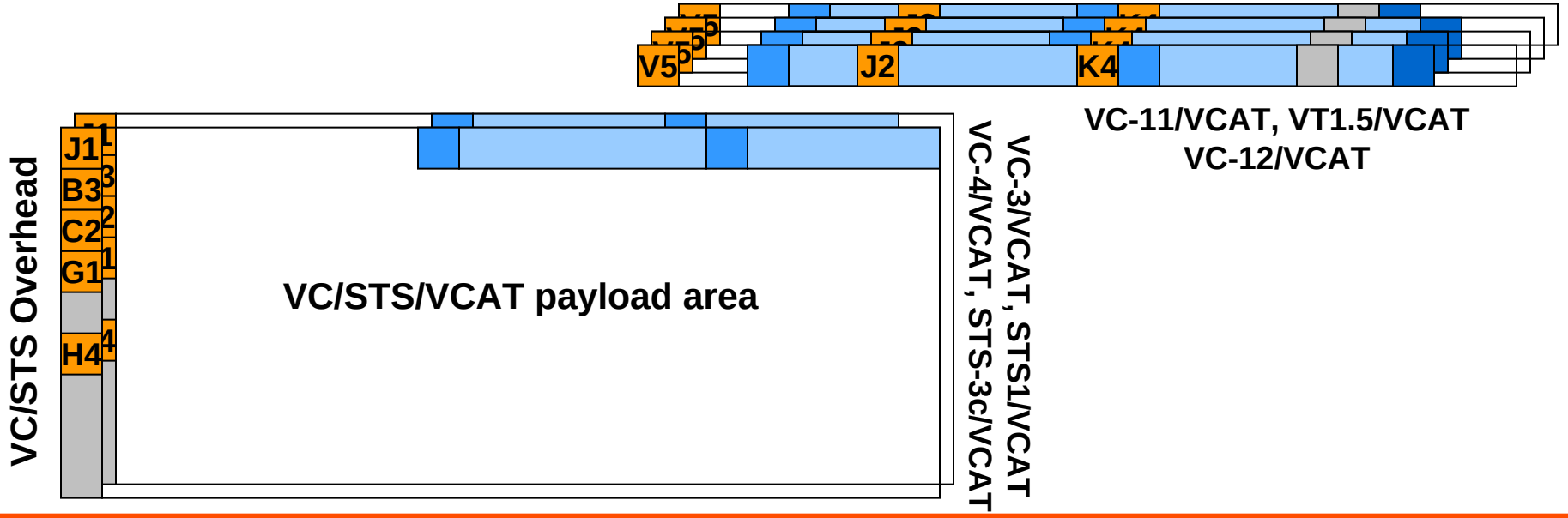


Mapping Payload Area into VC/STS/VT/VCAT frame

Multi VC/STS/VT connection

VC/STS/VT/VCAT frame

- VC/STS/VT/VCAT payload area (X_1 x 1.5M, X_1 x 2M, X_2 x 50M, X_2 x 150M (X_1=1..64, X_2=1..256))
- VC/STS/VT Overhead (0.4% or 2.9%)
  - VC-n Path Overhead (J1,B3,C2,G1 or V5,J2,K4[1])
  - VC-n VCAT Overhead (H4 or K4[2])



