

# SONET

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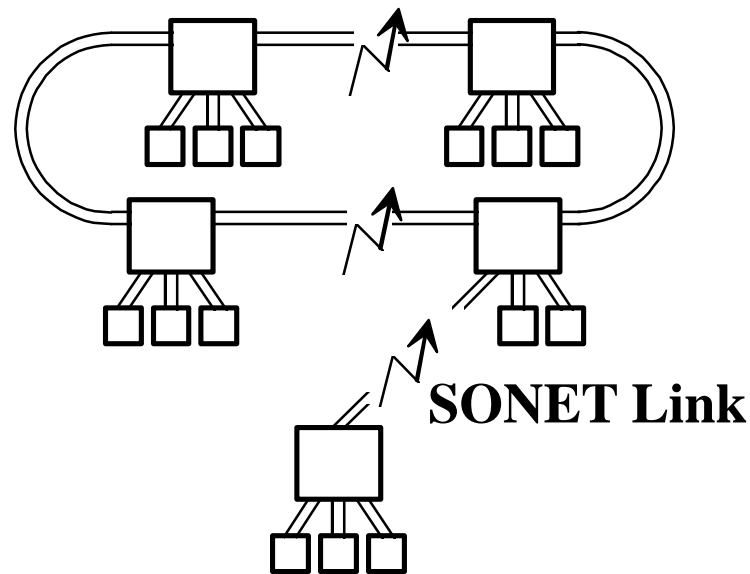
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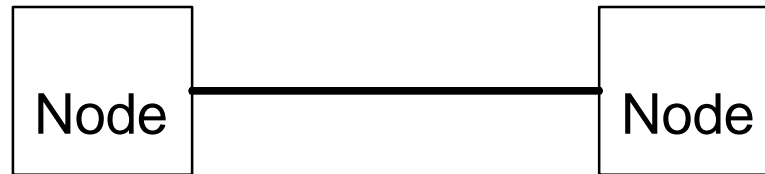
<http://www.cis.ohio-state.edu/~jain/>

# SONET

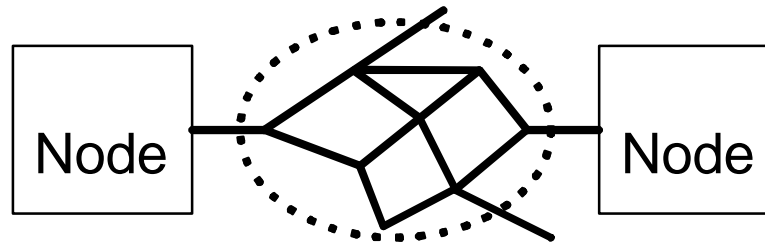
- ❑ Synchronous Optical Network
- ❑ Standard developed by ANSI and Exchange Carrier Standards Association (ECSA)
- ❑ CCITT: Synchronous Digital Hierarchy (SDH)
- ❑ SONET links can be used in place of dark fiber



# Two Views of SONET

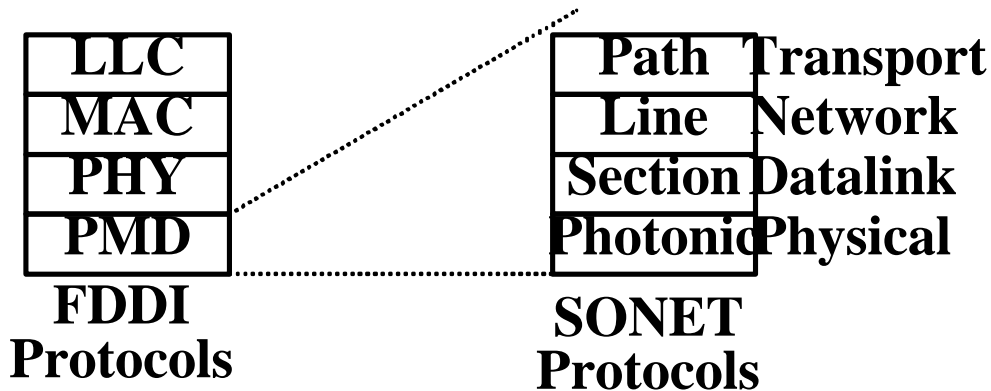


(a) Customer view: a link.



