CONSIDERATION FOR OTN NETWORKING FOR TIME SYNC

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OVERVIEW

› G.709 - OTN interfaces and multiplexing
› OTN Protection Switching
› OTN Timing Aspects
› Transport of PTP over OTN
› Summary
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.
ODUk bit rate: $239/(239-k) \times "STM-N"$

Frame Structure: OTUk and ODUk Frame Formats ($k=1,2,3,4$)
### OTUk AND ODUk OVERHEAD (k=1,2,3,4)

**ASSOCIATED OVERHEAD**

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<td>RES</td>
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**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

Clients (e.g. STM-N, ATM, IP, Ethernet, MPLS, ...)

LO ODUk
- ODUkP
- ODUkT

LO OPUk

HO ODUk
- ODUkP
- ODUkT

HO OPUk

OTUk
- OTUkV
- OCh
- OMSn
- OTSn

OTUkV
- OTUk
- OCh
- OChr
- OPSn
- OPSMnk

OTM-n.m
- Full functionality OTM interface
- Reduced functionality OTM interface

OTM-0.m, OTM-nr.m

OTM-0.mvn
- Multi Lane, Reduced functionality OTM interface

OTM-0.m, OTM-nr.m
- Multi Lane, Reduced functionality OTM interface

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 $\lambda$ Switched Path)

› L3 core domain technology ($s\lambda$SP)

› Broadcast TV distribution (e.g. DSLAMs, OLTs)
## Clients into LO OPUk Mapping

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G.709 – LO ODUS INTO HO OPUS

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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

Typical 1:1 Protection

Working and protection paths are asymmetrical and thus impacts delay variation.
OTN Timing Aspects
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.
Any of these GCC bytes can be used to transport 1588 PTP packets

Any of these reserved bytes can be used to transport 1588 PTP packets
The Use of Optical Supervisory Channel to Transport Sync

OTN Network Element

- OTM Interfaces
- OTU/ODU Processing
- OTM Interfaces

- OSC Processing
  - PTP
  - Local Timing

External Time source
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