IP Over SONET

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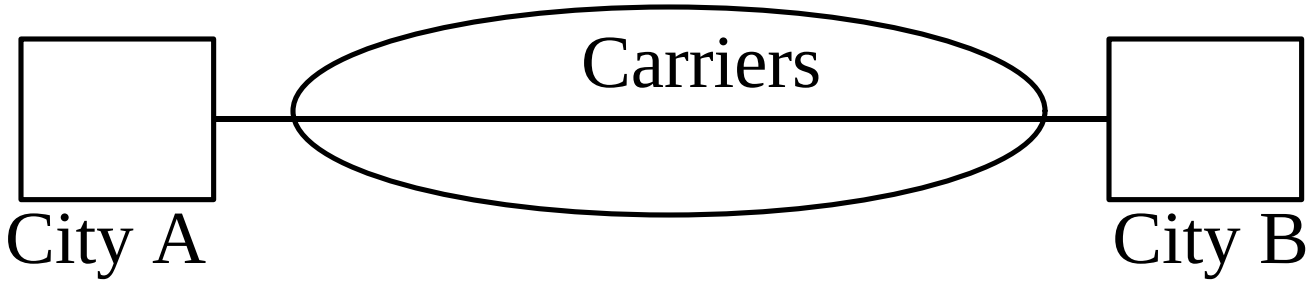
htt htm

Overview

- IP over SONET: Trends, Why?
- SONET: Key features
- SONET vs ATM
- IP over SONET: Key Issues

What is SONET?

- Synchronous optical network
- Standard for digital optical transmission (bit pipe)
- Developed originally by Bellcore.
  Standardized by ANSI T1X1
  Standardized by CCITT
  $\Rightarrow$ Synchronous Digital Hierarchy (SDH)
- You can lease a SONET connection from carriers



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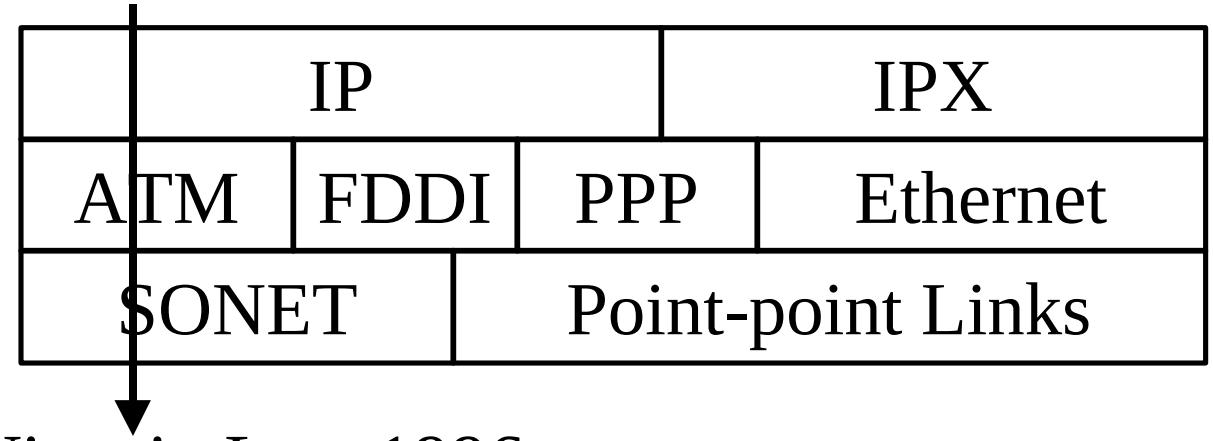
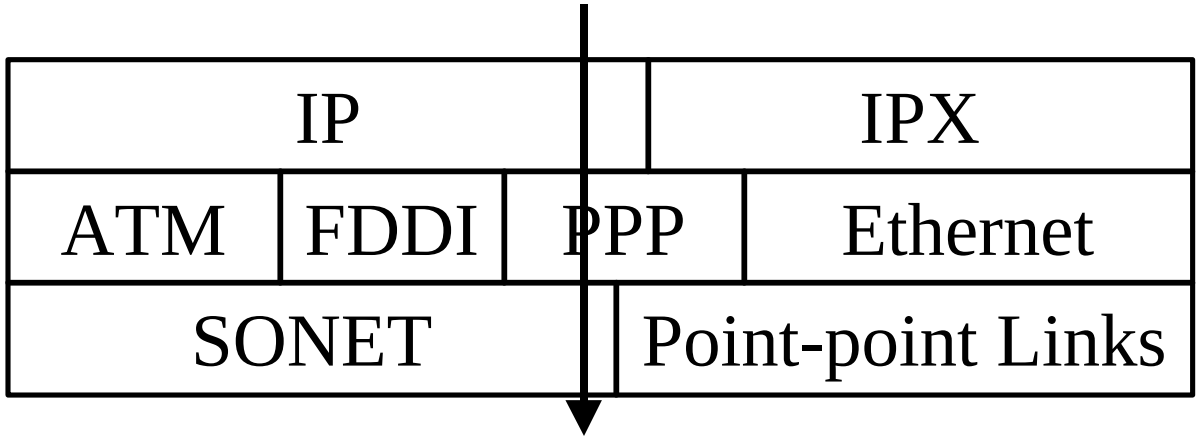
Changing Trends