(b) Carrier's view: a network.

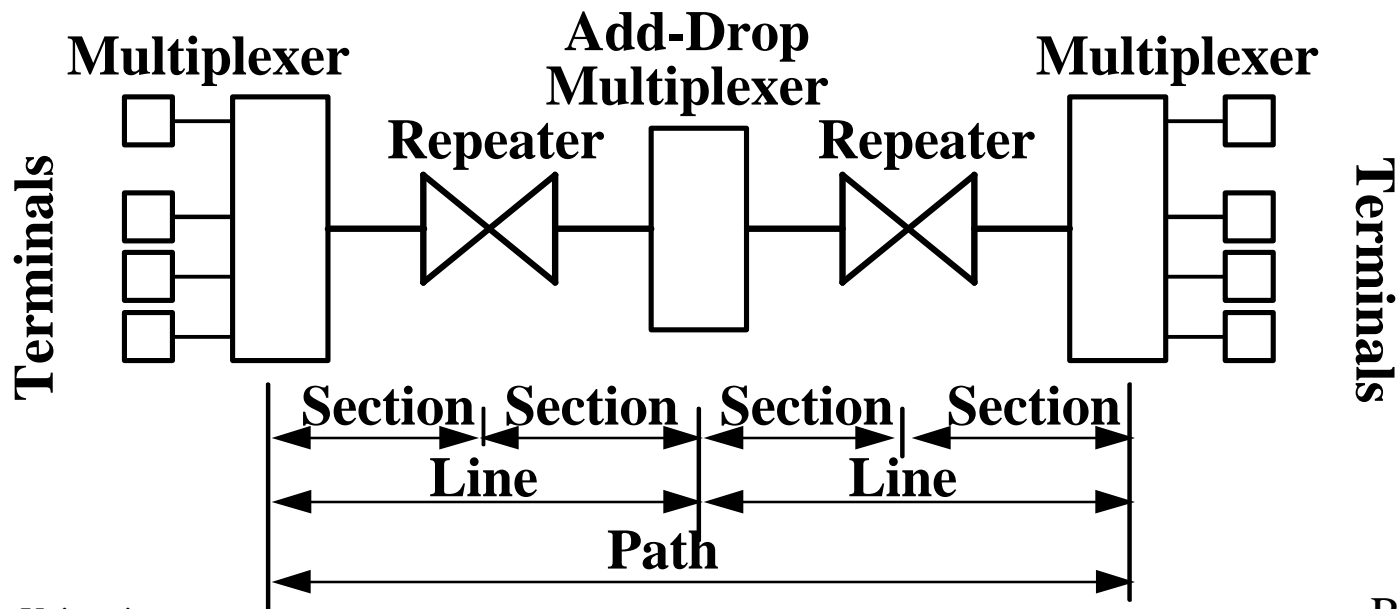
# Protocol Components of SONET



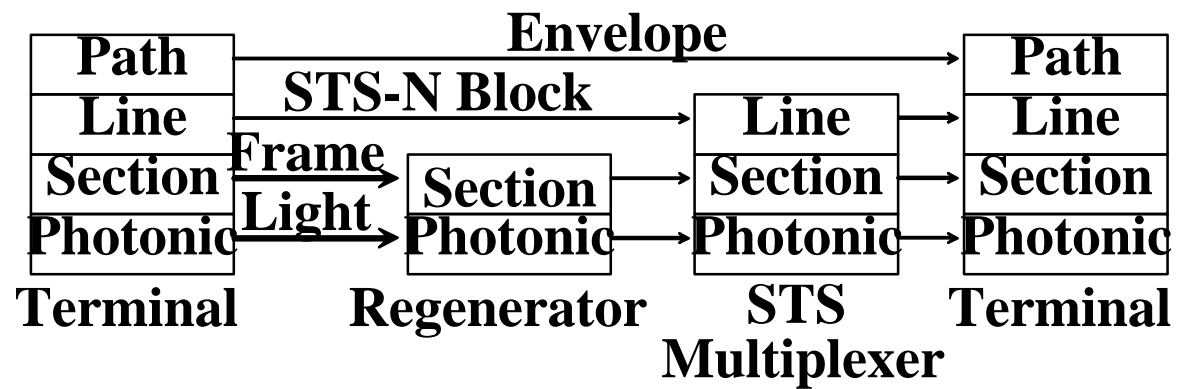
- ❑ Photonic Layer: Characteristics of fibers, transmitters, receivers and encoding (ANSI T1.106-1988)
- ❑ Section Layer: Transmission across a single link. Framing, scrambling, and error monitoring.
- ❑ Line Layer: Signaling between multiplexer switches. Frame synchronization. Multiplexing of data in 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



