SONET

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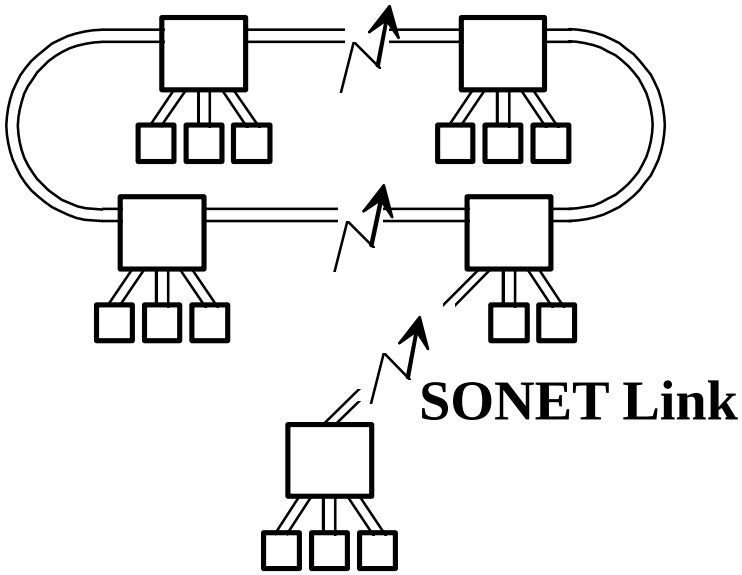
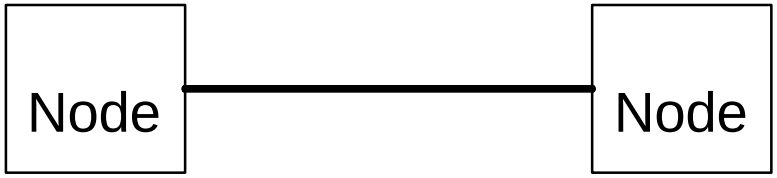
SONET

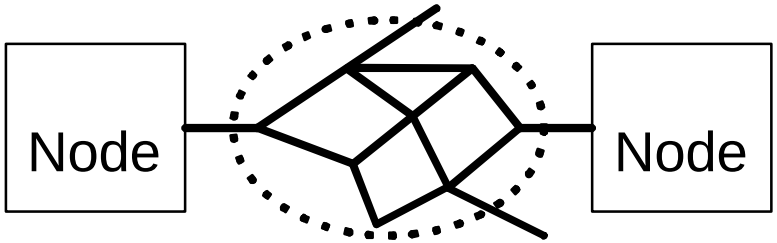
- Synchronous Optical Network
- Standard developed by ANSI and Exchange Carrier Standards Association (ECSA)
- CCITT: Synchronous Digital Hierarchy (SDH)
- SONET links can be used in place of dark fiber



Two Views of SONET

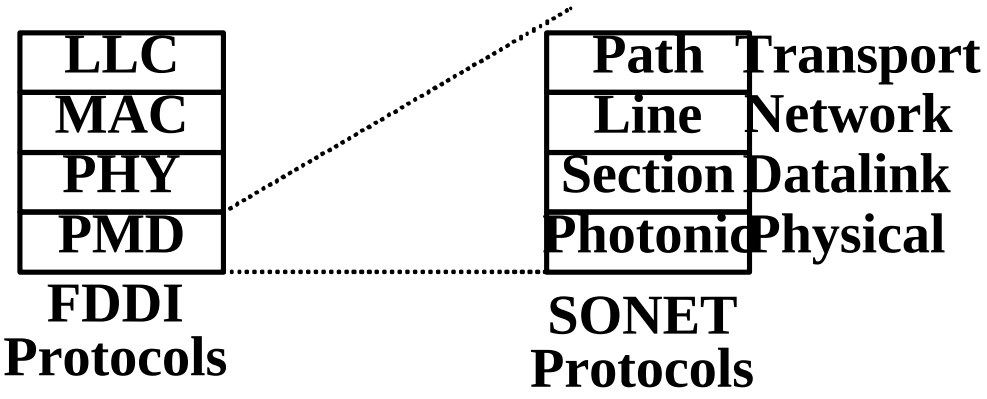


(a) Customer view: a link.



(b) Carrier's view: a network.