- View Until Early 1996:



- View in Late 1996:

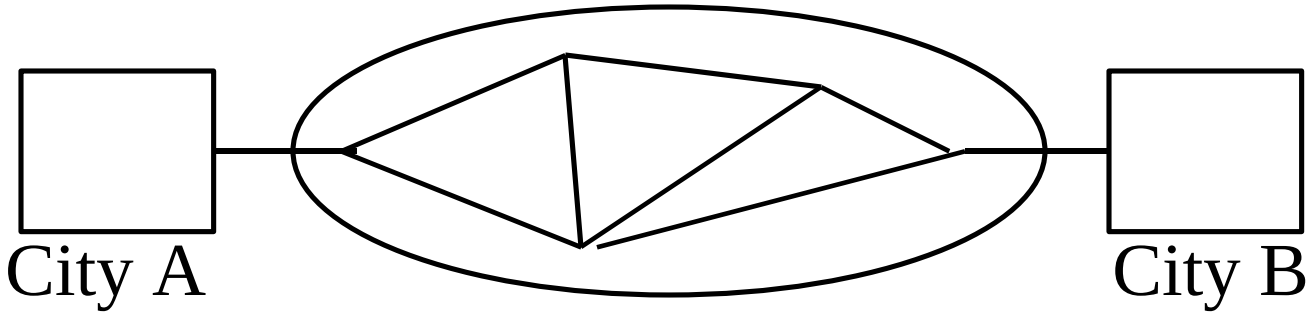


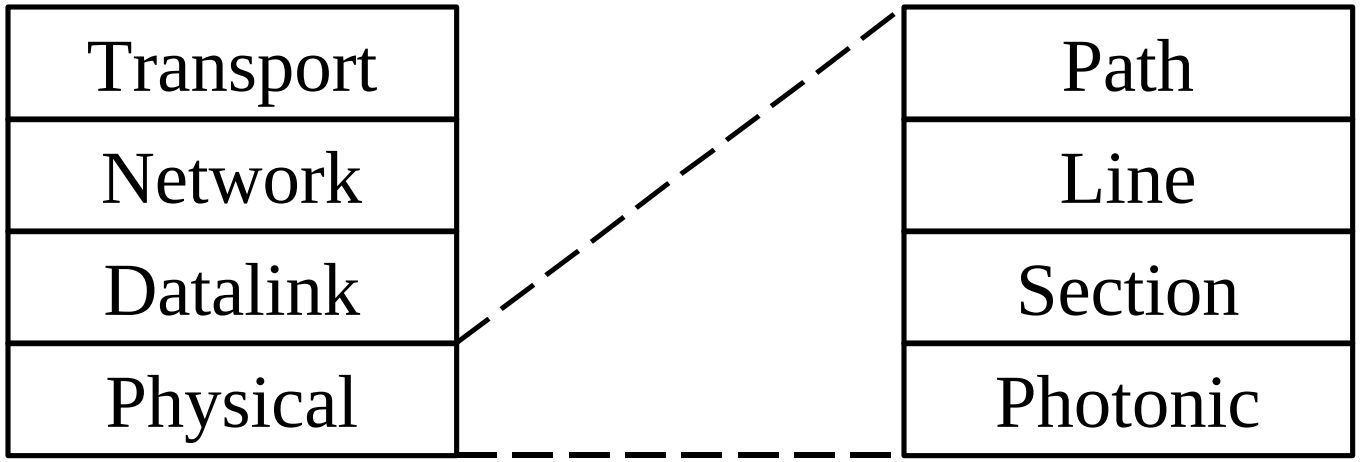
Trends (Cont)