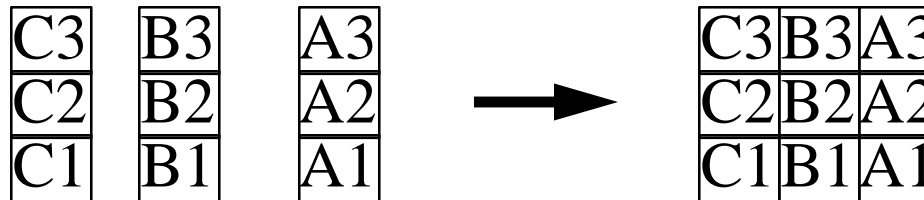
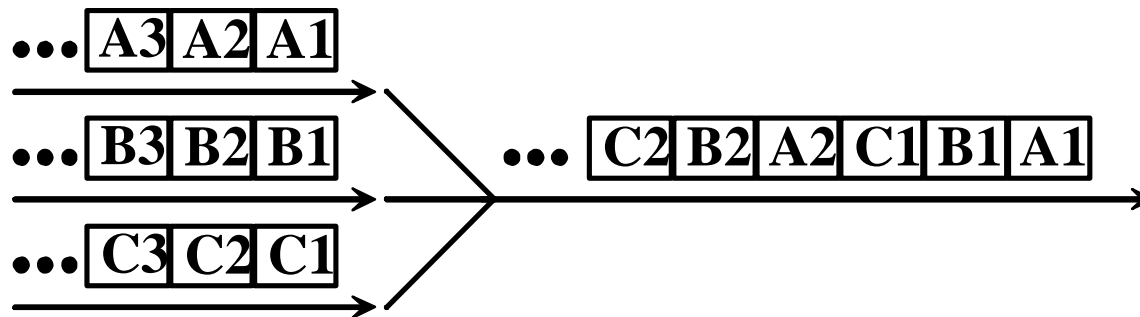
# SONET/SDH Signal Hierarchy

Synchronous Transport Signal Level  $n = \text{STS-}n = n \times 51.84 \text{ Mbps}$   
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

