Optical Transport Networks – Reality Check

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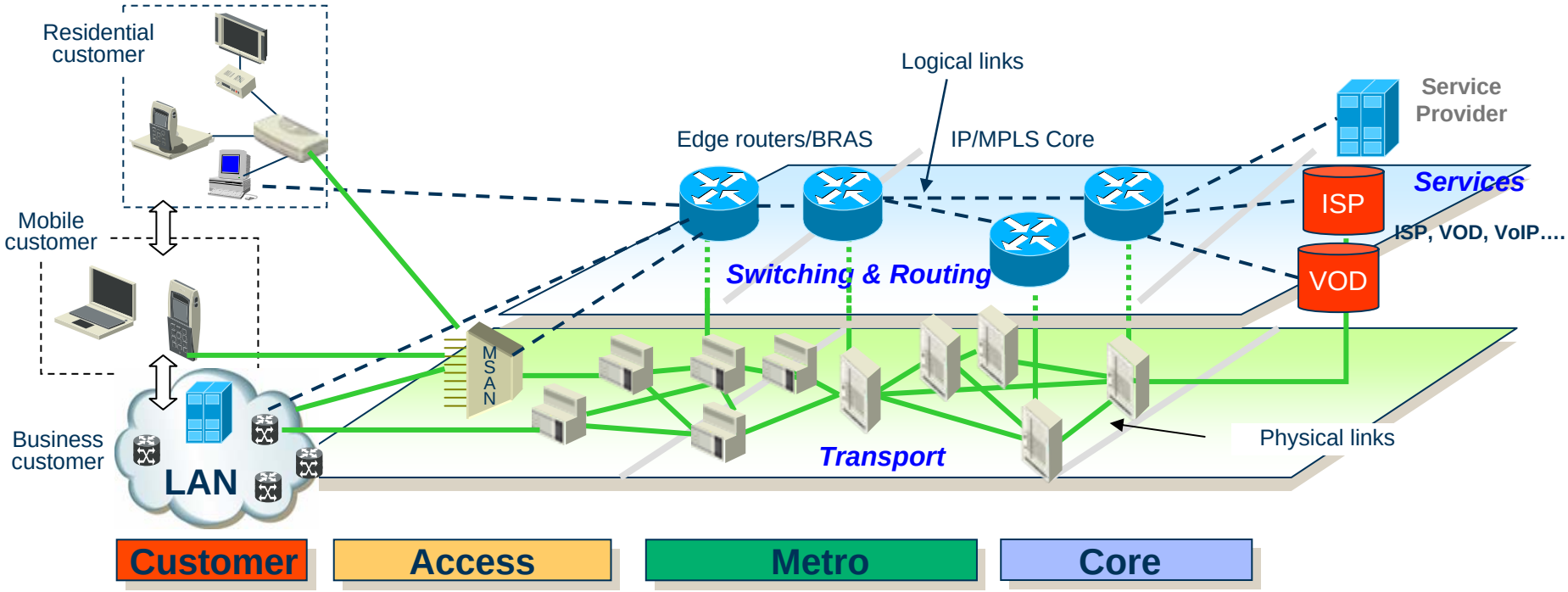
Topics

- Transport Network Functionality
- OTN Drivers
- OTN Structure and interfaces
- OTN Multiplexing
- Core Network Evolution from SDH to OTN
- Summary

