CONSIDERATION FOR OTN NETWORKING FOR TIME SYNC

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4TH., NOV., 2010

OVERVIEW

- G.709 - OTN interfaces and multiplexing
- OTN Protection Switching
- OTN Timing Aspects
- Transport of PTP over OTN
- Summary

G.709 : INTERFACES FOR THE OPTICAL TRANSPORT NETWORK (OTN)

This Recommendation defines the requirements for the transport of optical transport module of order n (OTM n) signals of the optical transport network. It defines the following:

– Optical transport hierarchy (OTH), Frame structure and bit rates

– Functionality of the overhead in support of multi-wavelength ON

– Formats for mapping client signals.

The new version of G.709 supports an extended set of constant bit rate client signals, a flexible ODUk, which can have any bit rate and a bit rate tolerance up to 100 ppm, a client/server independent generic mapping procedure to map a client signal into the payload of an OPUk, or to map an ODUj signal into the payload of one or more tributary slots in an OPUk. It also provides ODUk delay measurement capability.

FRAME STRUCTURE : OTU*k* AND ODU*k* FRAME FORMATS (*k*=1,2,3,4)

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

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

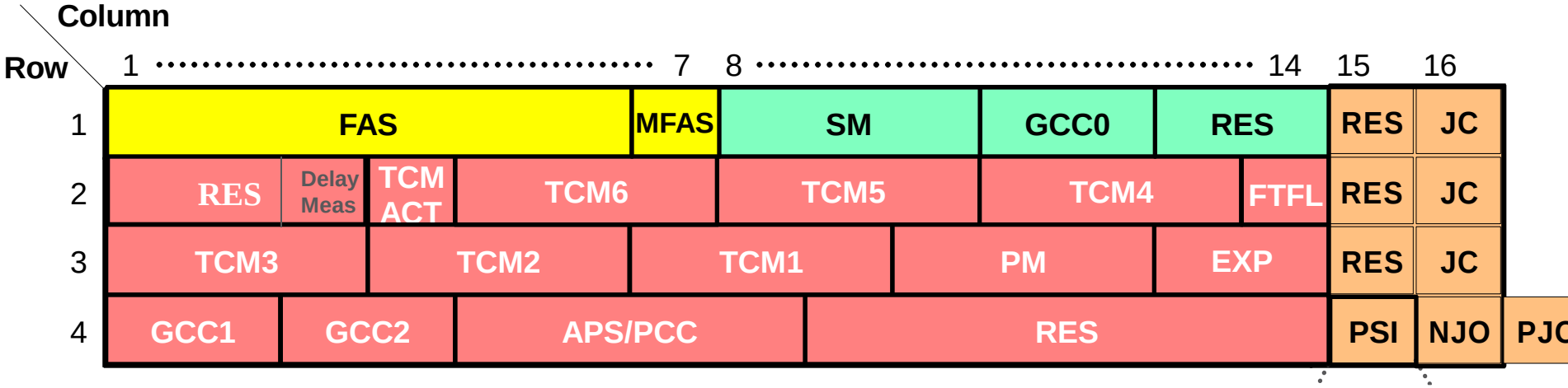
- **Client Signal**
- **OPU*k* - Optical Channel Payload Unit**
- **ODU*k* - Optical Channel Data Unit**
- **OTU*k* - Optical Channel Transport Unit**
- **Alignment**

***k* indicates the order:**

1	2.5G
2	10G
3	40G
4	100G

OTUK AND ODUK OVERHEAD (K=1,2,3,4)