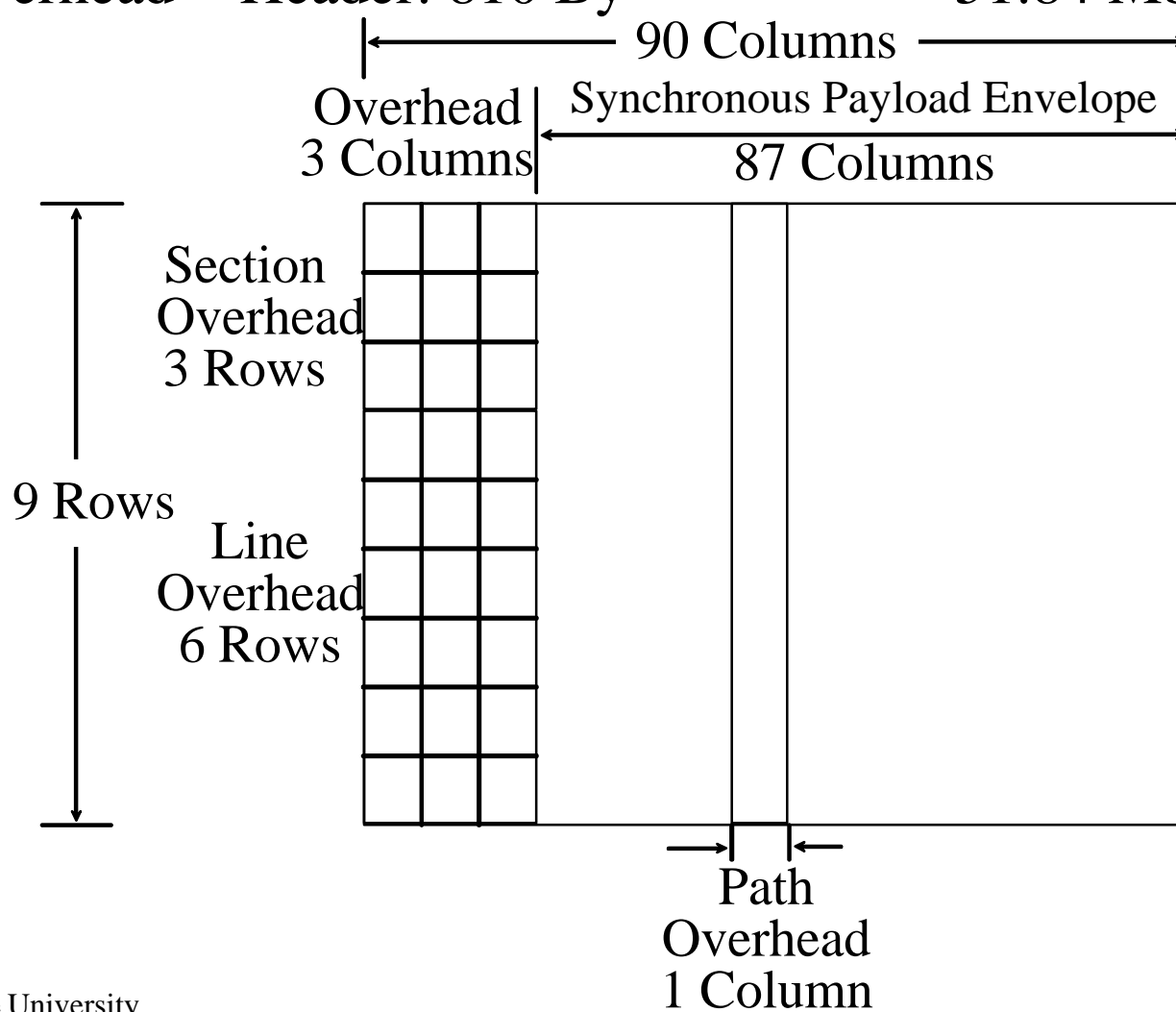
# Byte Multiplexing

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

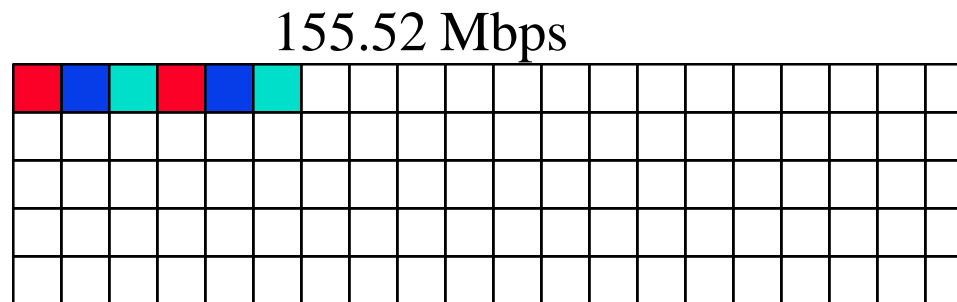
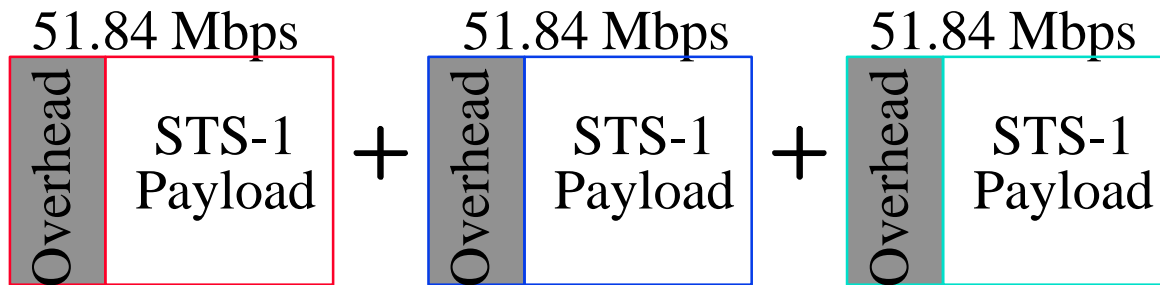