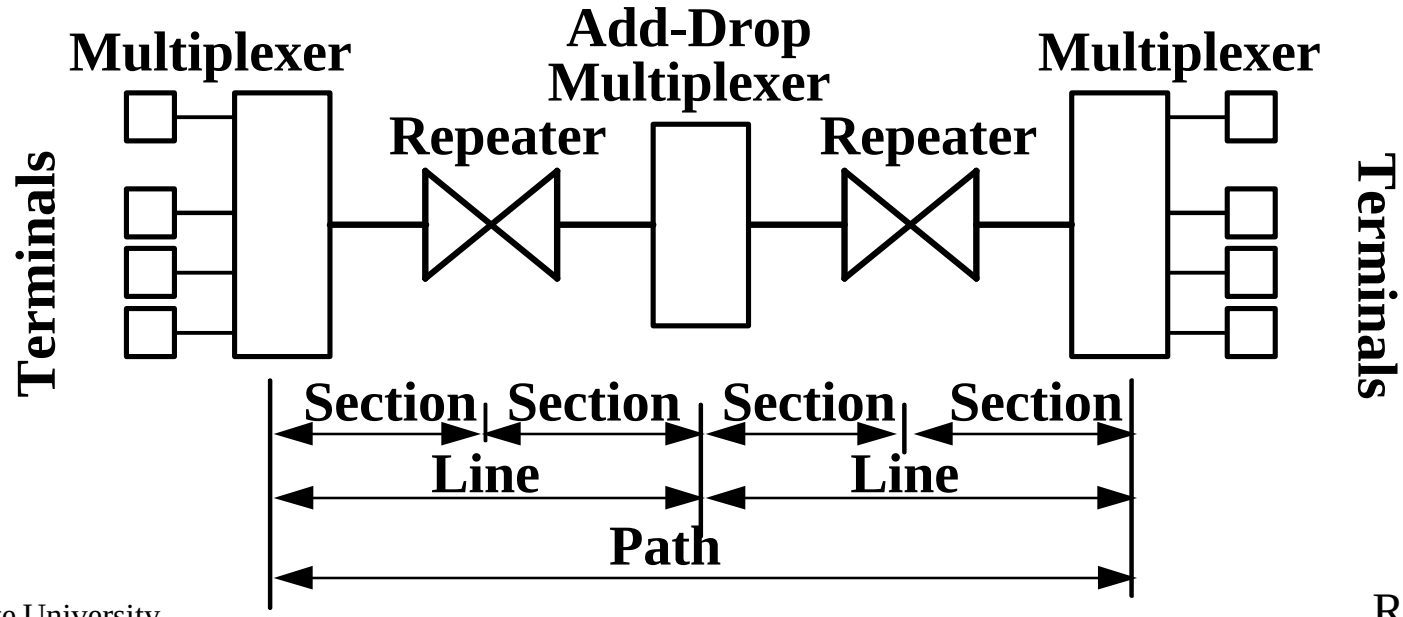
Protocol Components of SONET



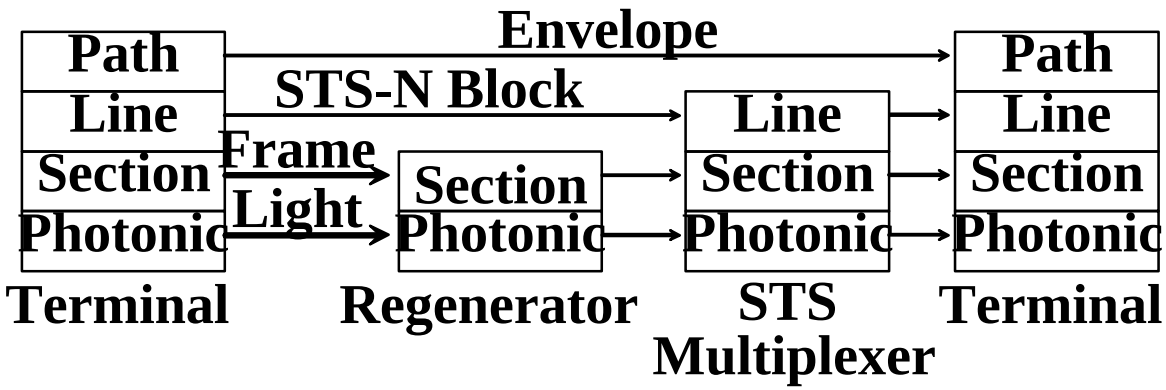
- Photonic Layer: Characteristics of fibers, transmitters, receivers and encoding (ANSI T1.106-1988)
- Section Layer: Transmission across a single link. Framing, scrambling, and error monitoring.
- Line Layer: Signaling between multiplexer switches. Frame synchronization. Multiplexing of data in to SONET frames.
- Path Layer: End-to-end signaling issues. Mapping DS3, FDDI, BISDN into SONET payload.