- Originally, ATM has been designed for high-speed transfer of data, voice, video
- Carriers were expected to move to ATM networks
- SONET was designed as a high-speed physical layer for transmission over fiber-optic links
- ATM was expected to run over carrier's SONET links
- "IP over SONET" allows IP datagram transfers over high-speed carrier links using PPP
- SONET is appearing as a competition to ATM

SONET Protocols

- Synchronous Optical **Network**





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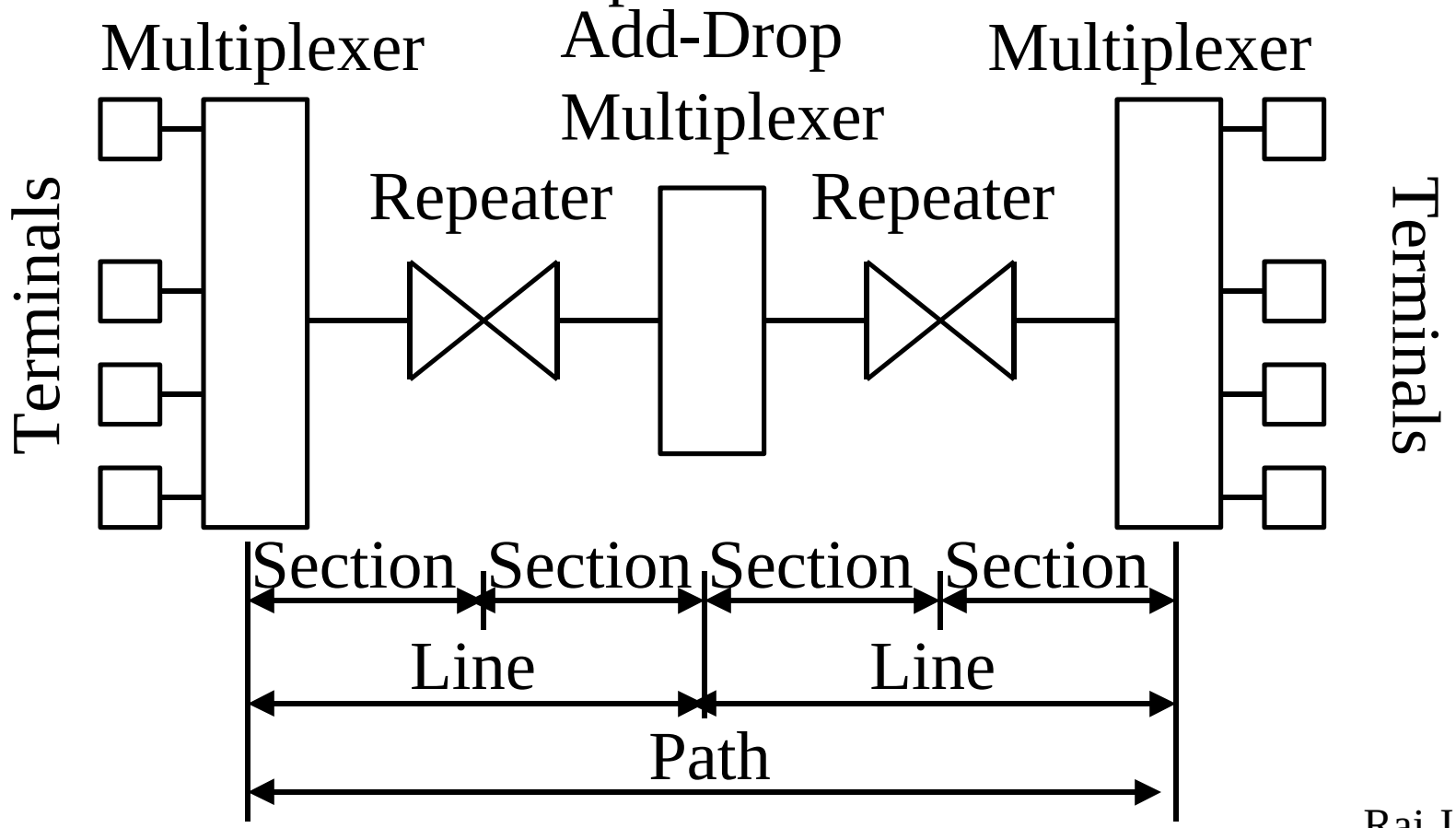
Physical Components

