SONET

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These slides are available at:

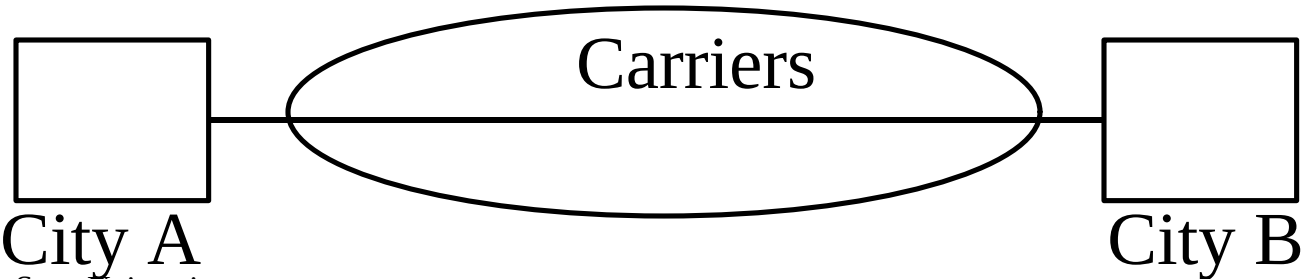
http://www.cis.ohio-state.edu/~jain/cis777-99/

What is SONET?

- Synchronous optical network
- Standard for digital optical transmission (bit pipe)
- Developed originally by Bellcore.
- Standardized by ANSI T1X1
- Standardized by CCITT

  ⇒ Synchronous Digital Hierarchy (SDH)

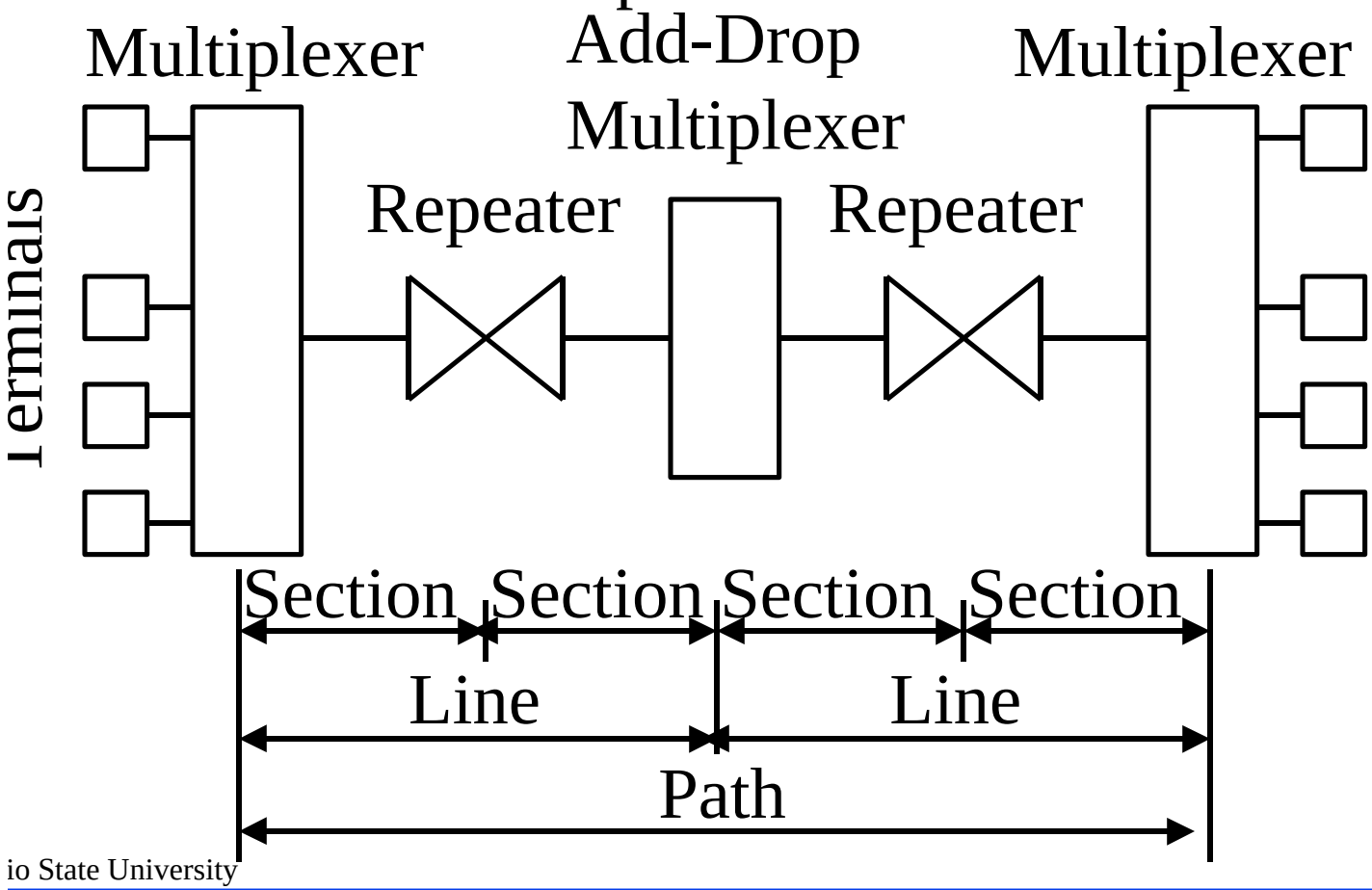
- You can lease a SONET connection from carriers