Physical Components of SONET

- Section: Single run of fiber. Clock synchronization and timing issues
- Line: Sections connected via repeaters. Between multiplexers or switches
- Path: End-to-end



Protocol Hierarchy



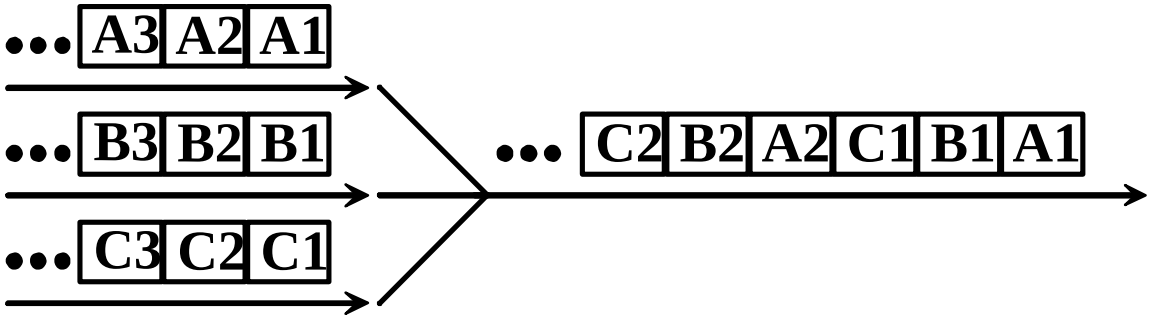
SONET/SDH Signal Hierarchy

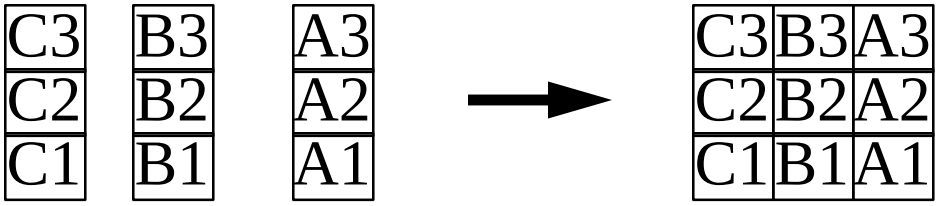
Synchronous Transport Signal Level n = STS-n = $n \times 51.84$ Mbps
STM=Synchronous Transport Module, OC=Opical Carrier level