- Section = Single run of fiber
- Line = Between multiplexers



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Signal Hierarchy

Synchronous Transport Signal Level n = STS-n = $n \times 51.84$ Mbps
STM=Synchronous Transport Module, OC=Optical Carrier level

ANSI Designation	Optical Signal	CCITT Designation	Data Rate (Mbps)	Payload Rate (Mbps)
STS-1	OC-1		51.84	50.112
STS-3	OC-3	STM-1	155.52	150.336
STS-9	OC-9	STM-3	466.56	451.008
STS-12	OC-12	STM-4	622.08	601.344
STS-18	OC-18	STM-6	933.12	902.016
STS-24	OC-24	STM-8	1244.16	1202.688
STS-36	OC-36	STM-12	1866.24	1804.032
STS-48	OC-48	STM-16	2488.32	2405.376
STS-96	OC-96	STM-32	4976.64	4810.176
STS-192	OC-192	STM-64	9953.28	9620.928

Automatic Protection Switching

- 100 μs or more is "loss of signal"
  2.3 μs or less is not "loss of signal"
  In-between is up to implementations
- Most implementations use 13-27 μs
  ⇒ Higher speed lines ⇒ maintain sync for more bits
- APS allows switching circuits on fault
- May take up to 50 ms to complete
- Wastes entire links as standby.
- Protection by routers works faster than by SONET

IP/PPP/SONET vs IP/ATM/SONET

1. Overhead:
   - SONET claimed to provide 25-30% higher throughput than ATM.
   - IPOA encaptulation, AAL5 trailer, ATM cell headers eliminated in SONET
   - 155.52 Mbps Link $\Rightarrow$ 149.76 ATM $\Rightarrow$ 135.63 ATM payload
   - 9.5% more throughput (135.63 Mbps vs 149 Mbps) = 9 T1 Lines out of 96
   - 6% for ABR flow control. Nothing for UBR/CBR/VBR.
   - Signaling overhead for SVCs.

PPP/SONET vs ATM/SONET (Cont)

2. SONET Reliability through APS
   APS wastes entire links as standby.
   Long APS times can badly interact with routing
3. ATM provides multiservice integration
4. ATM provides traffic management (oversubscription)
5. SONET needs to be provisioned.
   ATM allows SVCs also.
6. ATM allows multiple secure VCs on the same physical interface.

PPP/SONET vs ATM/SONET (Cont)

7. SONET managed by TL-1 protocol. Will migrate to CMIP. IP and ATM can be managed by SNMP. Can't configure SONET equipment/ bandwidth from IP platform.
8. PPP byte stuffing create unpredictable traffic $\Rightarrow$ QoS difficult
9. No Priorities or preemption in IP/PPP/SONET $\Rightarrow$ QoS not feasible currently
10. PPP is a single-destination protocol. You can reach only one destination using one link. ATM is a multi-destination protocol.