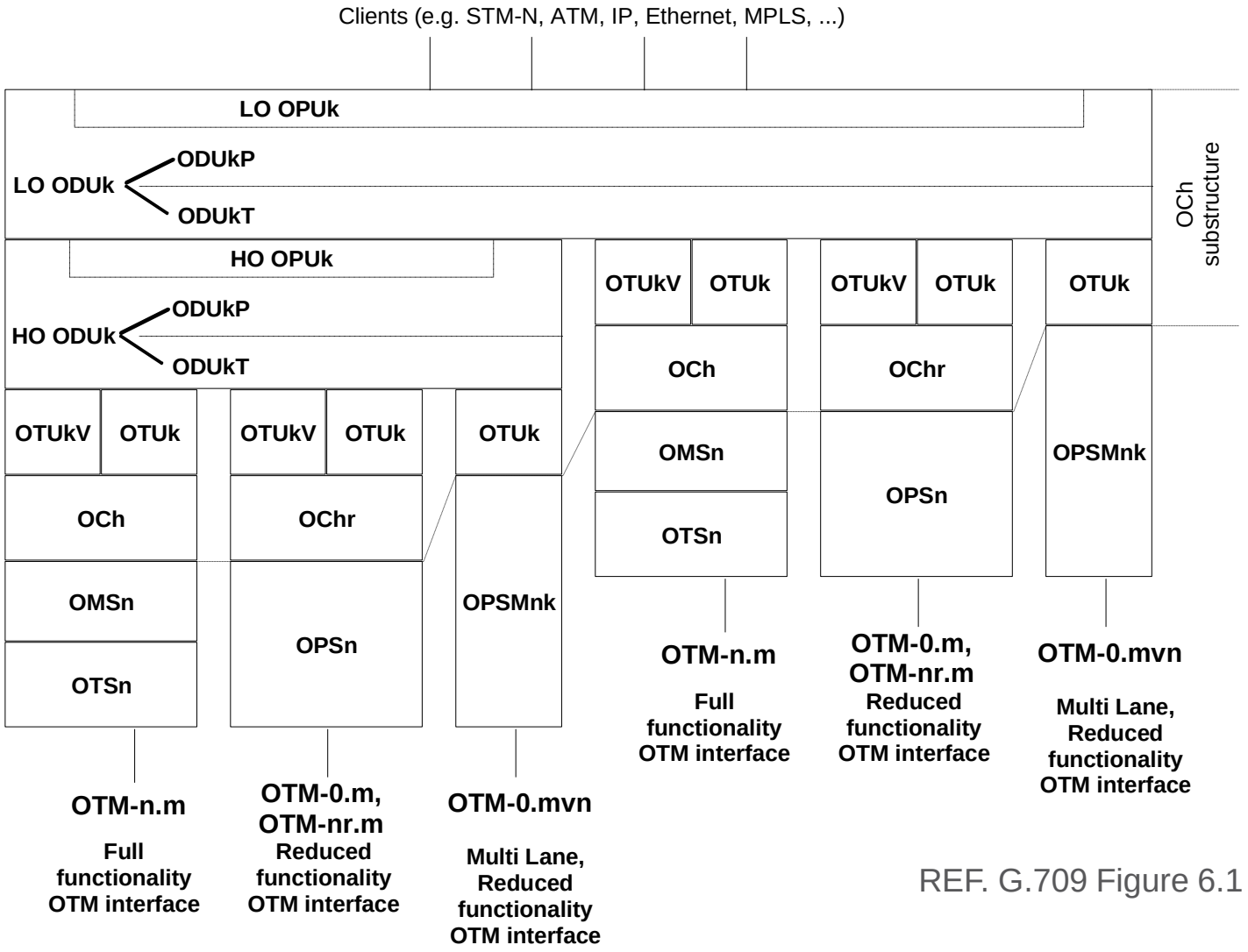
«ASSOCIATED OVERHEAD»



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
For ODU multiplexing two PJO bytes are allocated

MFAS: MultiFrame Alignment Signal
PCC: Protection Communication Control channel
PM: Path Monitoring
PSI: Payload Structure Identifier
RES: Reserved for future international standardisation
SM: Section Monitoring
TCM: Tandem Connection Monitoring

STRUCTURE OF OTN INTERFACES



REF. G.709 Figure 6.1

G.709 : KEY FEATURES

- Generic Mapping Procedure (GMP)
  - Client/server agnostic, asynchronous mapping method
  - Groups of M-bytes of client data mapped using sigma/delta distribution algorithm
  - Default 8-bit timing information (1-bit optional)
- Flexible ODU (ODUflex)
  - Any bit rate in the range 1.25G to 104G
    Transported in one or more HO OPUk Tributary Slots