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

Byte Multiplexing

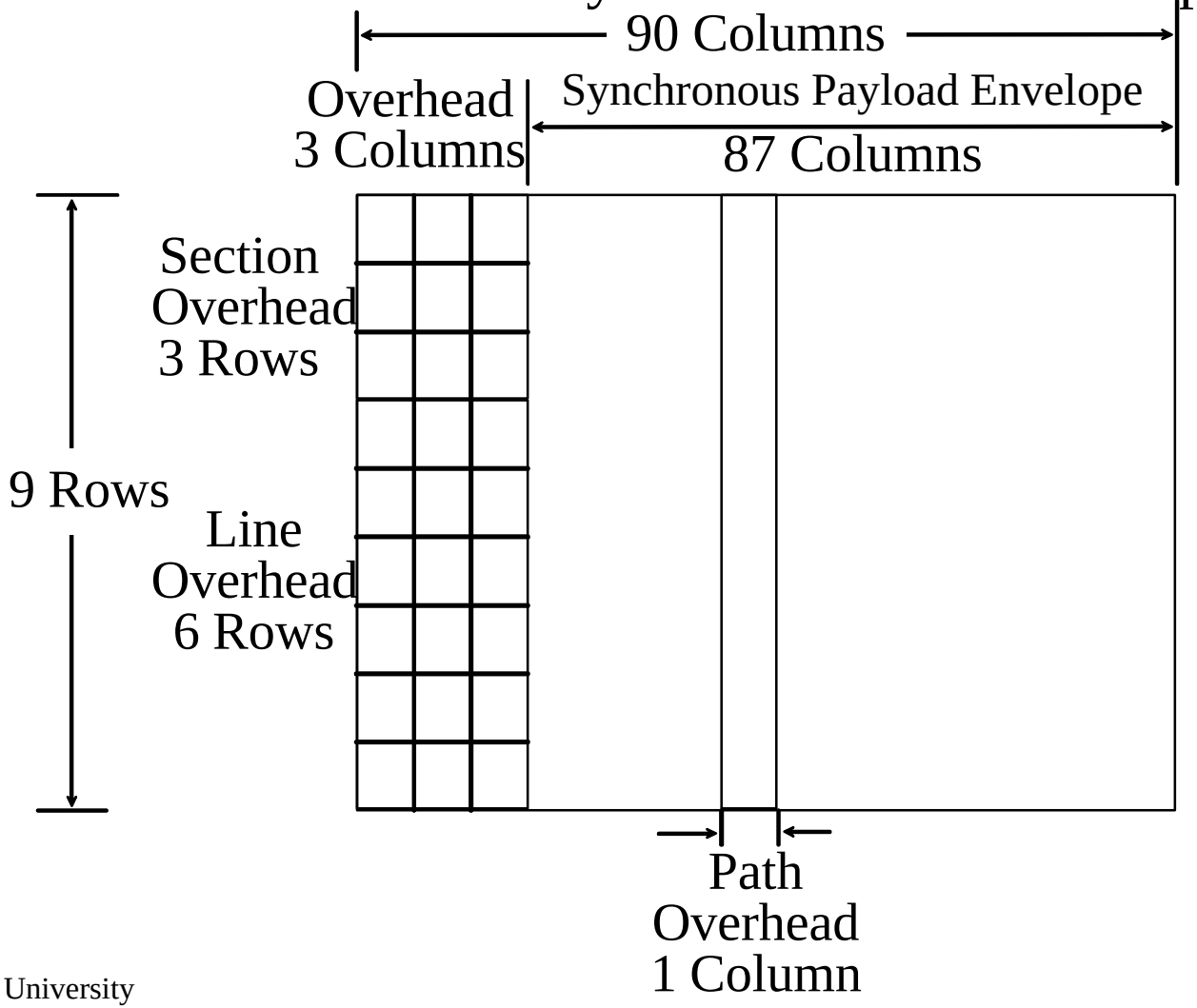
- Also known as byte interleaving
- Easier to view in two dimension