Physical Components

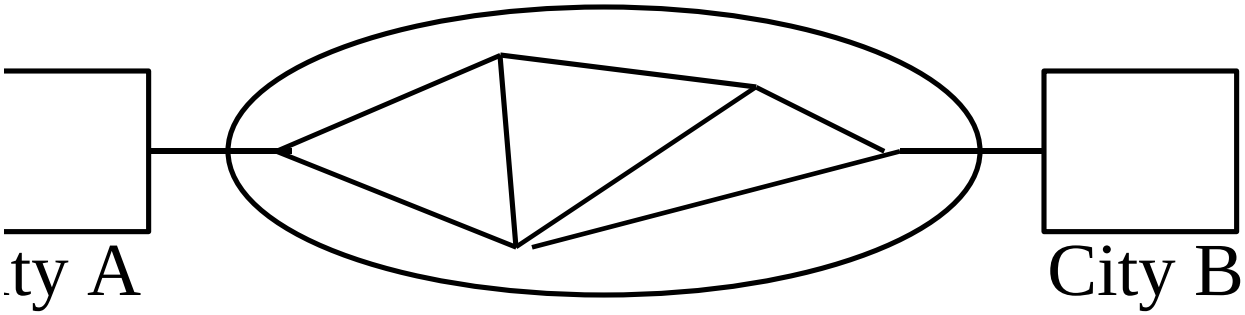
Section = Single run of fiber

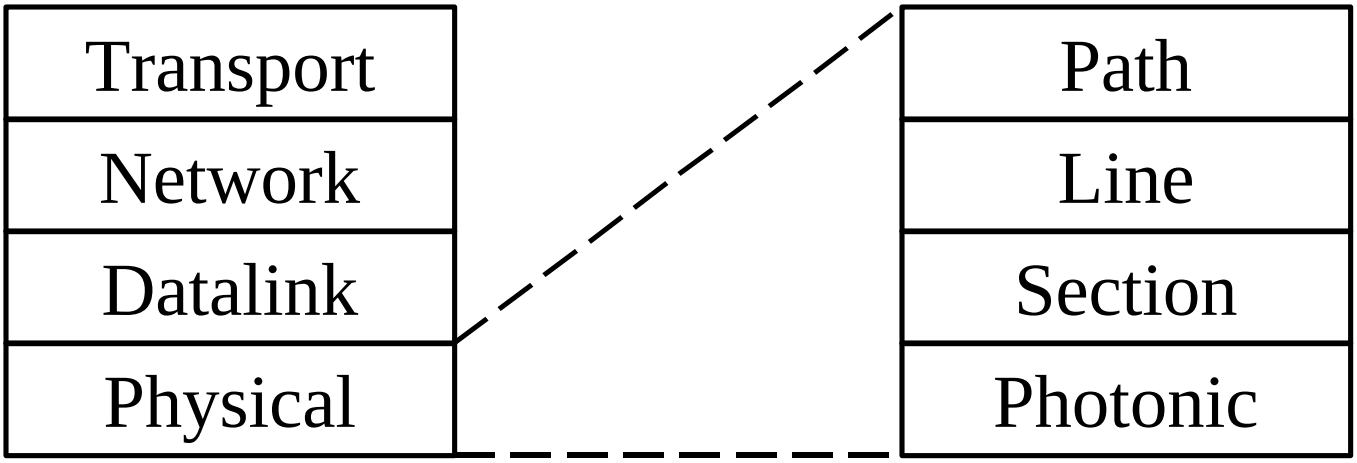
Line = Between multiplexers



SONET Protocols

Synchronous Optical **Network**