  Two flavours
  - CBR clients
    - Bit rate is “239/238 □ client bit rate”, tolerance is “client tolerance”
    - Meets stringent client jitter/wander performance specifications
    - Supports synchronous clients (STM-N, syncE)
  - Packet clients
    - sub Lambda
    - Bit rate recommended to be locked to HO ODUk clock
    - n X 1.249G (n=1..8), n X 1.254G (n=9..32), n X 1.301G (n=33..80)
  - Relaxed performance specifications, no jitter/wander requirements
    - Under study if ODUflex(GFP) should be able to carry network synchronisation/timing information to complement STM-N and syncE

OTN APPLICATIONS

- L1 network (access, metro, core)
  - Support L2 and L3 interfaces
  - Support business services
  - Support Gbit/s carrier-carrier/wholesale services
- L2 core domain technology (sub λ Switched Path)
- L3 core domain technology (sλSP)
- Broadcast TV distribution (e.g. DSLAMs, OLTs)

CLIENTS INTO LO OPUK MAPPING

	OPU0	OPU1	OPU2	OPU2e	OPU3	OPU4	OPUflex
STM-1	GMP	-	-	-	-	-	-
STM-4	GMP	-	-	-	-	-	-
STM-16	-	AMP, BMP	-	-	-	-	-
STM-64	-	-	AMP, BMP	-	-	-	-
STM-256	-	-	-	-	AMP,BMP	-	-
1000BASE-X	GMP	-	-	-	-	-	-
10GBASE-R	-	-	-	BMP	-	-	-
40GBASE	-	-	-	-	GMP	-	-
100GBASE	-	-	-	-	-	GMP	-
FC-100	GMP	-	-	-	-	-	-
FC-200	-	GMP	-	-	-	-	-
FC-400	-	-	-	-	-	-	BMP
FC-800	-	-	-	-	-	-	BMP
FC-1200	-	-	-	BMP	-	-	-
ESCON	GMP	-	-	-	-	-	-
DVB-ASI	GMP	-	-	-	-	-	-

G.709 – LO ODUS INTO HO OPUS

	2.5G TS			1.25 G TS			
	HO-OPU1	HO-OPU2	HO-OPU3	HO-OPU1	HO-OPU2	HO-OPU3	HO-OPU4
LO-ODU0	*	*	*	AMP	GMP	GMP	GMP
LO-ODU1	-	AMP	AMP	-	AMP	AMP	GMP
LO-ODU2	-	-	AMP	-	-	AMP	GMP
LO-ODU2e	-	-	-	-	-	GMP	GMP
LO-ODU3	-	-	-	-	-	-	GMP
LO-ODflex	-	-	-	-	GMP	GMP	GMP
PT	(←----------		20 ----------→		←----------	21 ----------→	

* Mapped into ½ of 2.5G Time Slots (TS)