The Transport Network Functionality



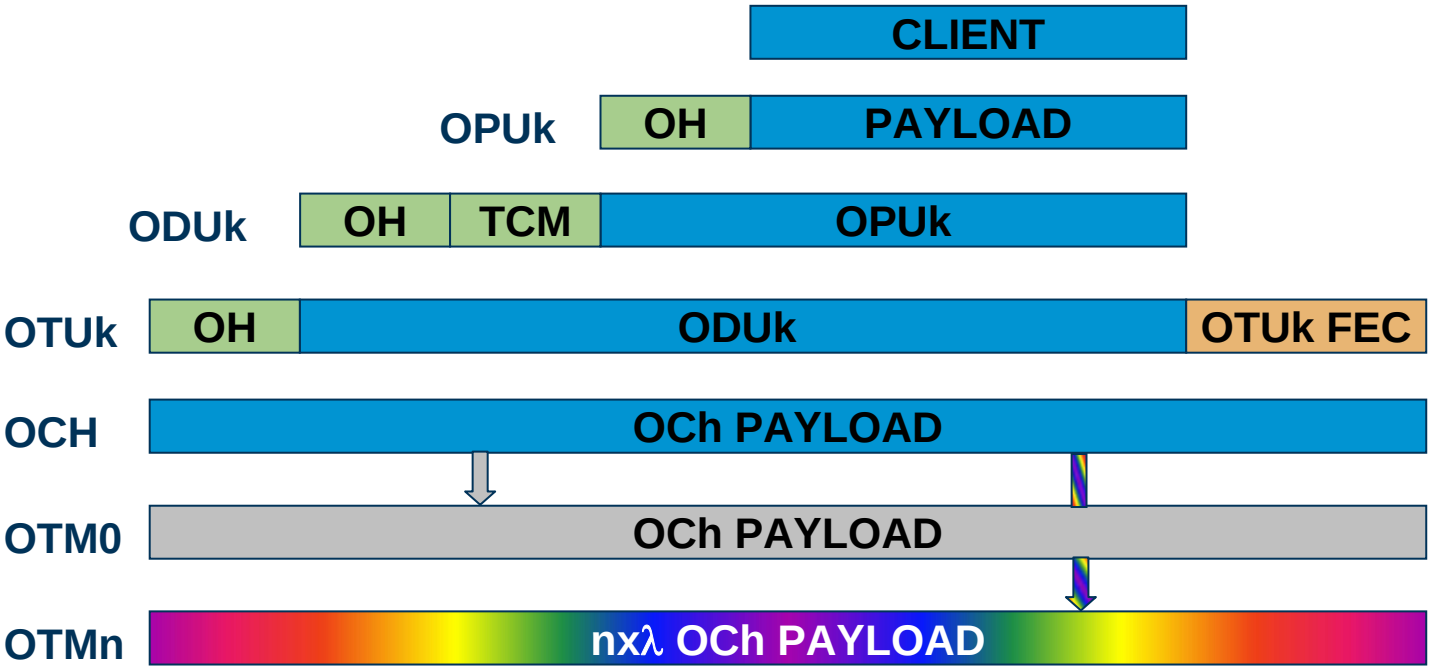
- Independent of legacy, current or future services/protocols/technologies and can carry all of them
- Facilitates scalability, fault location and offers open interfaces independent of the services carried over it
- Efficiently fills pipes using multiplexing/aggregation
- Provides equipment/network protection and resilience, independently of the higher client/server layer (QoS)
- Provides performance monitoring of transmission and connectivity (ie. QoS and fault finding)
- Provisions (switches/grooms) semi-permanent p2p (link) connections

Market Drivers for Optical Transport Network (OTN) deployment

- Phenomenal growth of IP traffic
- The need for higher granularity payloads – A wrapper around high bandwidth payloads and strong FEC
- The need of OAM functionality- monitoring, fault location , path trace etc
- Migrating towards VoIP resulting in demand for a coarse bandwidth granularity for the transport of services
- Enterprise Networks are migrating towards GbE
- Emerging of high bandwidth-demanding applications such as storage networks and Grid Computing
- Carriers' carrier services require high capacity fixed bandwidth
- Cost efficient