Protocols (Cont)

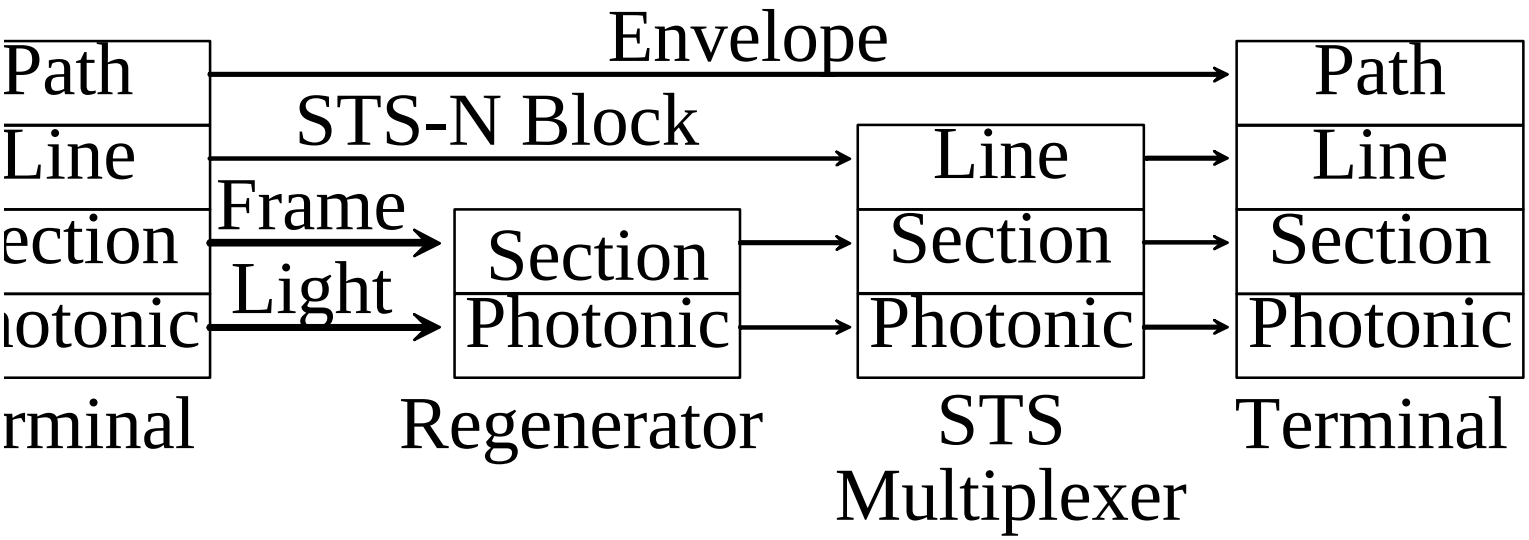
Photonic Layer: Characteristics of fibers, transmitter receivers and encoding (ANSI T1.106-1988)

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.