PPP/SONET vs ATM/SONET (Cont)

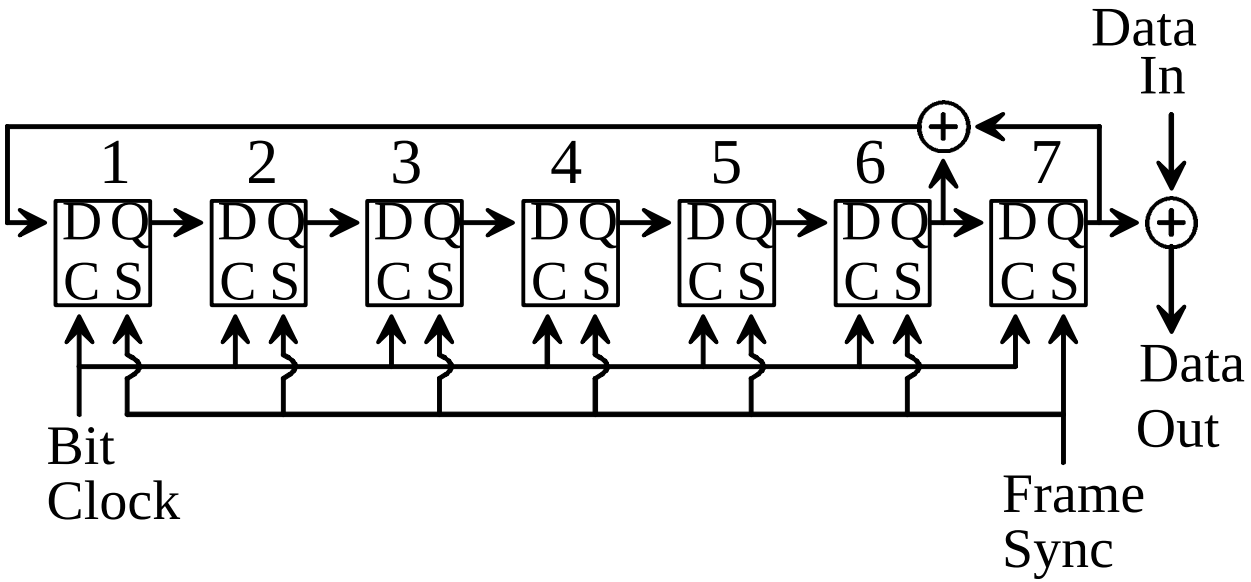
SONET allows multiple destinations from one link using multiple OC-n frames but PPP cannot use this feature.

11. Multicast: No support in SONET.
    Handled in IP.
    Multicast over SONET being designed.
    Multiple Access Protocol Over SONET (MAPOS)
12. Delay: Every hop of SONET
    introduces a 125-μs delay regardless of speed
    ⇒ Cut through routing is difficult
13. SONET payload scrambling is an issue.

Scrambling: Introduction

1. Add random sequence
2. Divide by a number and send quotient.
   Similar to CRC.

Both implemented by shift-registers.
Analyzed using polynomials. $1+x^6+x^7$



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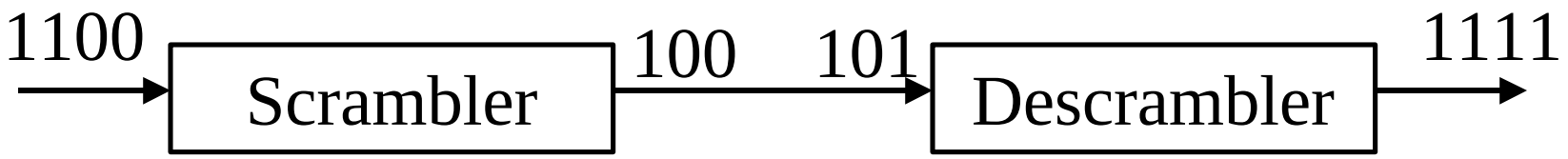
Scrambling (Cont)

- Set-Reset Synchronous scrambler:
  Add a fixed random bit pattern.
  Need to tell where to start adding
  ⇒ Need to synchronize.
- Self-synchronous scrambler: Divide by a fixed number. No need for synchronization.
  Errors multiply.
- Example: Send 12 using divider 3 ⇒ Send 4.
  Received 5 ⇒ 15.