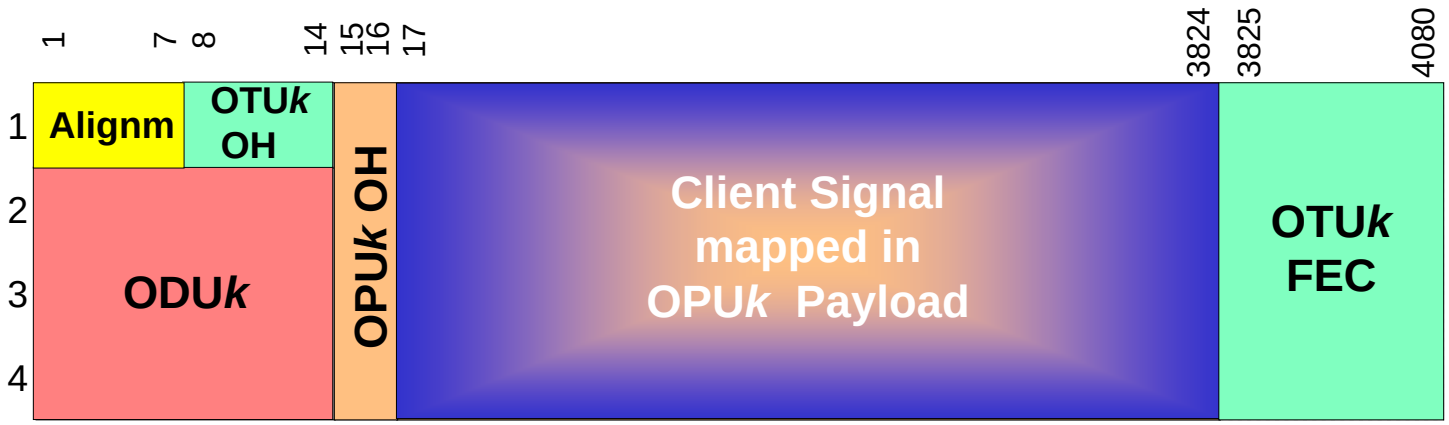
Standardised OTN structure

OTN provides all the components required for a managed optical layer



The introduction of client mapping into OPUs was standardised (in ITU-T Recommendation G.709) over five years ago but only recently being deployed in optical networks.

Frame Structure : OTU*k* and ODU*k* frame formats (*k*=1,2,3)



ODU*k* bit rate: 239/(239-k) * "STM-N"

OTU*k* bit rate: 255/(239-k) * "STM-N"

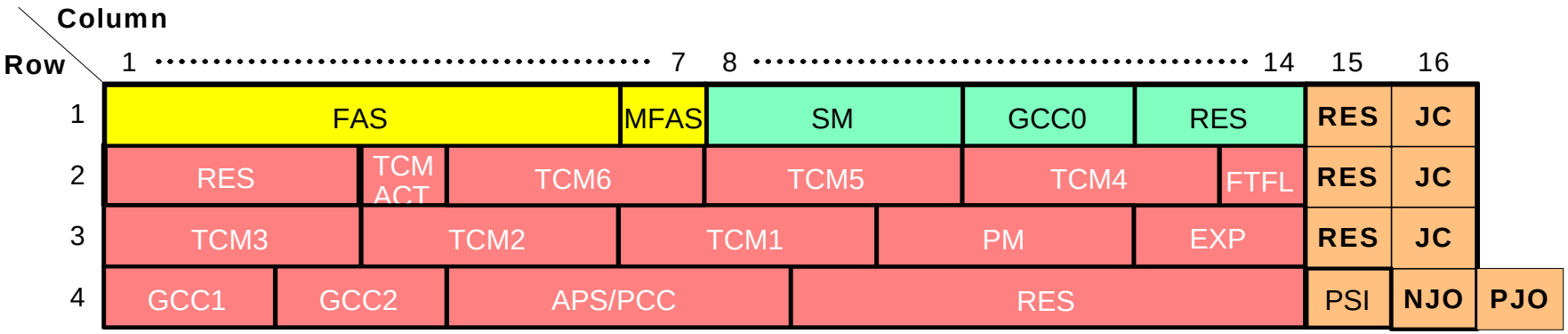
- Client Signal
- OPU*k* - Optical Channel Payload Unit
- ODU*k* - Optical Channel Data Unit
- OTU*k* - Optical Channel Transport Unit
- Alignment

k indicates the order:

1	2.5G
2	10G
3	40G

OTU*k*/ODU*k* Overhead (*k*=1,2,3)

«Associated overhead with the frame»