Protocol Hierarchy



Signal Hierarchy

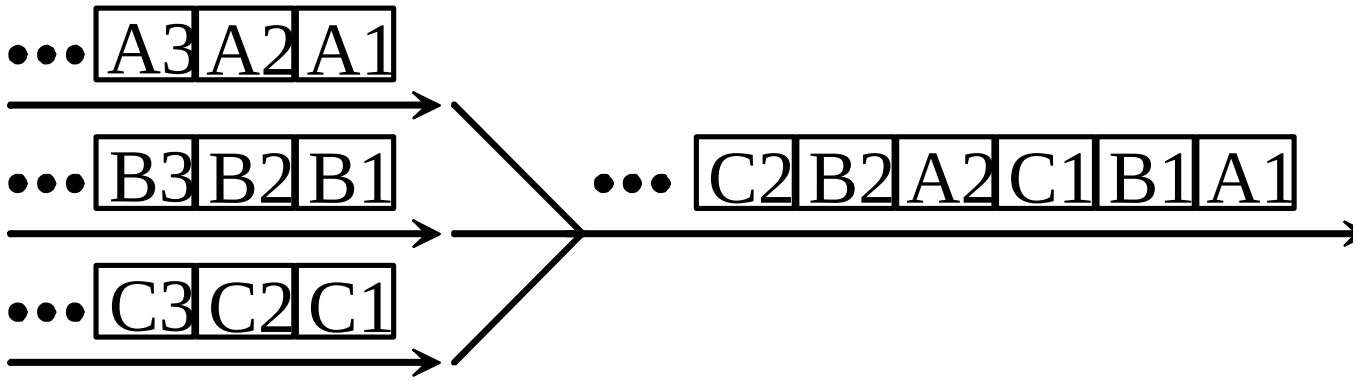
nchronous Transport Signal Level n = STS-n = $n \times 51.84$ Mb
M=Synchronous Transport Module, OC=Optical Carrier lev

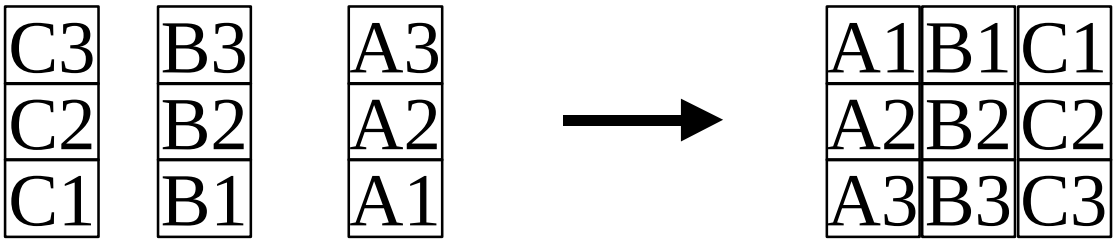
NSI esignation	Optical Signal	CCITT Designation	Data Rate (Mbps)	Payload Rate (Mbps)
S-1	OC-1		51.84	50.112
S-3	OC-3	STM-1	155.52	150.336
S-9	OC-9	STM-3	466.56	451.008
S-12	OC-12	STM-4	622.08	601.344
S-18	OC-18	STM-6	933.12	902.016
S-24	OC-24	STM-8	1244.16	1202.688
S-36	OC-36	STM-12	1866.24	1804.032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