PT = Payload Type LO : Low Order HO: High Order

GMP : Generic Mapping Procedure

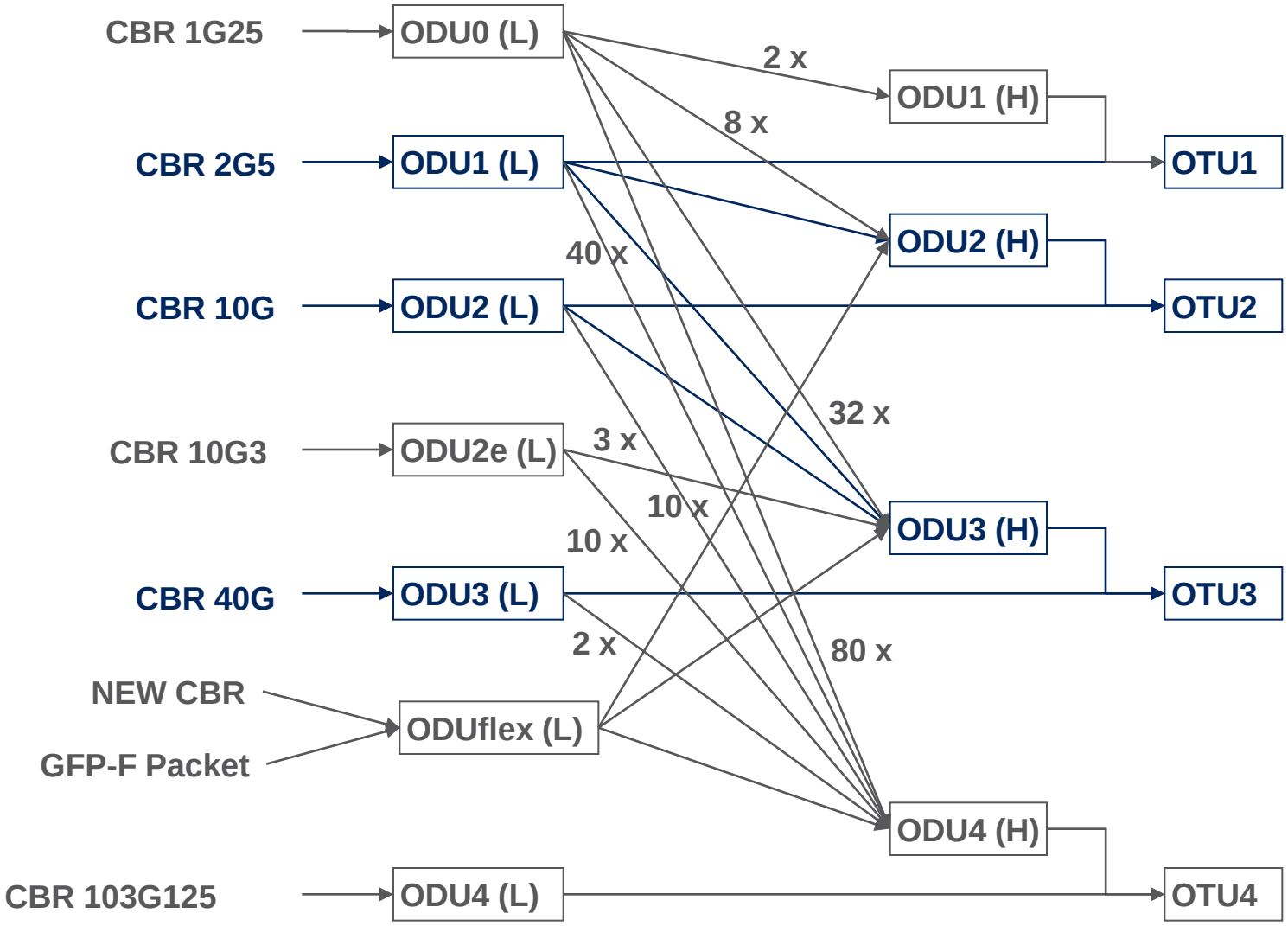
AMP: Asynchronous Mapping Procedure

Implementation/Management should be based on 1.25TS

2.5G TS will be managed as 2X1.25TS

BMP : Bit-synchronous mapping procedure

Current G.709 (12/2009)



OTN PROTECTION SWITCHING

- G.873.1 Linear Protection
  - Approved in 2003
  - Currently being updated and scheduled for consent in Feb 2011

- G.873.2 Ring Protection
  - Currently draft and scheduled for consent Dec 2011

Working and protection paths are not necessary congruent.
Delay variation due to asymmetry is an issue for synchronisation

