WAN PHY CLOCK ACCURACY AND TRANSPORT OVER OTN

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INTRODUCTION

- Goal of presentation
  - Describe the impact of the +/- 100 ppm frequency accuracy for 10 GbE WAN PHY on the ability to transport this signal over the OTN, and present a solution which is optimized for both LAN and WAN
- Reason for developing WAN PHY
  - 10 GbE PAR states (under scope)
    - "... In addition to the traditional LAN space, add parameters and mechanisms that enable deployment of Ethernet over the Wide Area Network operating at a data rate compatible with OC-192c and SDH VC-4-64c payload rate."
  - Wide area networks which operate at these compatible rates
    - SONET (T1.105, GR-253)
    - SDH (G.707)
    - OTN (G.709)
      - Optical Transport Network (OTN) includes capability for DWDM

TRANSPORT OVER SONET/SDH

- ELTE will terminate WAN PHY to make the signal SONET/SDH compatible
- Some Functions of ELTE
  - Accommodate WAN PHY jitter levels
  - Allow for any unused SONET/SDH overhead
  - Accommodate potential +/- 100 ppm frequency offset
- Accommodation of WAN PHY frequency offset
  - ELTE clock recovery circuit must have at least +/- 100 ppm pull-in range
  - ELTE will terminate the WAN PHY SONET line; difference in frequency between SPE in WAN PHY and outgoing SPE will be taken up by pointer adjustments
  - STS pointer mechanism accommodates up to +/- 320 ppm
    - 10 GbE WAN PHY - 100 ppm
    - SONET NE clock - 20 ppm (but normally traceable to Stratum1)
    - 320 ppm is pointer mechanism limit; may be other, more stringent limits

OTN - BACKGROUND

- Optical Transport Network (OTN)
  - New transport networking layer
  - Uses DWDM, resulting in terabit/second per fiber (transport level)
  - Gigabit/second paths at 2.5 Gbit/s, 10 Gbit/s, 40 Gbit/s (networking level)
  - Service transparency for client
  - Wavelength level switching
  - Enhanced OAM & networking functionality for all services
- OTN is standardized in ITU-T Recommendation G.709
  - Approved in February, 2001
- OTN Transport
  - Multiple optical channels, one per wavelength
  - Each optical channel transports a digital frame structure, which has payload and overhead areas
  - both asynchronous and bit-synchronous payload mappings into this frame

OTN -- SONET/SDH CLIENT MAPPINGS

- Asynchronous mapping of SONET/SDH client into optical channel
  - Optical channel transmitter clock is independent of client clock
  - Frequency difference is taken up via byte stuffing
  - Maximum frequency difference that can be accommodated between optical channel frame and client is +/- 65 ppm
  - Frequency accuracy of optical channel transmitter clock is +/- 20 ppm
    - Therefore, maximum client offset that can be accommodated is +/- 45 ppm
    - SONET can be accommodated, because SONET signal has frequency accuracy of +/- 20 ppm
    - WAN PHY cannot be accommodated because its frequency accuracy is +/- 100 ppm

OTN -- SONET/SDH CLIENT MAPPINGS (Cont.)

- Bit-synchronous mapping of SONET/SDH client into optical channel
  - optical channel data rate is derived from client rate via clock recovery circuit
  - Frequency tolerance of optical channel rate is +/- 20 ppm
- Optical channel rates and mappings were chosen such that
  - would have same nominal rates for asynchronous and bit-synchronous mappings
  - jitter and wander accumulation for SONET/SDH clients would meet the respective requirements (e.g., ITU-T Recommendation G.825)

OTN -- TRANSPORT OF 10 GbE WAN PHY AS CLIENT

- Neither asynchronous nor bit-synchronous mapping can accommodate signal whose frequency accuracy is +/- 100 ppm
  - For asynchronous mapping, even the use of an optical channel transmitter clock whose frequency offset was zero would allow at most +/- 65 ppm to be accommodated
    - This is a consequence of the stuffing mechanism
  - For synchronous mapping, at most +/- 20 ppm can be accommodated because the OTN transport timing is derived from the client timing

OTN -- TRANSPORT OF 10 GbE WAN PHY AS CLIENT (Cont.)