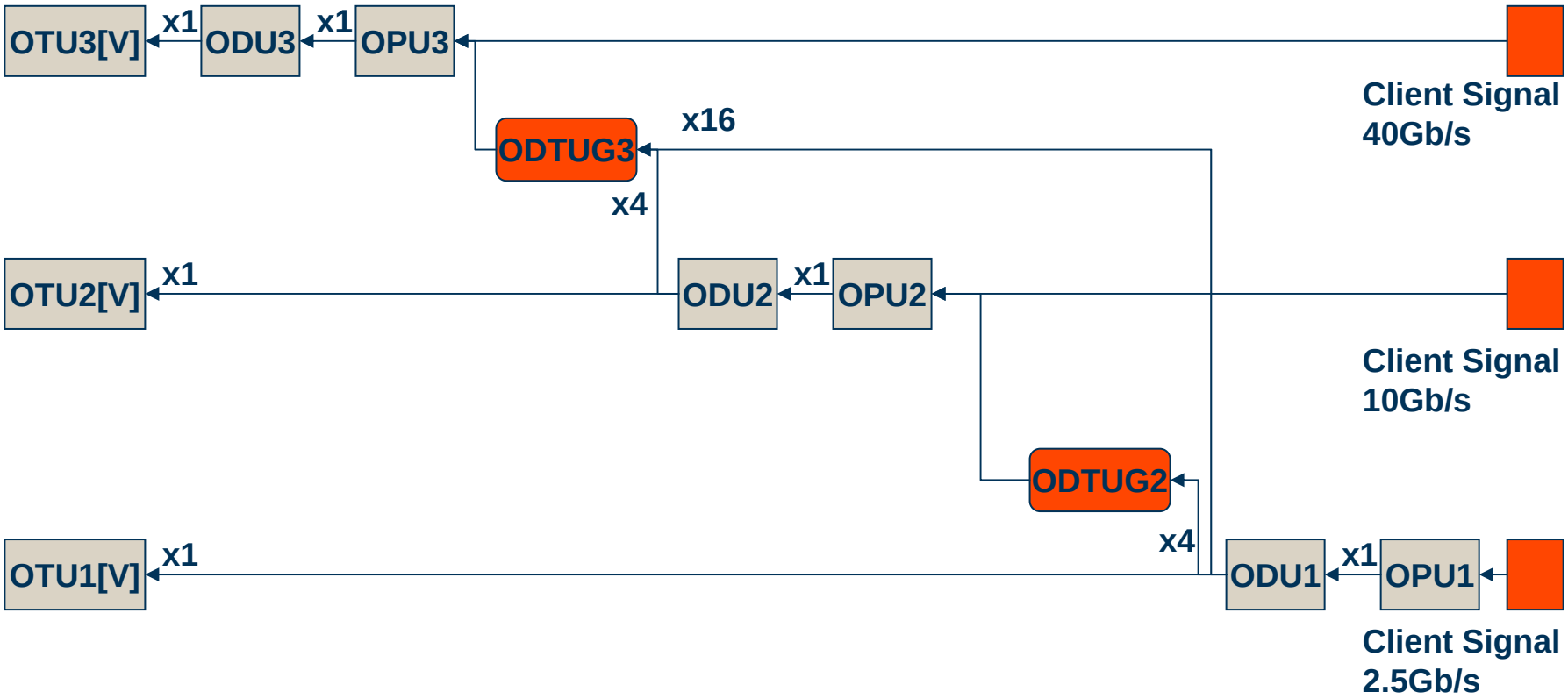
ACT: Activation/deactivation control channel
APS: Automatic Protection Switching coordination channel
EXP: Experimental
FAS: Frame Alignment Signal
FTFL: Fault Type & Fault Location reporting channel
GCC: General Communication Channel
JC: Justification Control
MFAS: MultiFrame Alignment Signal
NJO: Negative Justification Opportunity
PCC: Protection Communication Control channel
PJO: Positive Justification Opportunity
PSI: Payload Structure Identifier
PM: Path Monitoring
RES: Reserved for future international standardisation
SM: Section Monitoring
TCM: Tandem Connection Monitoring