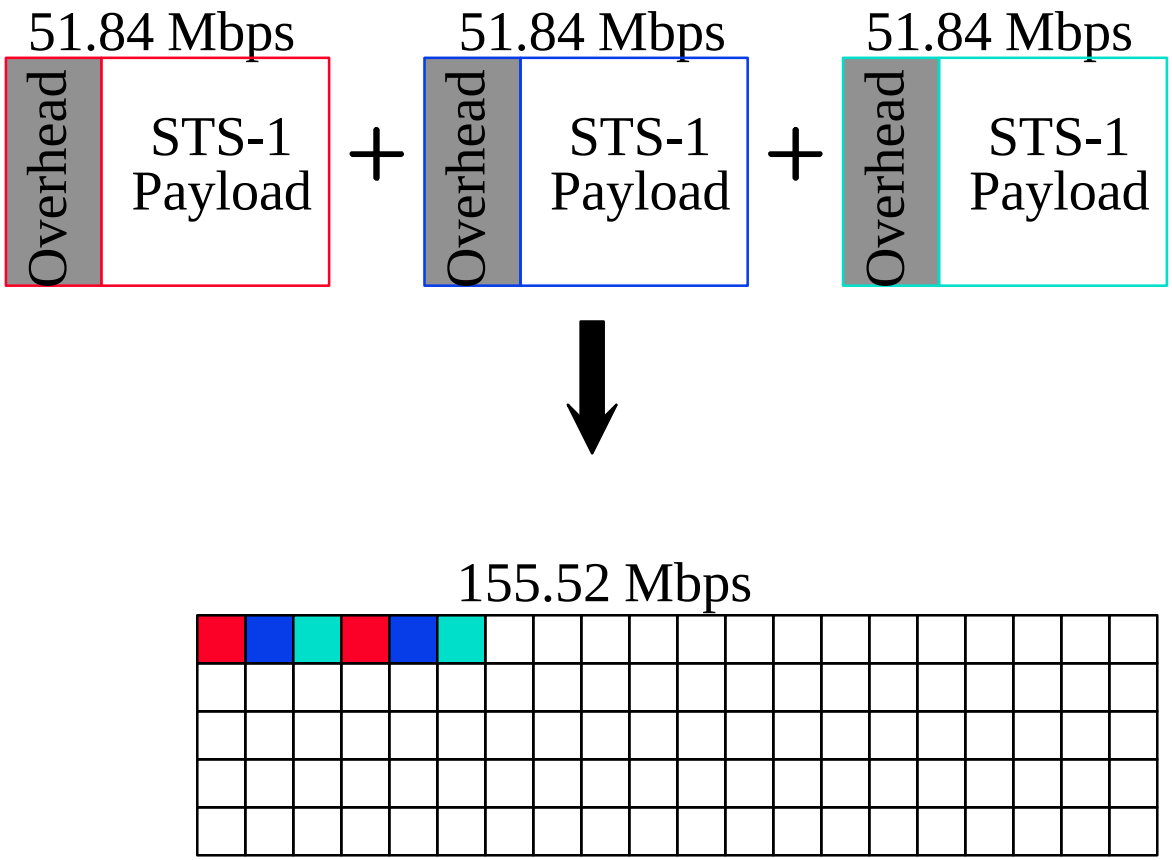


STS-1 Frame Format

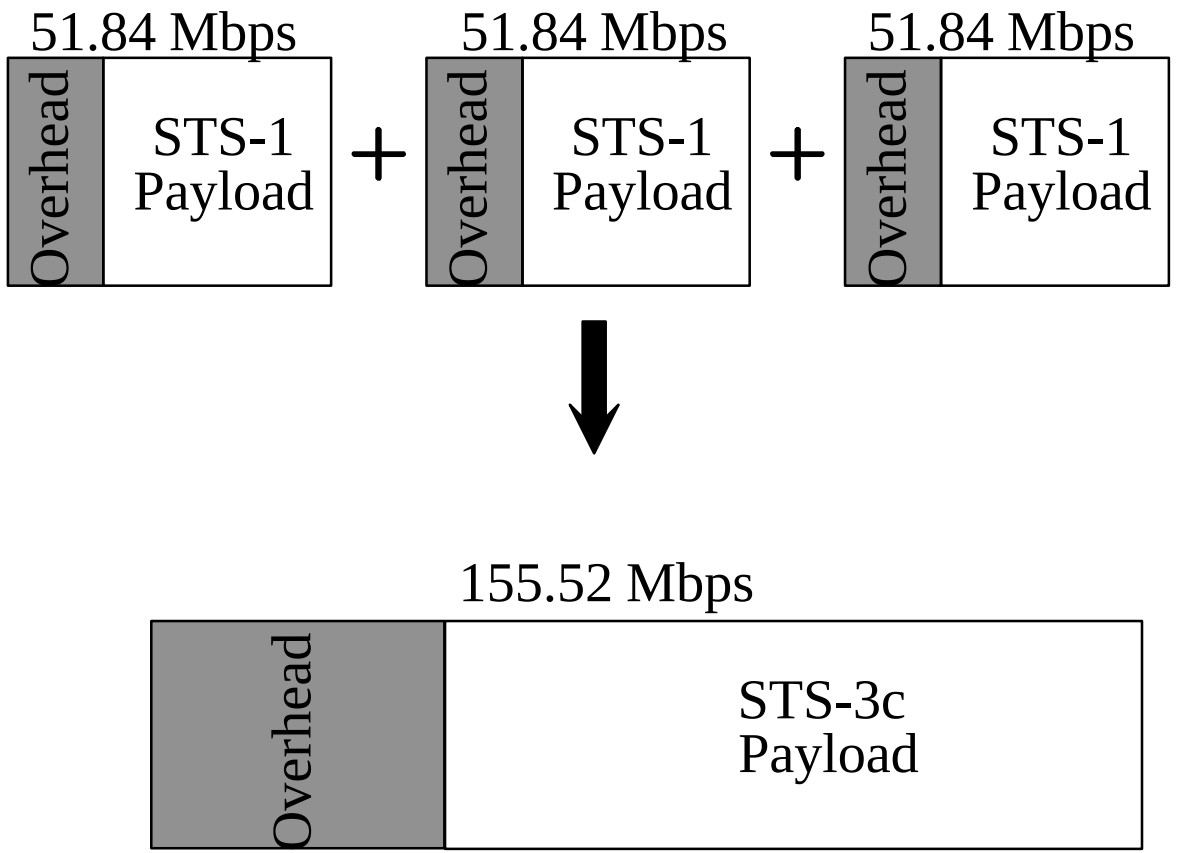
- Overhead = Header. 810 Bytes/125 ms = 51.84 Mbps