Byte Multiplexing

Also known as byte interleaving

Easier to view in two dimension

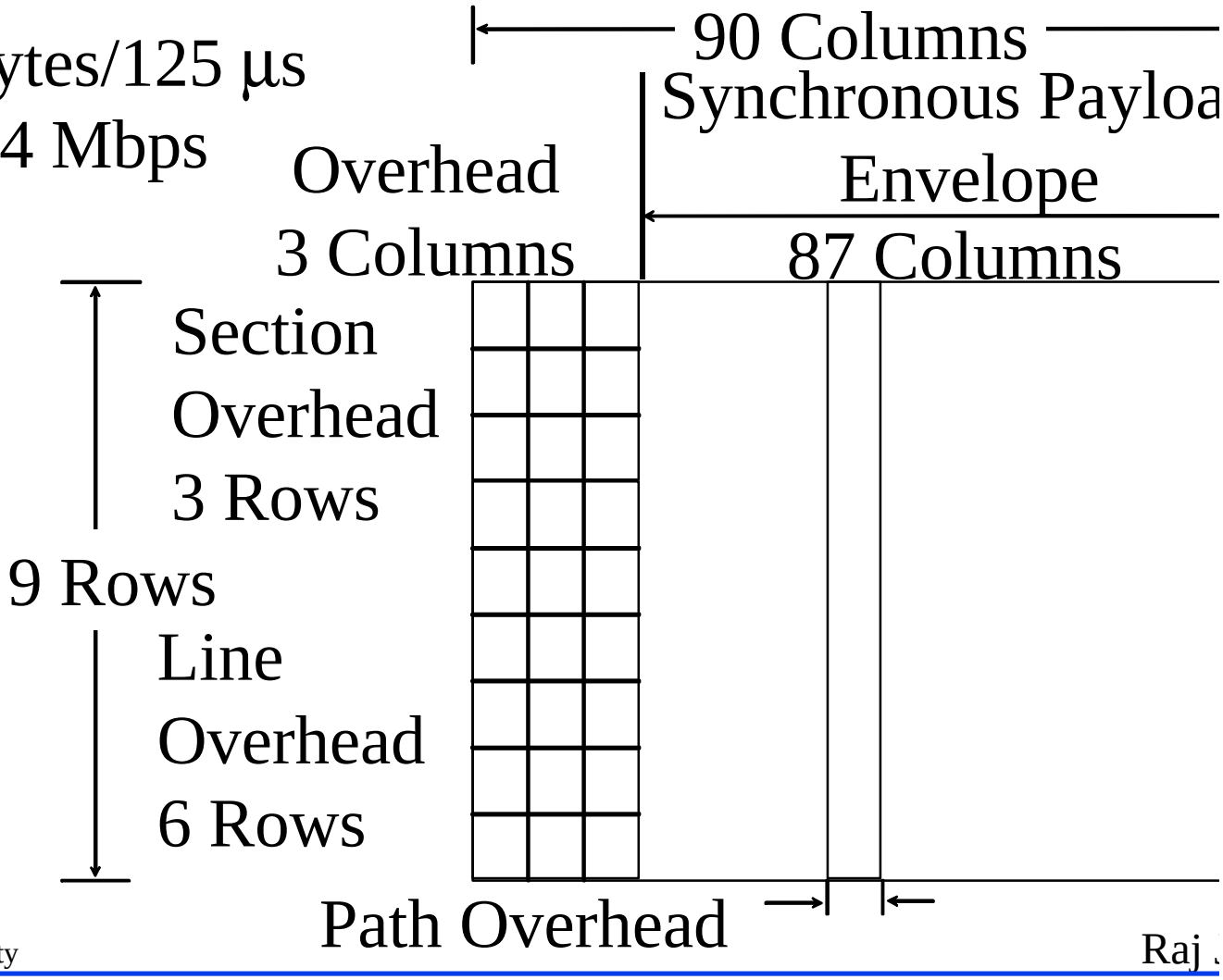