- ***Note that an integrated ELTE-like device will not work here***
  - In SONET/SDH, the ELTE takes advantage of the pointer mechanism to accommodate the frequency offset
    - Pointer mechanism can accommodate +/- 320 ppm
    - ELTE device can be a regular STM-64/OC-192 interface card, as long as it supports a +/- 100 ppm pull-in range and can accommodate the respective jitter
  - For the OTN with asynchronous mapping, the optical channel transmitter clock is already independent of the client clock; the problem is that the stuffing mechanism can only accommodate +/- 65 ppm
    - One cannot simply terminate the WAN PHY SONET Line (SDH MS) as there is no way of accommodating a sustained frequency offset between WAN PHY clock and OPU clock that exceeds 65 ppm (and OPU clock can be off by as much as 20 ppm, leaving hard limit of 45 ppm)
    - Would essentially need a stand-alone ELTE to terminate the +/- 100 ppm STM-64/OC-192 multiplex section (line) and create a new STM-64/OC-192 multiplex section with +/- 20 ppm accuracy

OTN -- TRANSPORT OF 10 GbE WAN PHY AS CLIENT (Cont.)

- Solution/Proposal
  - Add to the relevant transmitter tables in Clause 52 (see ballot comments) an indication that +/- 20 ppm frequency accuracy is needed for the signaling speed if transport over the optical transport network is desired
    - This would be an option
  - Receiver requirement (pull-in range) remains +/- 100 ppm
    - Allows for interoperability of 20 ppm 10 GbE option with ELTE interface with SONET/SDH network (would not need inventory of both options; 20 ppm would cover both cases)
    - Note that 20 ppm option does not impose any additional requirements on 100 ppm option
  - Even though 45 ppm is hard limit, should pick a value less than this to allow some margin
    - 20 ppm is a practical value for which oscillators are commercially available

IMPACT OF 20 PPM OPTION

- No change to existing WAN PHY specs
- No impact on the 100 ppm option
- 20 ppm option interworks with 100 ppm ELTE for SONET/SDH (i.e., works for both options)
- 20 ppm option would cost at most 1% more than 100 ppm option, assuming
  - 100 ppm oscillator is free (smaller increase if cost of 100 ppm oscillator is accounted for
  - target cost of 10 GbE is 3X that of 1 GbE
  - current cost of available 20 ppm oscillators

IMPACT (Cont.)

- Extra functionality needed in stand-alone ELTE if no 20 ppm option
  - 10 GbE WAN PHY frame alignment
  - descrambling
  - section, line (RS/MS) termination (and consequent actions/reporting)
  - STS-192c pointer processing
  - section, line overhead addition
  - scrambling
- This extra functionality terminates the WAN PHY multiplex section (line) and creates a new SONET/SDH multiplex section (line)
- Above is needed in both directions

BACKUP

OTN - BACKGROUND

- Some of the OTN layers (for complete description, see G.709)
  - Optical Transport Section (OTS)
    - lowest layer
    - analog (optical domain)
    - includes (among other things) the set of wavelengths carrying the optical channels and non-associated overhead
  - Optical Channel (OCh)
    - highest analog layer; maps to one wavelength
  - OTUk
    - lowest digital layer; client of OCh
    - OTUk has frame format, with payload and overhead
    - k = 1, 2, 3 corresponds to rates of 2.5 Gbit/s, 10 Gbit/s, 40 Gbit/s, respectively
    - OTUk is terminated at 3R regenerator, which includes clock recovery

OTN - BACKGROUND (Cont.)

- Some of the OTN layers (Cont.)
  - ODUk
    - Highest digital layer
    - Includes ODUk and OPUk frame
    - ODUk provides for performance monitoring
    - OPUk provides for client mapping (in OPUk frame)
- The OPUk, ODUk, and OTUk frames are synchronous to each other
  - May view full OTUk frame with OTUk, ODUk, and OPUk overhead, and client payload area