Optical Transport Hierarchy (OTH) - Payloads

- ODU1, ODU2 and ODU3 can carry SDH structured payloads at STM-16/OC-48, STM-64/OC-192 and STM256/OC768 respectively
- ODU1, ODU2 and ODU3 can carry IP/MPLS, Ethernet, Escon etc as OTN clients

Payload	Nominal Bit Rate	SDH/SONET Rate
2.5 Gb/s	**2 488 320 kb/s**	**STM-16 / OC-48**
OPU1	**2 488 320 kb/s**	
OTU1	***2 666 057.143 kb/s***	
10 Gb/s	**9 953 280 kb/s**	**STM-64 / OC-192**
OPU2	**9 995 276.992 kb/s**	
OTU2	***10 709 225.316 kb/s***	
40 Gb/s	**39 813 120 kb/s**	**STM-256 / OC-768**
OPU3	**40 150 159.322 kb/s**	
OTU3	***43 018 413.559 kb/s***	

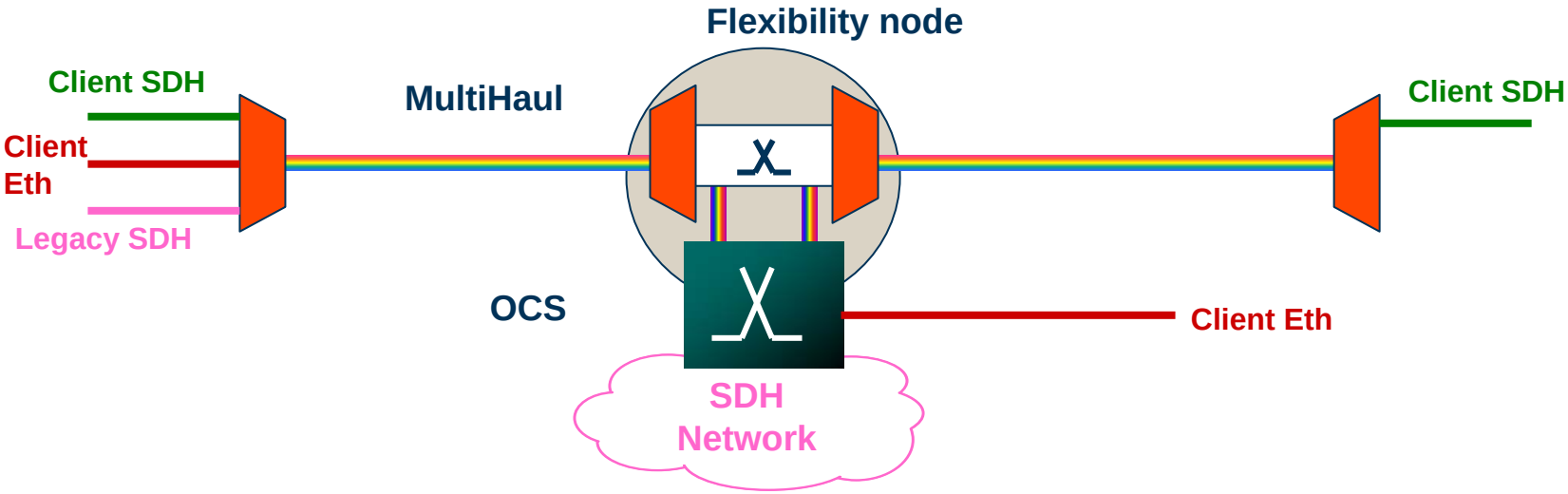
Multiplexing ODUs



OTH Protection Switching Overview

- Optical Multiplex Section (OMS)
  - Requires optical switches
  - Linear protection (1+1, 1:N)
  - Ring protection (Shared Protection Ring - SPRing)
- Optical Channel (Och)
  - Requires optical or electrical switches
  - Linear protection (1+1,1:N)
  - Ring protection (Shared Protection Ring - SPRing)
- Optical Data Unit (ODU)
  - Can be implemented by electrical switches
  - Subnetwork Connection Protection (SNCP)
  - Ring protection (Shared Protection Ring - SPRing)