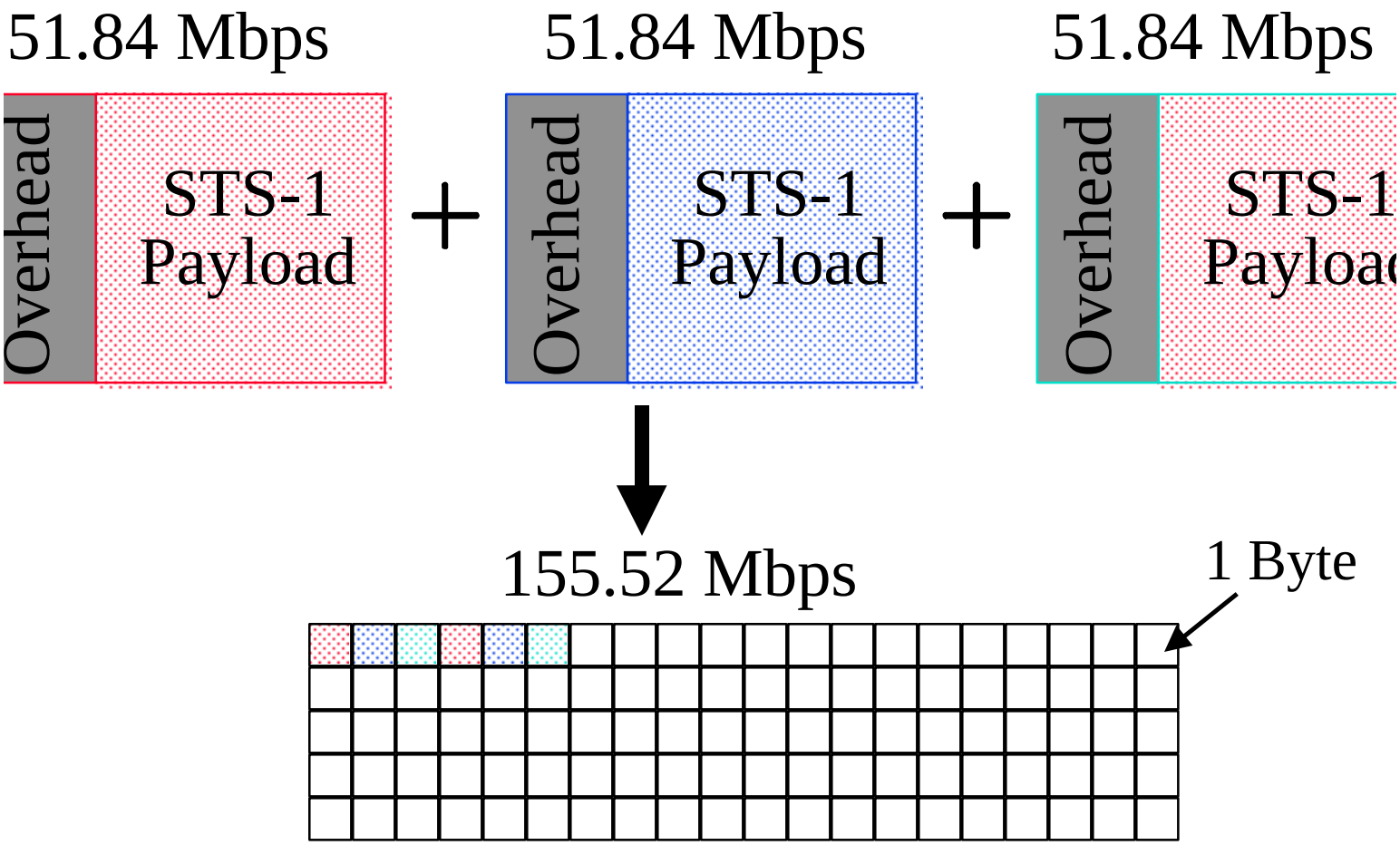
STS-1 Frame Format

Overhead = Header.