# STS-1 Frame Format

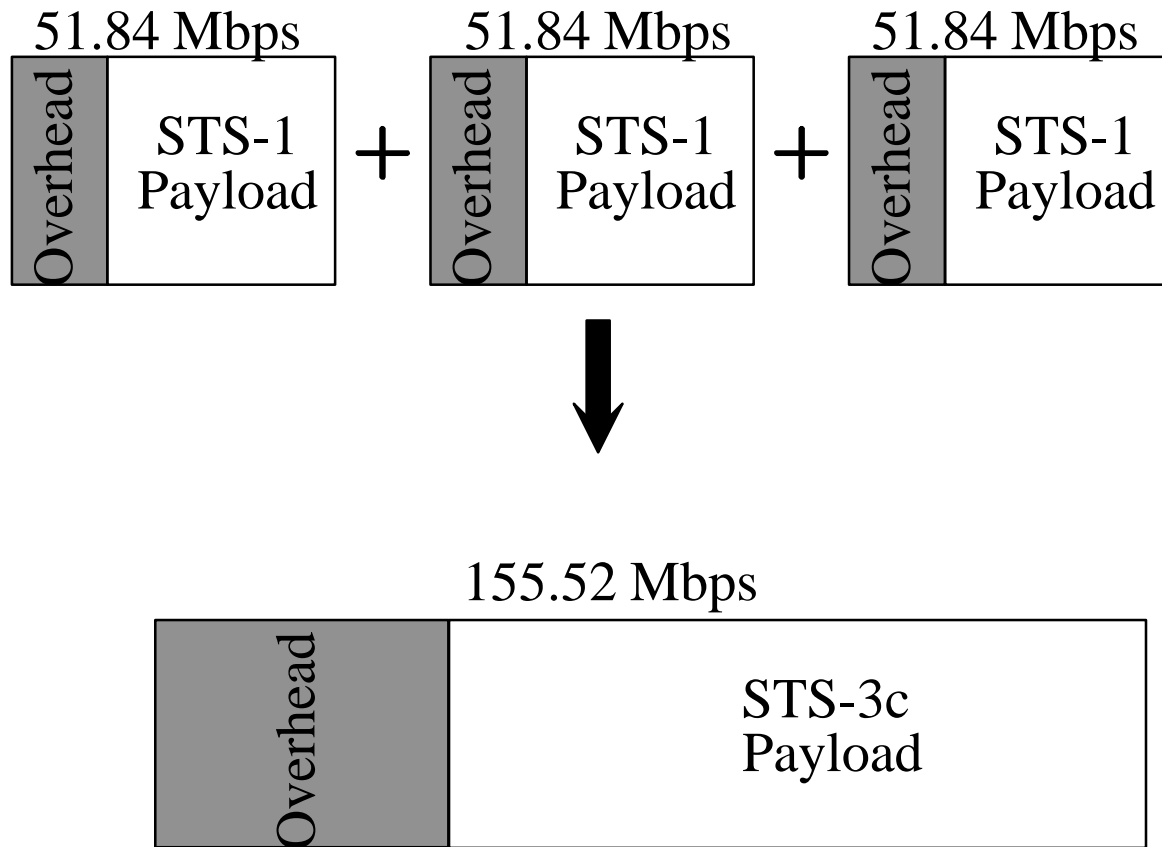
- Overhead = Header.  $810 \text{ Bytes}/125 \text{ ms} = 51.84 \text{ Mbps}$