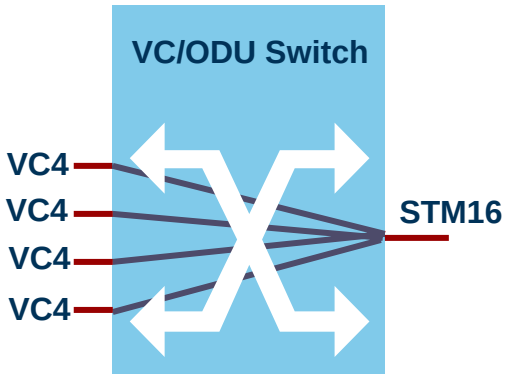
OTN Transport –Hybrid Flexibility node



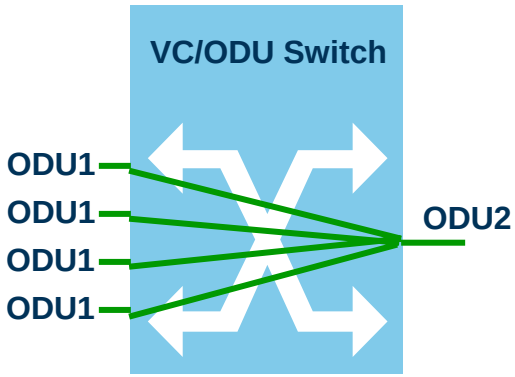
- Client signals carried transparently and monitored over OTN layer
- With wavelength flexibility and ODU/SDH multiplexing & switching
- Multihaul system applies G.709 to map client signals
  - Monitoring, path trace….. In optical layer
- OCS can switch/multiplex SDH and ODU in same fabric
  - Common interface between SDH and OTN network layers
  - Client SDH and data mapped into ODU (standard GFP mapping into SDH)
  - Coloured optics and wrapper compatible with MultiHaul
- Common management and ASTN control plane across SDH and MultiHaul products

Benefits of a hybrid SDH/OTH network

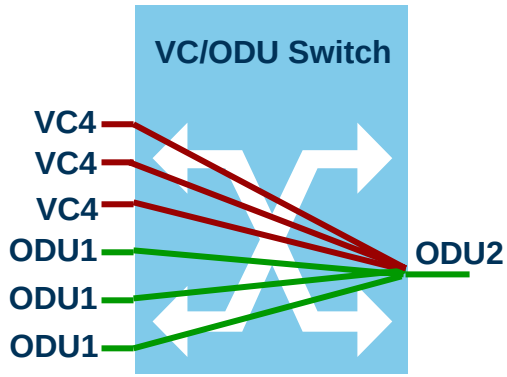
- Switching of VC4 traffic
- Switching of non SDH structured ODU traffic
- Multiplexing of ODU1 to ODU2 traffic
  - 4 x ODU1 to ODU2
  - Mixing of structured and non structured SDH traffic in an ODU2