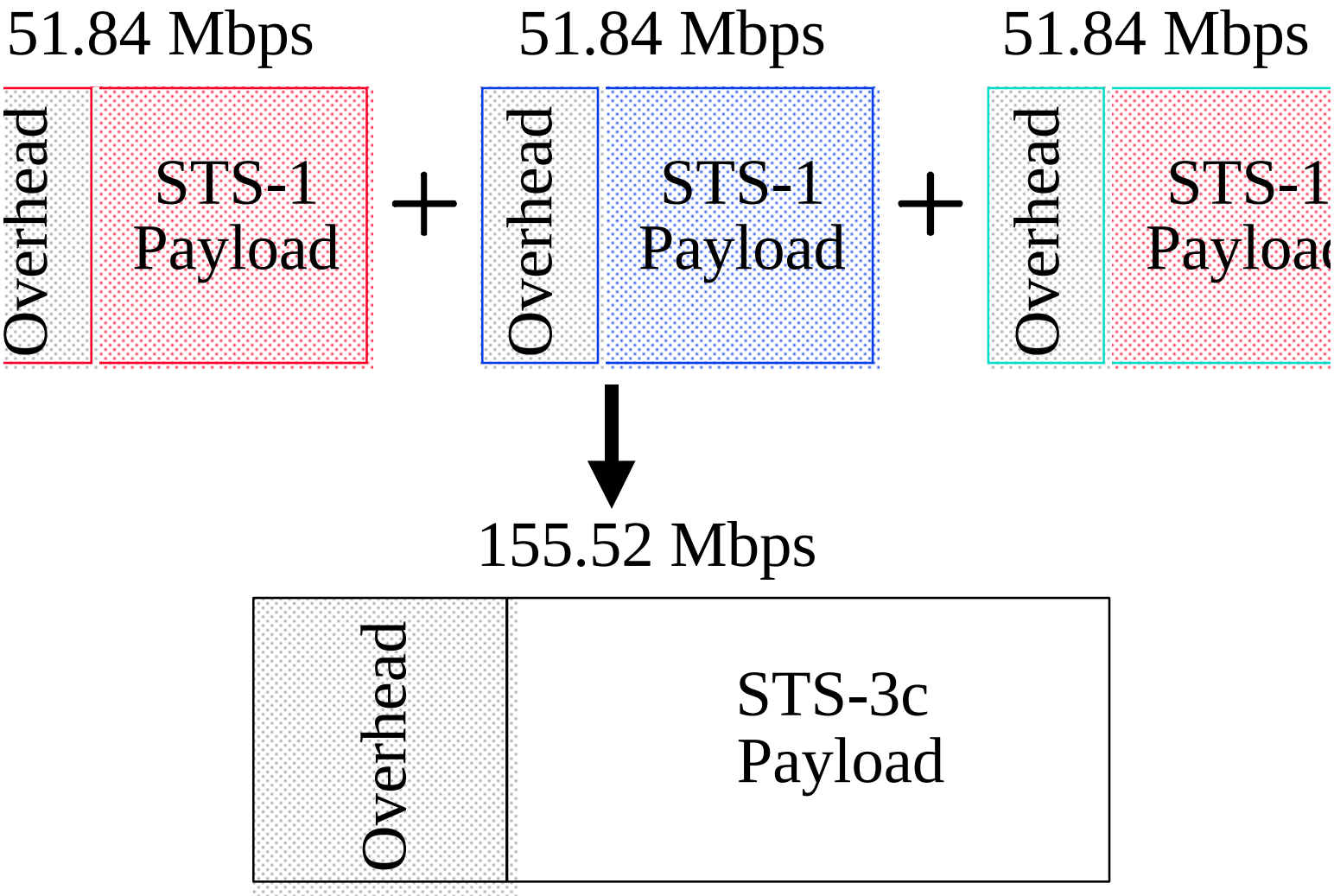
810 Bytes/125 μs
= 51.84 Mbps