ODU LINEAR PROTECTION

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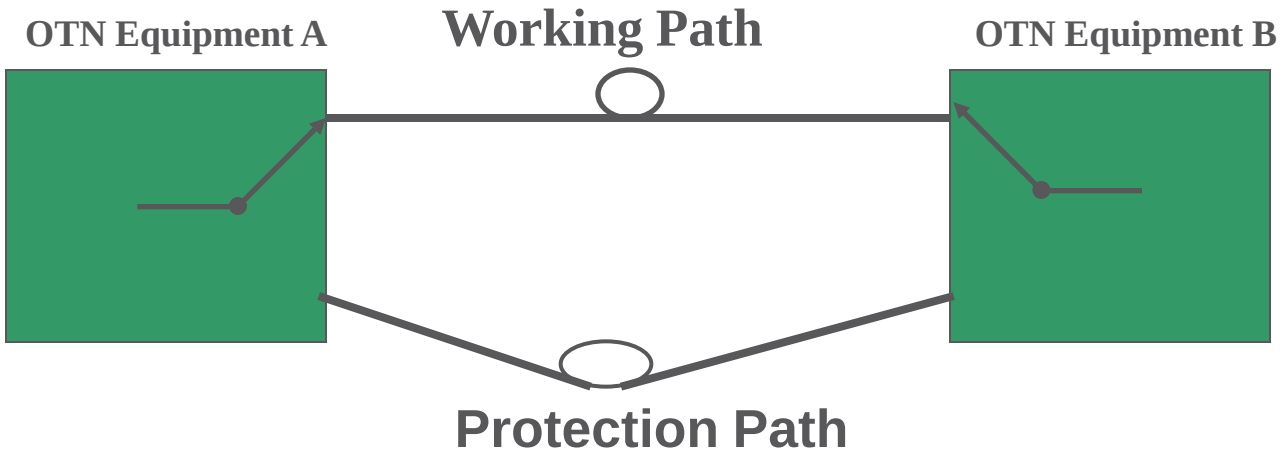
› Typical 1:1 Protection



Working and protection paths are asymmetrical and thus impacts delay variation.

ITU-T OTN STANDARDS

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Network Architecture (G.872)

Terms and Definitions for OTN (G.870)

Structures & Mappings (G.709, G.7041, G.7042, G.Sup43)

Physical Layer (G.959.1, G.693, G.694.x, G.695, G.696.1, G.697, G.698.x, G.Sup39)

Equipment Functional Model (G.798, G.806)

Equipment Mngmt Function (G.874, G.7710, M.3100)

Information Model (G.874.1)

Protection Switching (G.873.1, G.808.1)

Automatic Power Shutdown Procedures for Optical Transport Systems (G.664)

Automatic Discovery for OTN Transport Entities (G.7714.x)

Jitter/Wander Performance (G.8251, O.173)

Bringing into Service & Maintenance for the OTN (M.2401)

Data & Signaling Communication Network (G.7712)

Error Performance (G.8201)

OTN Timing Aspects

CURRENT SYNC NETWORKS

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- The current synchronization network is frequency based with distribution via physical layer (SDH or Synchronous Ethernet)
  - Architecture for frequency delivery is based on G.803 (SDH)
  - Clock selection defined in G.781
    - Based on QL and priority
    - SDH QL: dedicated Multiplex Section overhead
    - Ethernet: QL channel based on IEEE802.3 slow protocol and defined in G.8264
- New packet based frequency delivery
  - Use of NTP or PTP
  - Frequency delivery using packet methods (IEEE1588 or NTP) follows G.803, with PTP packets mapped into IP via UDP.

- OTN supports frequency synchronization:
  - Physical layer
    Timing transparent mappings support physical layer timing (both SDH and Ethernet)
  - Packet based
    Data mappings support IP/UDP (e.g. via Ethernet)