Multiplexing

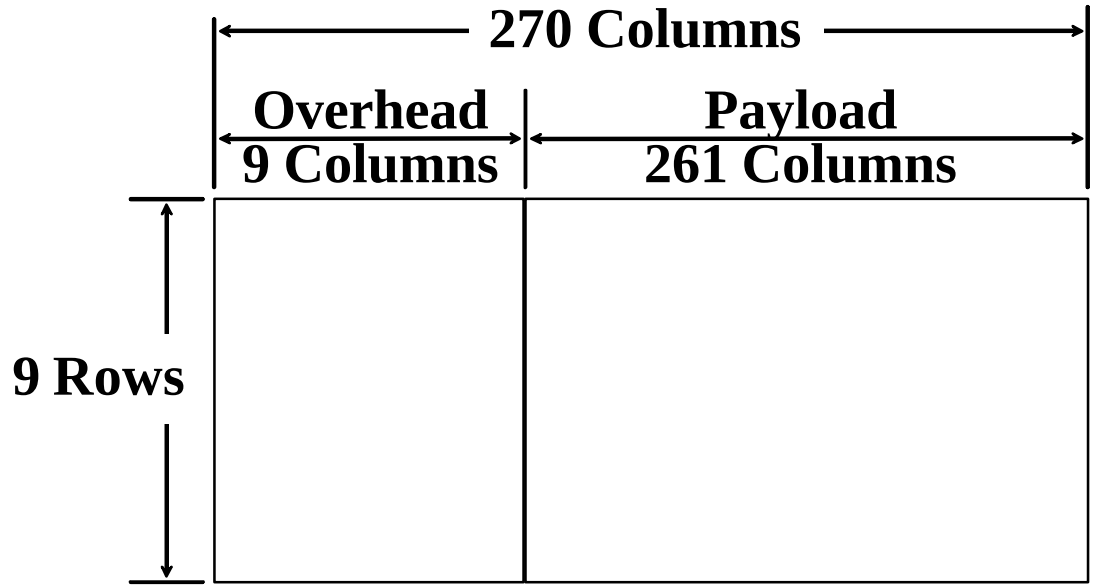


Concatenation



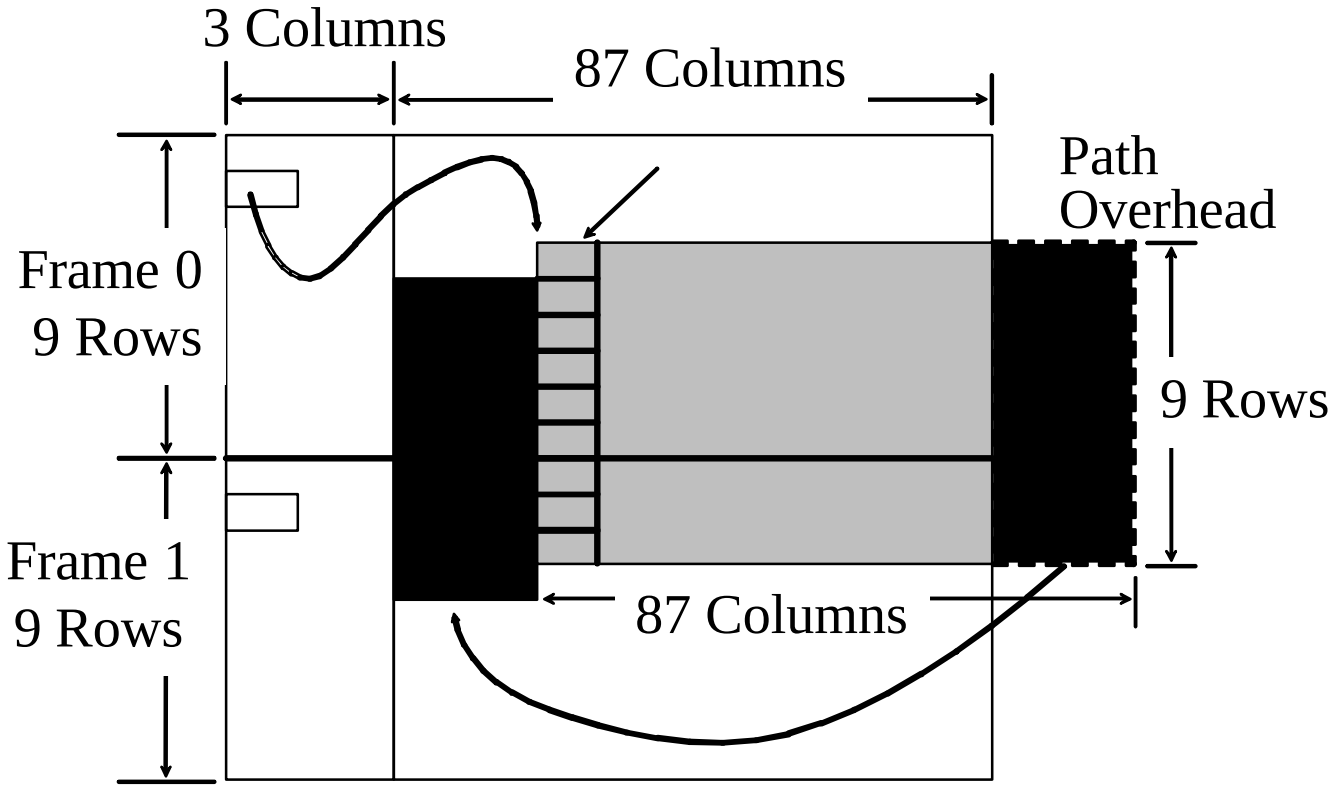
STS-3c Frame Format

- STS-3c is similar to STM-1



Location of SPE in STS-1

- SPE supplied by the user ⇒ Can arrive at any time ⇒ SPE can straddle two successive STS-1 frames

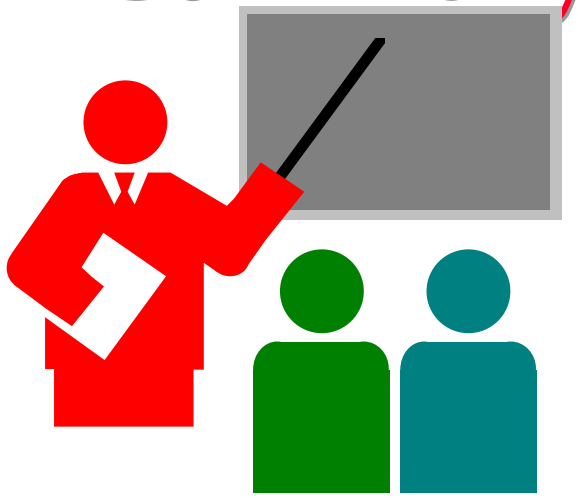


Scrambling

- 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 pseudorandom sequence, which is XOR'ed to incoming bits.