Transport Ethernet Interface Summary

802.3 Ethernet, Fast Ethernet, Gigabit Ethernet and 10G Ethernet interfaces

PDH, SDH/SONET and OTN transport Ethernet interfaces

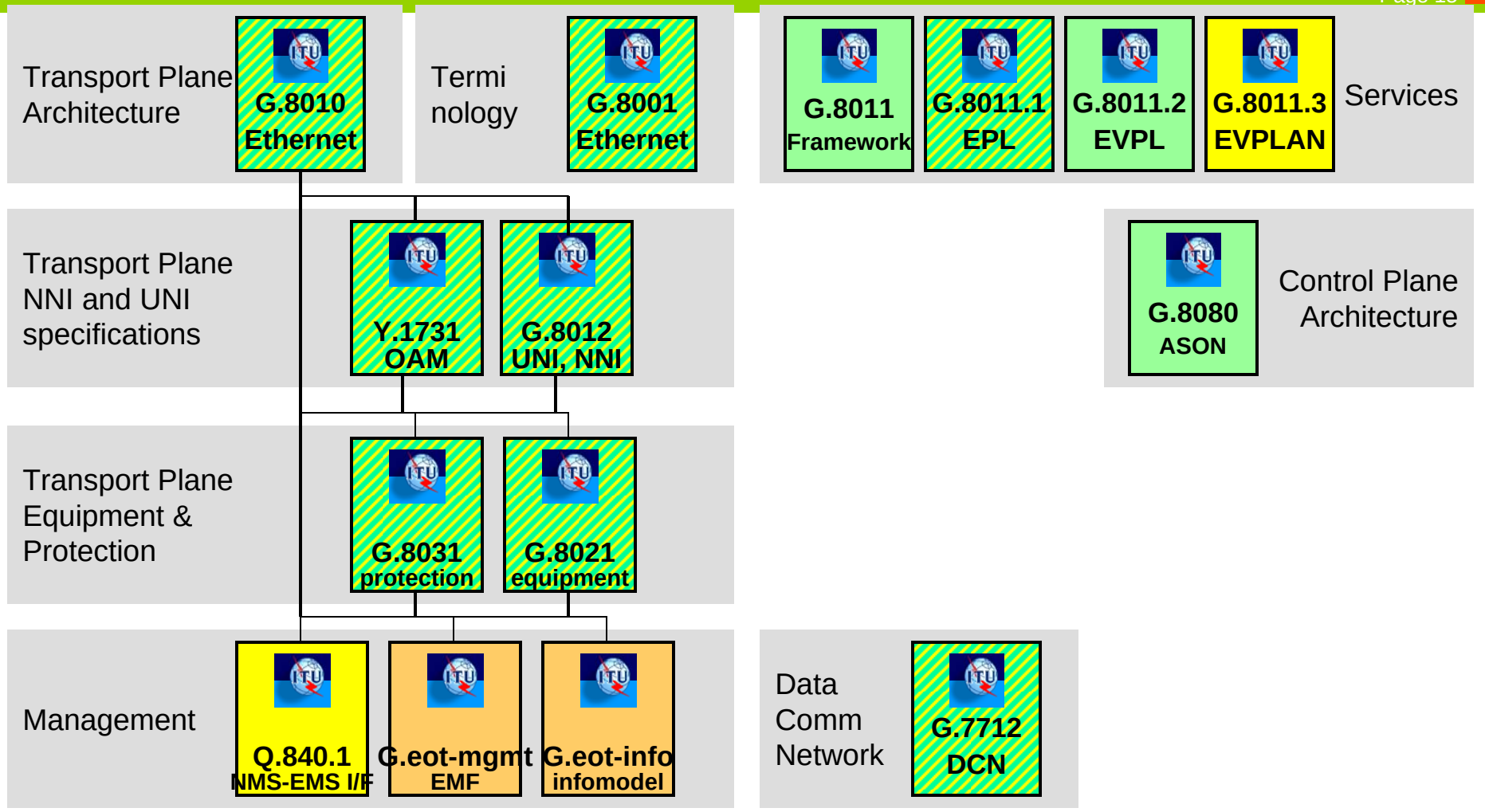
- Generic Framing Procedure (GFP) encapsulation of Ethernet frames
- Virtual Concatenation (VCAT) for optimized bandwidth granularity
  - PDH: X x DS1, X x DS3, X x E1 and X x E3
  - SDH/SONET: X x VC-n (n=11,12,3,4), X x STS-n (n=1,3c), X x VT1.5
  - WDM: STM-N/VC-4-Nc (N=16,64,256), OC-N/STS-Nc (N=48,192,768)
  - OTN: X x ODUk/OTUk ➔ e.g. multi lane/wavelength
- Link Capacity Adjustment Scheme (LCAS) for survivability and hitless bandwidth modifications
- Enhanced link aggregation function with VCAT/LCAS (octet de-interleave)
- Single-lane and multi-lane versions
- Bit rates between 1.5 Megabit/s and 10 Terabit/s