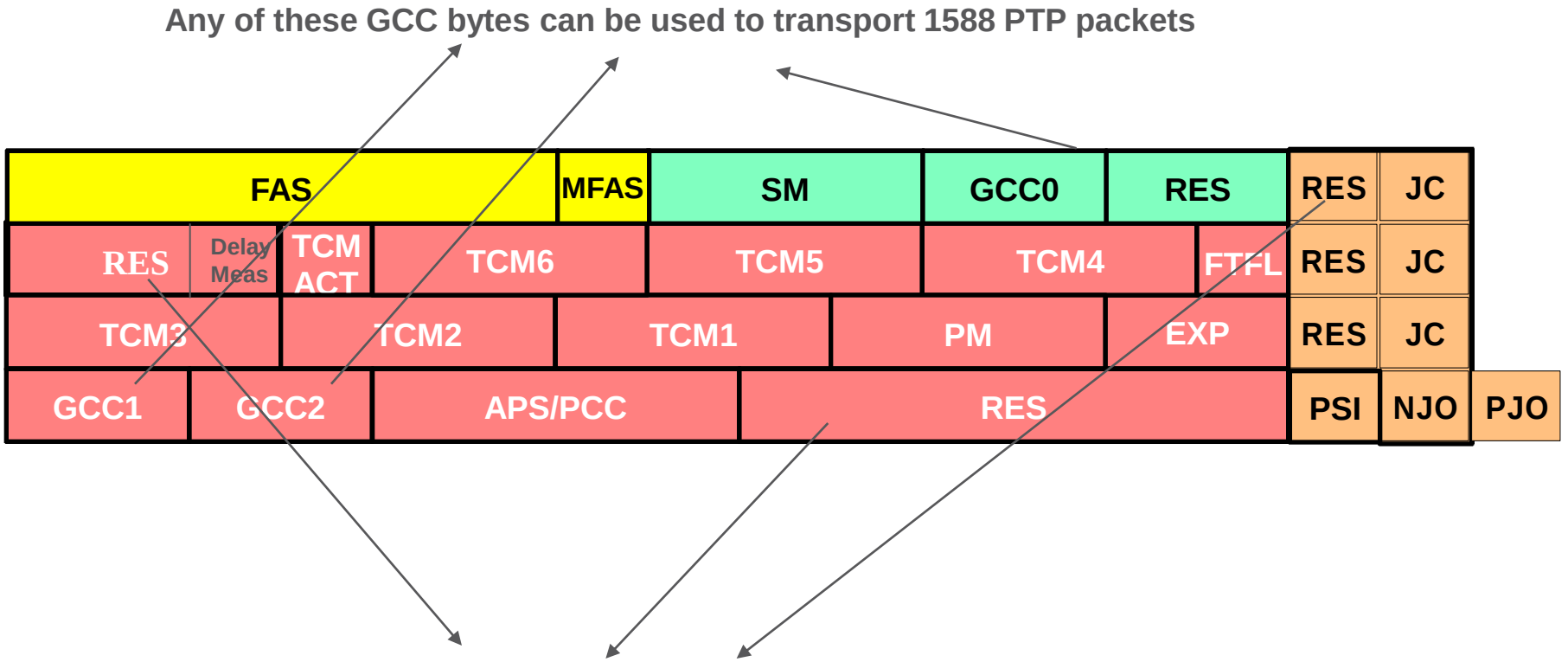
TRANSPORT OF SYNC OVER OTN – POTENTIAL ISSUES

• Phase/time defines new network clocks (BC/TC) and has additional network constraints . (Complexity of integrating BC/TC into transport OTN equipment)
• Initial discussion of transport of Time sync (IEEE1588-PTP) over OTN identified the following:

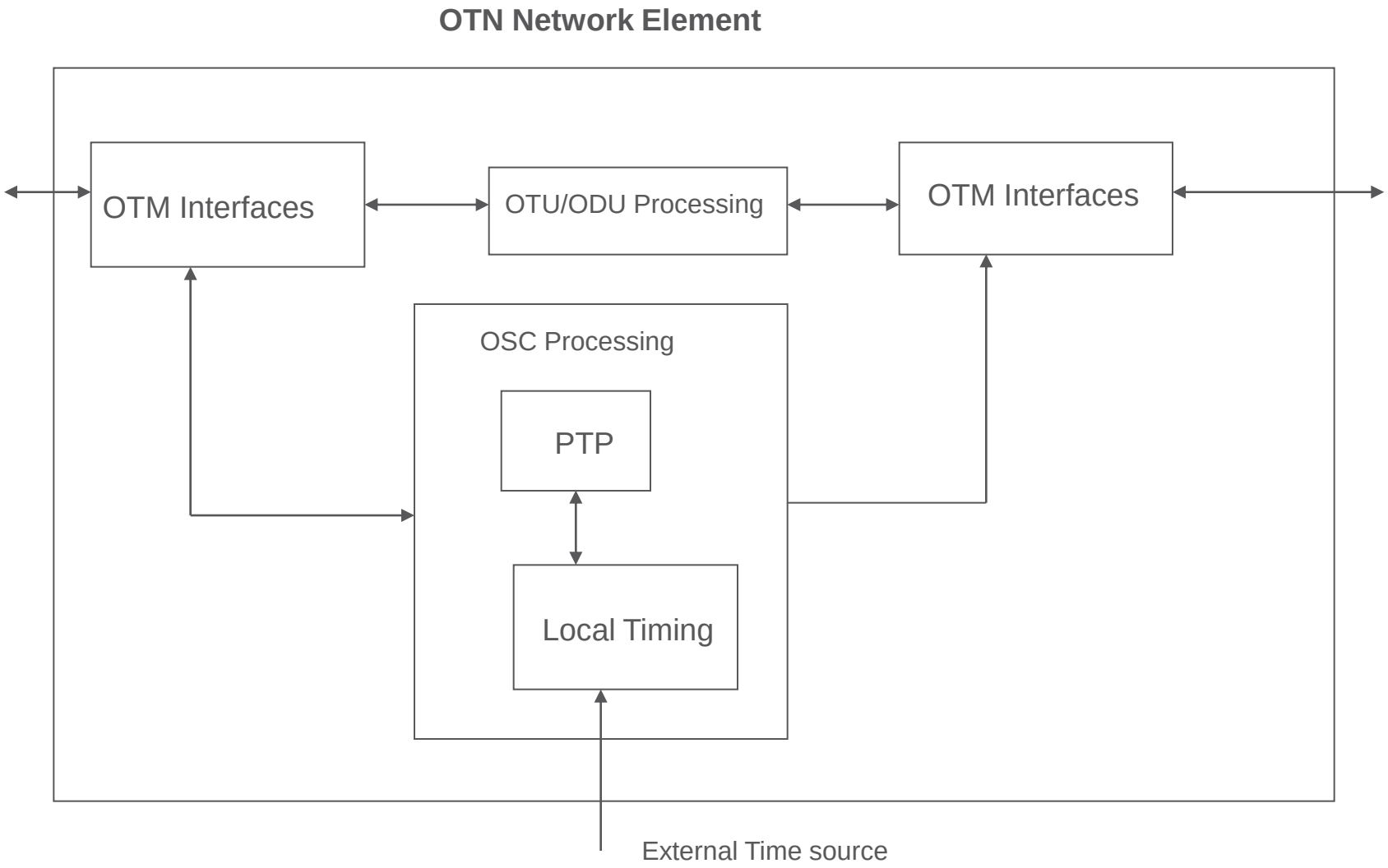
- Transport of PTP client in a timing transparent mapping (eg. ODU0)
  (No impact on current design/deployment, protection switching paths asymmetry/delay asymmetry is an issue)
- A possible candidate is to use the OTN overhead (Reserved byte) to carry 1588 messages
- Using the Generic Communication Channel (GCC) in the OTN overhead
- Using the Optical Supervisory Channel (OSC is not standard)

No Decision yet.

THE USE OF OTN OVERHEAD TO TRANSPORT SYNC PACKETS

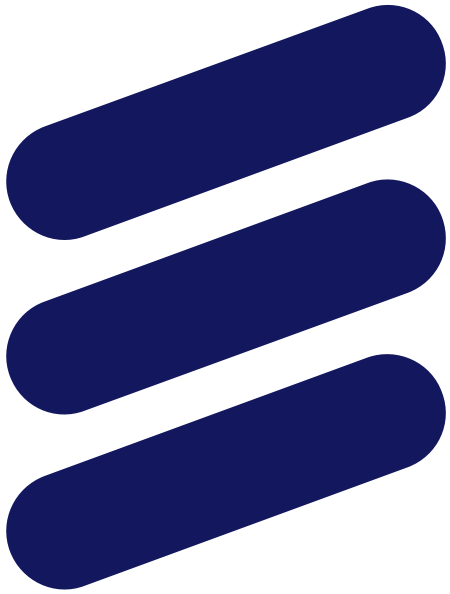


THE USE OF OPTICAL SUPERVISORY CHANNEL TO TRANSPORT SYNC



SUMMARY

- Enhanced G.709 offers multitude of valuable new features in OTN
- Market interest in OTN is growing
- Deployment of OTN based on G.709 is accelerated
- Sync transport over OTN is a major requirement
- Frequency sync transport via client signals is already defined (Sync E included)
- For time sync transport a similar approach, perhaps, is also possible. Other solutions are also under discussion



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