Switching of VC4s into an STM16



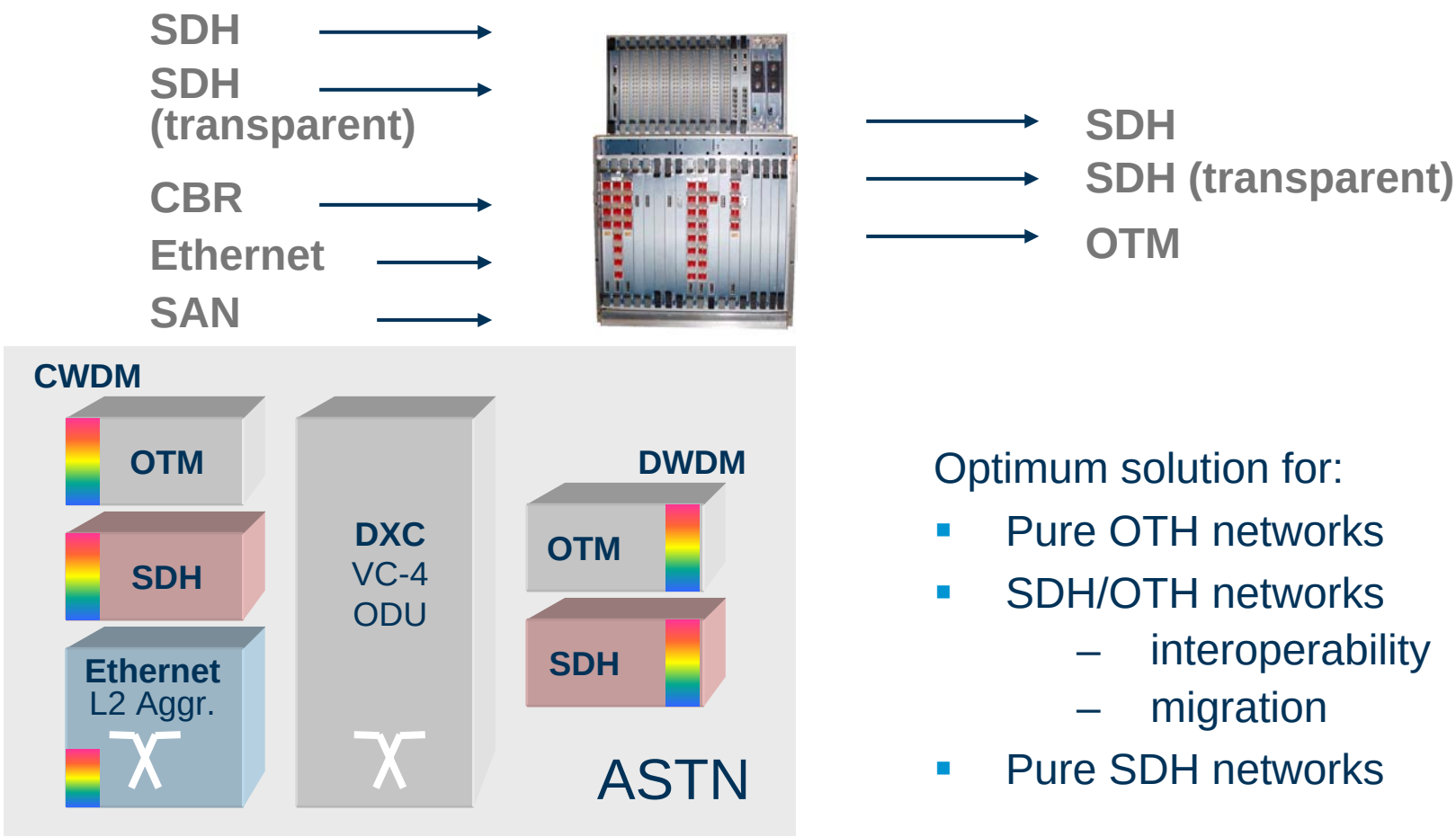
Switching of ODU1s into an ODU2



Switching of ODU1s into an ODU2 where one of the ODU1s is SDH Structured

Combined OTN/SDH/SONET switching fabrics offer cost savings through consolidation in a common platform

Flexible and modular SDH/OTH solution



Optimum solution for:

- Pure OTH networks
- SDH/OTH networks
  - interoperability
  - migration
- Pure SDH networks

ITU-T OTN Recommendations

Topics	Rec. No.
Architectual aspects	G.872
Structures and mapping	G.709
Equipment functional characteristics	G.798
Management aspects	G.874, G.875
Optical Physical layer parameters	G.959.1, G.691, G.692, G.693, G.694,G.695, G.696, G.697, G.698
Compoment and characteristics	G.661, G.661, G.663, G.666, G.671
Error performance	G.8201
Bringing-into-service, maintenance, test	M.2401, O.173
Control of Jitter & Wander	G.8251
OTN Linear protection	G.873
Optical Safety Aspects	G.664
Control Plane Architecture (ASON)	G.8080

Summary

- OTN is the common optical backbone network of the future
- OTN can provide transparent transport of various client signals such as Ethernet, IP/MPLS, ATM and SDH/SONET signals
- OTN provides excellent OAM functionality, resilience, FEC and FCAP capabilities to transport data services
- OTN hierarchy, interfaces and equipment are now fully standardised
- Automatically switched OTN (ie. ASON Control Plane functionality) are currently being deployed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