# Multiplexing

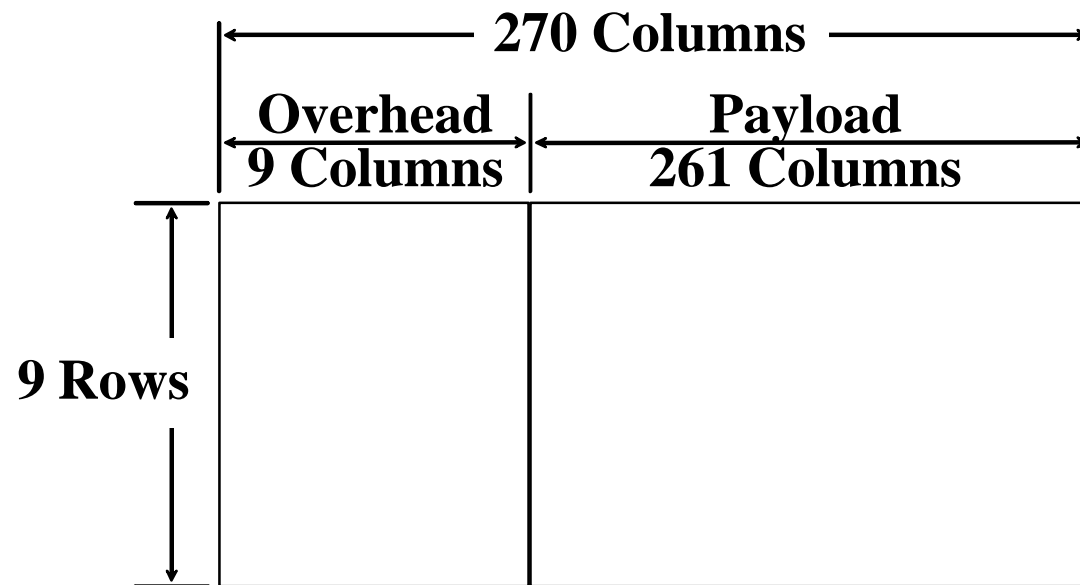


# Concatenation



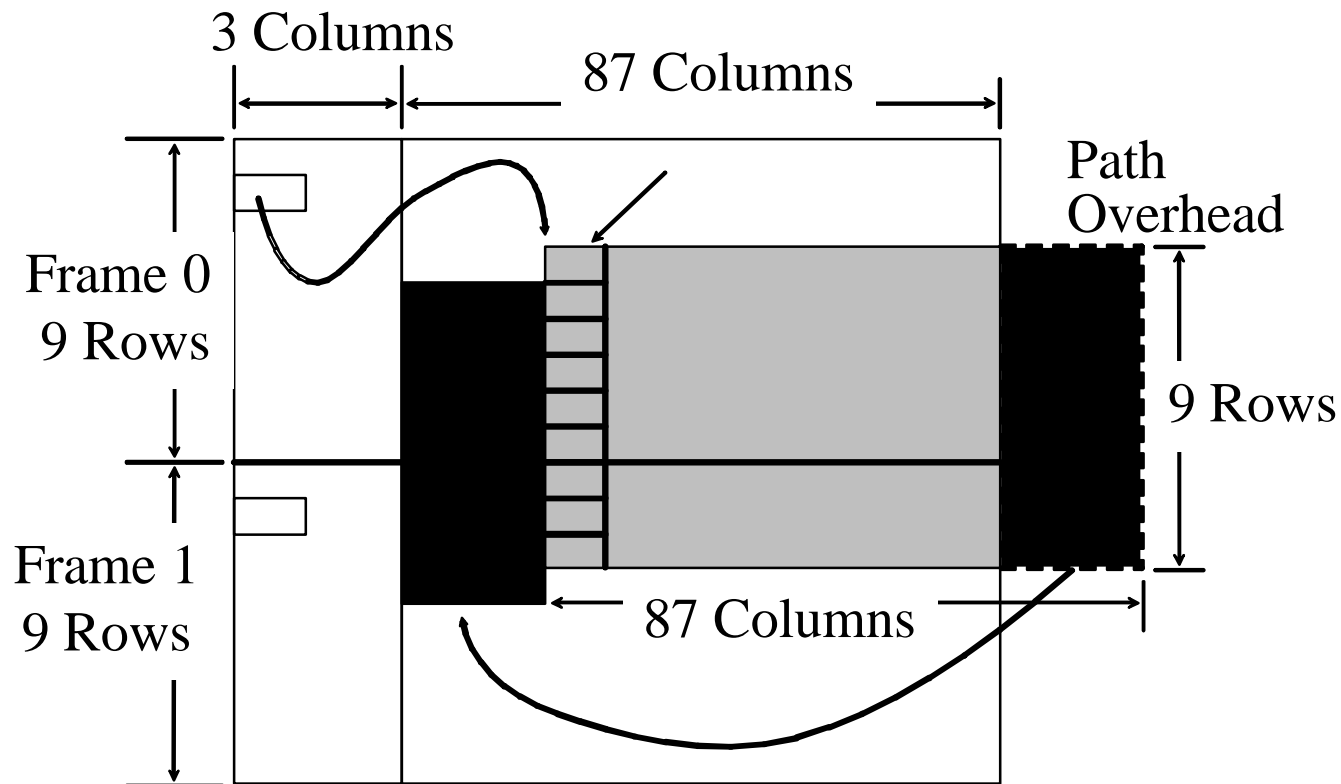
# STS-3c Frame Format

- STS-3c is similar to STM-1



# Location of SPE in STS-1

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



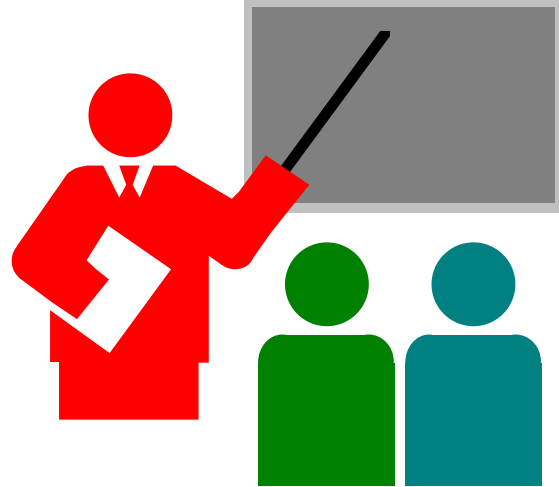
# Scrambling

- ❑ SONET uses NRZ coding. 1 = Light On, 0 = Light Off.
- ❑ Too many 1's or 0's  $\Rightarrow$  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