Backup

Abbreviations

ASON: Automatic Switched Optical Network
CCAT: Contiguous Concatenation
CI: Characteristic Information
DCN: Data Communication Network
EPL: Ethernet Private Line
EVPL: Ethernet Virtual Private Line
EVPLAN: Ethernet Virtual Private LAN
GCH: GFP Core Header
GFP: Generic Framing Procedure
GPH: GFP Payload Header
IFG: Inter Frame Gap
LCAS: Link Capacity Adjustment Scheme
NNI: Network Node Interface
OAM: Operation, Administration & Maintenance
OC-N: Optical Carrier level N
ODUk: Optical channel Data Unit level k
OPUk: Optical channel Payload Unit level k
OTN: Optical Transport Network
OTUk: Optical channel Transport Unit level k
PDH: Plesiochronous Digital Hierarchy
SDH: Synchronous Digital Hierarchy
SONET: Synchronous Optical Network
STM-N: Synchronous Transport Module level N
STS: Synchronous Transport Signal
UNI: User Network Interface
VC: Virtual Container
VCAT: Virtual Concatenation
VT: Virtual Tributary
WDM: Wavelength Division Multiplex

Transport Ethernet Recommendations



approved Rec | consented Rec | Rec under revision | Rec in progress | Rec started | Reco not planned yet

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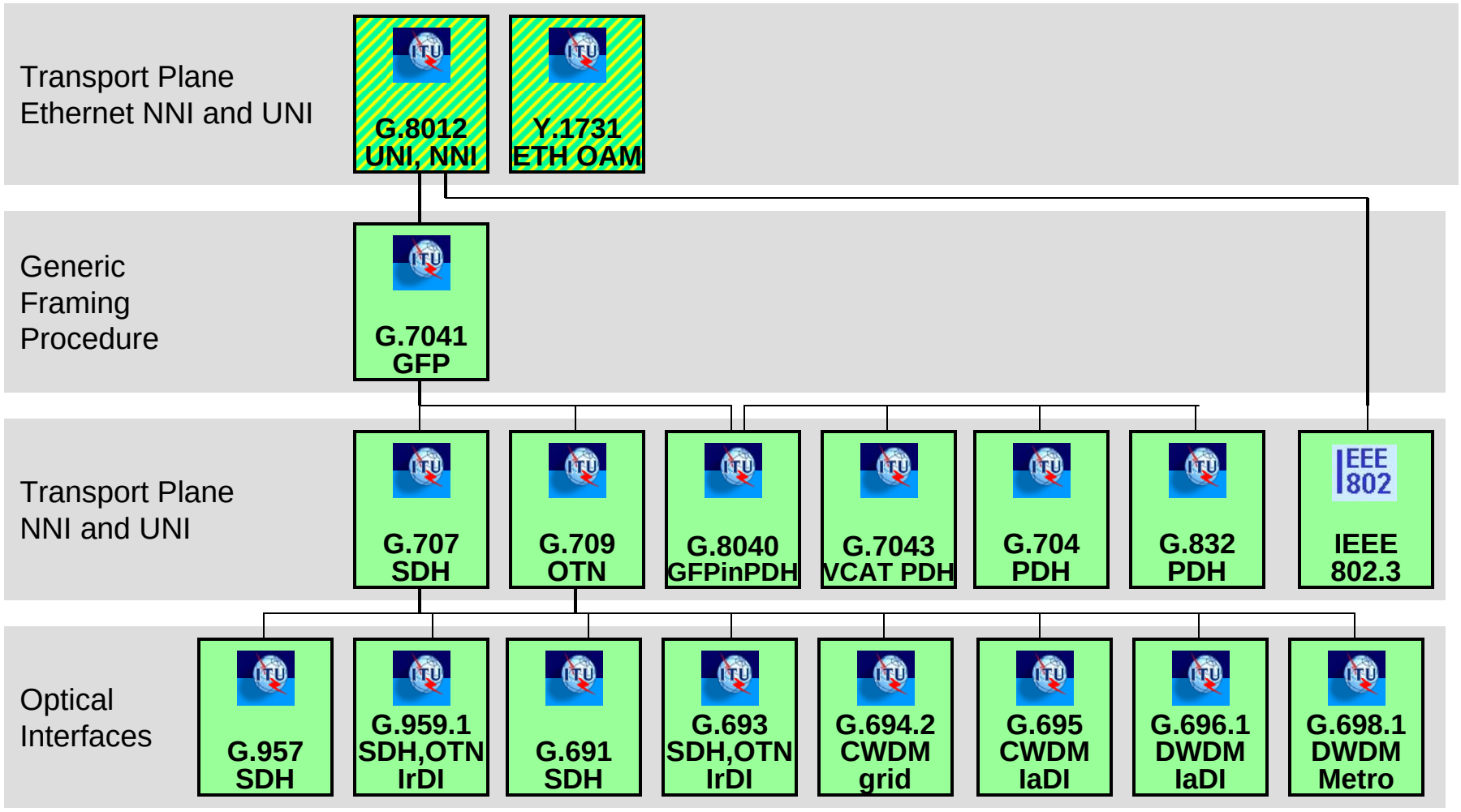
Transport Ethernet Interface Recommendations & Standards