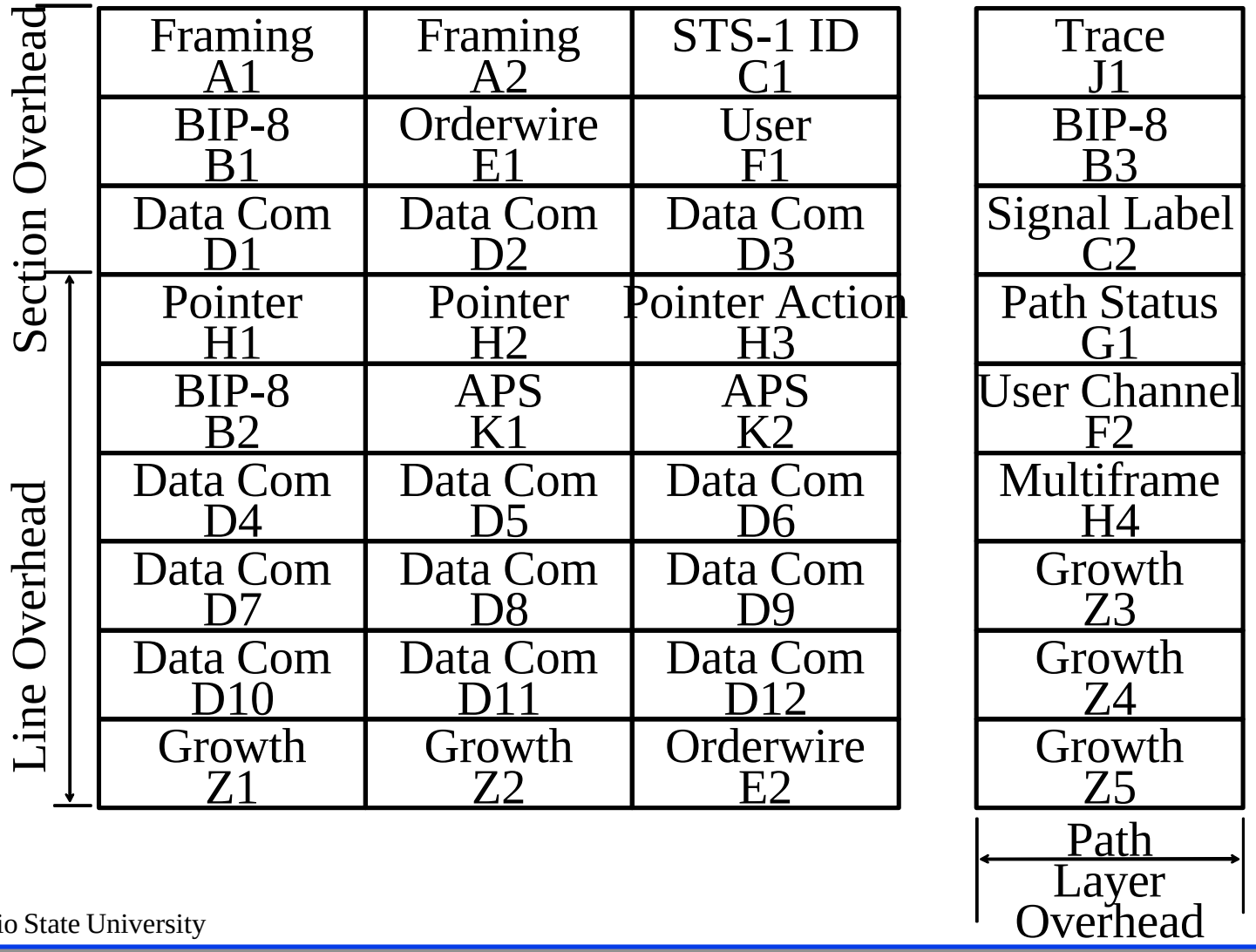
  1111 1110-0000 0100-0001 1000-0101 0001-1110 0100-0101 1001-1101 0100-1111 1010-0001 1100-0100 1001-1011 0101-1011 1101-1000 1101-0010 1110-1110 0110-0101 010
- If user data is identical to (or complement of) the pseudorandom sequence, the result will be all 0's or 1's.

Summary



- T1, DS1, DS3, ...
- SONET
- SDH
- STS-n, STM-n
- STS-3c

STS-1 Overhead Bytes



STS-3c Overhead bytes

A1	A1	A1	A2	A2	A2	C1	C1	C1
B1			E1			F1		
D1			D2			D3		
H1	H1	H1	H2	H2	H2	H3	H3	H3
B2	B2	B2	K1			K2		
D4			D5			D6		
D7			D8			D9		
D10			D11			D12		
Z1	Z1	Z1	Z2	Z2	Z2	E2		

(a) Section and line overhead

J1
B3
C2
G1
F2
H4
Z3
Z4
Z5

(b) Path overhead