Scrambling

- SONET uses NRZ coding.
  1 = Light On, 0 = Light Off.
- Too many 1's or 0's ⇒ Loss of bit clocking information
- All bytes (except some overhead bytes) are scrambled
- Polynomial $1 + x^6 + x^7$ with a seed of 1111111 is used to generate a pseudo-random sequence, which is XOR'ed to incoming bits.

  1111 1110-0000 0100-0001 … 010
- If user data is identical to (or complement of) the pseudo-random sequence, the result will be all 0's or 1's.

Payload Scrambling Issue

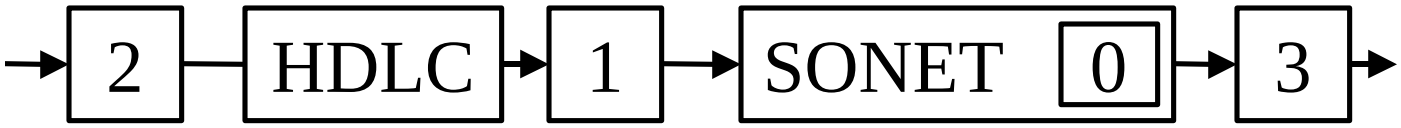
- 21 1500-byte datagrams will ensure
  2080 bits of 0's/1's (13 μs at STS-3c)
  resulting in Loss of signal, framing, and Sync
  [T1X1.5/97-134, 97-130]
- Standard requires 2.3-100 μs LOS.
  Most interfaces are on the low end.
  Most interfaces can't keep clock sync after 80 bits
- Carriers tariffs based on failures and errors guarantees
  ⇒ Customer can cause excessive failures and
  no way for carriers to trace it.
- A single packet can disrupt a large number of users.
- APS is triggered ⇒ Disruption could last up to 50 ms.

Scrambling: Solutions

1. ANSI T1X1.5+IETF recommend using $1+x^{43}$ for PPP over SONET for STS-1 through STS-48. Higher or lower rates require further study.

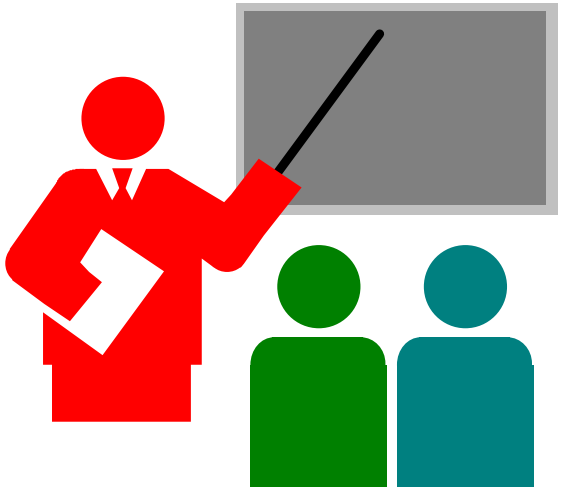
- A path signal label different from 207 will be used to differentiate scrambled and non-scrambled payloads.
- Self-synchronous scrambler ⇒ error-multiplying. 1-bit error on the line ⇒ 2-bit errors in packet
- Some error patterns detectable w/o scrambler are undetectable with scrambler
- FCS bit ordering (lsb) and scrambler bit ordering (msb) also have some effect.

Solutions (Cont)



2. Scramble PPP before HDLC framing
   ⇒ Requires disabling errored HDLC frame discard. Does not protect against framer errors.
3. Scramble the SONET scrambler output.
4. Use $1+x^2+x^{19}+x^{21}+x^{40}$ set-reset frame synchronous scrambler
5. Avoid long sequences of zeros in the SONET scrambler output by pattern matching HDLC packet and byte-stuffing.

Summary



- IP over SONET = IP over PPP in HDLC-like framing over SONET/SDH
- SONET does not provide QoS, Dynamic bandwidth (SVCs), QoS multiplexing, traffic management
- Payload scrambling is a hot issue

References

- For a detailed list of references, see http://www.cis.ohio-state.edu/~jain/refs/snt_refs.htm
- RFC 1619, PPP over SONET/SDH,
- RFC 1662, PPP in HDLC-like Framing
- RFC 1661, The Point-to-Point Protocol (PPP)