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Transport Ethernet Interfaces Recommendations & Standards

G.704 Synchronous frame structures used at 1544, 6312, 2048, 8448 and 44 736 kbit/s hierarchical levels

G.707 Network node interface for the synchronous digital hierarchy (SDH)

G.709 Interfaces for the Optical Transport Network (OTN)

G.832 Transport of SDH elements on PDH networks - Frame and multiplexing structures

G.7041 Generic framing procedure (GFP)

G.7042 Link capacity adjustment scheme (LCAS) for virtual concatenated signals

G.7043 Virtual concatenation of plesiochronous digital hierarchy (PDH) signals

G.8012 Ethernet UNI and Ethernet NNI

G.8040 GFP frame mapping into Plesiochronous Digital Hierarchy (PDH)

IEEE Std 802.3 Information technology – Telecommunication and Information Exchange Between Systems – LAN/MAN – Specific requirements – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications

Transport Ethernet Interfaces Recommendations & Standards

G.957 Optical interfaces for equipments and systems relating to the synchronous digital hierarchy

G.959.1 Optical transport network physical layer interfaces

G.691 Optical interfaces for single-channel STM-64 and other SDH systems with optical amplifiers

G.693 Optical interfaces for intra-office systems

G.694.2 Spectral grids for WDM applications: CWDM wavelength grid

G.695 Optical interfaces for coarse wavelength division multiplexing applications

G.696.1 Longitudinally compatible intra-domain DWDM applications

G.698.1 Multichannel DWDM applications with single-channel optical interfaces

VCAT Group Sizes

PDH VCAT	Minimum payload (kbit/s)	Maximum payload (kbit/s)	Step size (kbit/s)
DS1-Xv, X = 1 to 16	≈ 1 533	≈ 24 528	≈ 1 533
E1-Xv, X = 1 to 16	1 980	31 680	1 980
E3-Xv, X = 1 to 8	33 856	270 848	33 856
DS3-Xv, X = 1 to 8	≈ 44 134	≈ 353 072	≈ 44 134
SDH VCAT	**Minimum payload (kbit/s)**	**Maximum payload (kbit/s)**	**Step size (kbit/s)**
VC-11-Xv, X = 1 to 64	1 600	102 400	1 600
VC-12-Xv, X = 1 to 64	2 176	139 264	2 176
VC-3-Xv, X = 1 to 256	48 384	12 386 304	48 384
VC-4-Xv, X = 1 to 256	149 760	38 338 560	149 760
OTN VCAT	**Minimum payload (kbit/s)**	**Maximum payload (kbit/s)**	**Step size (kbit/s)**
ODU1-Xv, X = 1 to 256	2 488 320	637 009 920	2 488 320
ODU2-Xv, X = 1 to 256	≈ 9 995 277	≈ 2 558 709 902	≈ 9 995 277
ODU3-Xv, X = 1 to 256	≈ 40 150 519	≈ 10 278 532 946	≈ 40 150 519