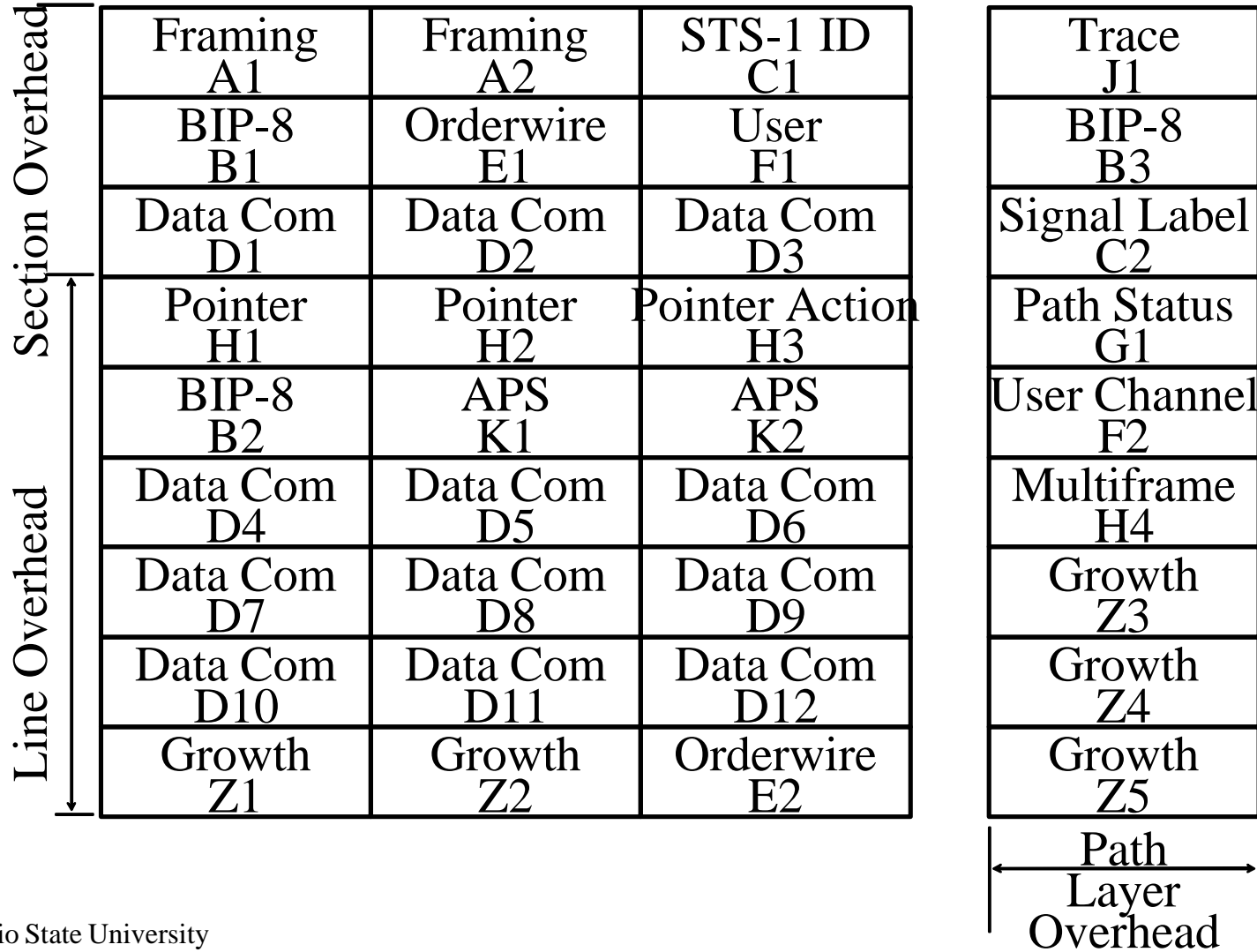
- ❑ If user data is identical to (or complement of) the pseudorandom sequence, the result will be all 0's or 1's.

# Summary



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

# STS-1 Overhead Bytes



# STS-3c Overhead bytes

<b>A1</b>	<b>A1</b>	<b>A1</b>	<b>A2</b>	<b>A2</b>	<b>A2</b>	<b>C1</b>	<b>C1</b>	<b>C1</b>	<b>J1</b>
<b>B1</b>			<b>E1</b>			<b>F1</b>			<b>B3</b>
<b>D1</b>			<b>D2</b>			<b>D3</b>			<b>C2</b>
<b>H1</b>	<b>H1</b>	<b>H1</b>	<b>H2</b>	<b>H2</b>	<b>H2</b>	<b>H3</b>	<b>H3</b>	<b>H3</b>	<b>G1</b>
<b>B2</b>	<b>B2</b>	<b>B2</b>	<b>K1</b>			<b>K2</b>			<b>F2</b>
<b>D4</b>			<b>D5</b>			<b>D6</b>			<b>H4</b>
<b>D7</b>			<b>D8</b>			<b>D9</b>			<b>Z3</b>
<b>D10</b>			<b>D11</b>			<b>D12</b>			<b>Z4</b>
<b>Z1</b>	<b>Z1</b>	<b>Z1</b>	<b>Z2</b>	<b>Z2</b>	<b>Z2</b>	<b>E2</b>			<b>Z5</b>

(a) Section and line overhead (b) Path overhead