Multiplexing

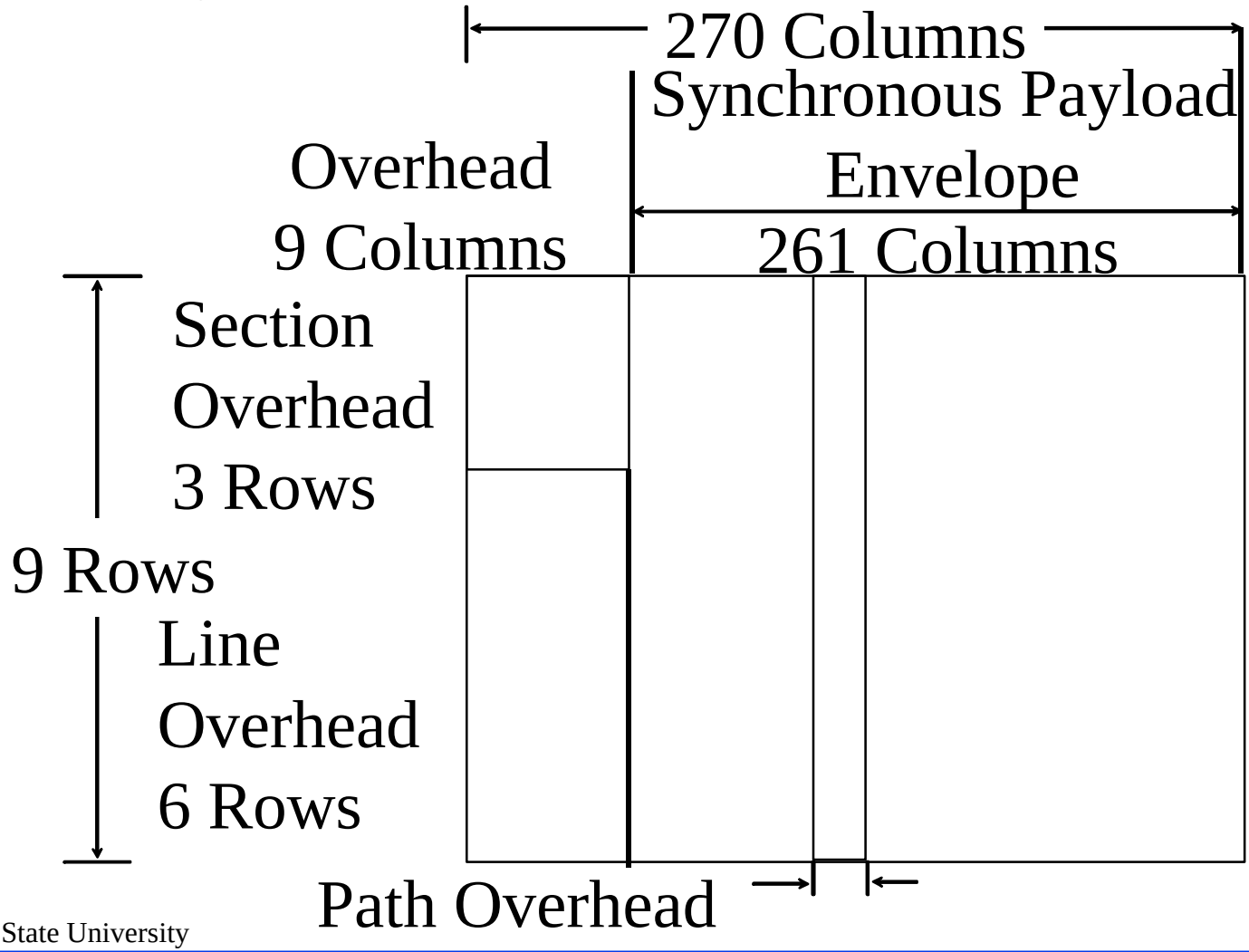


Concatenation



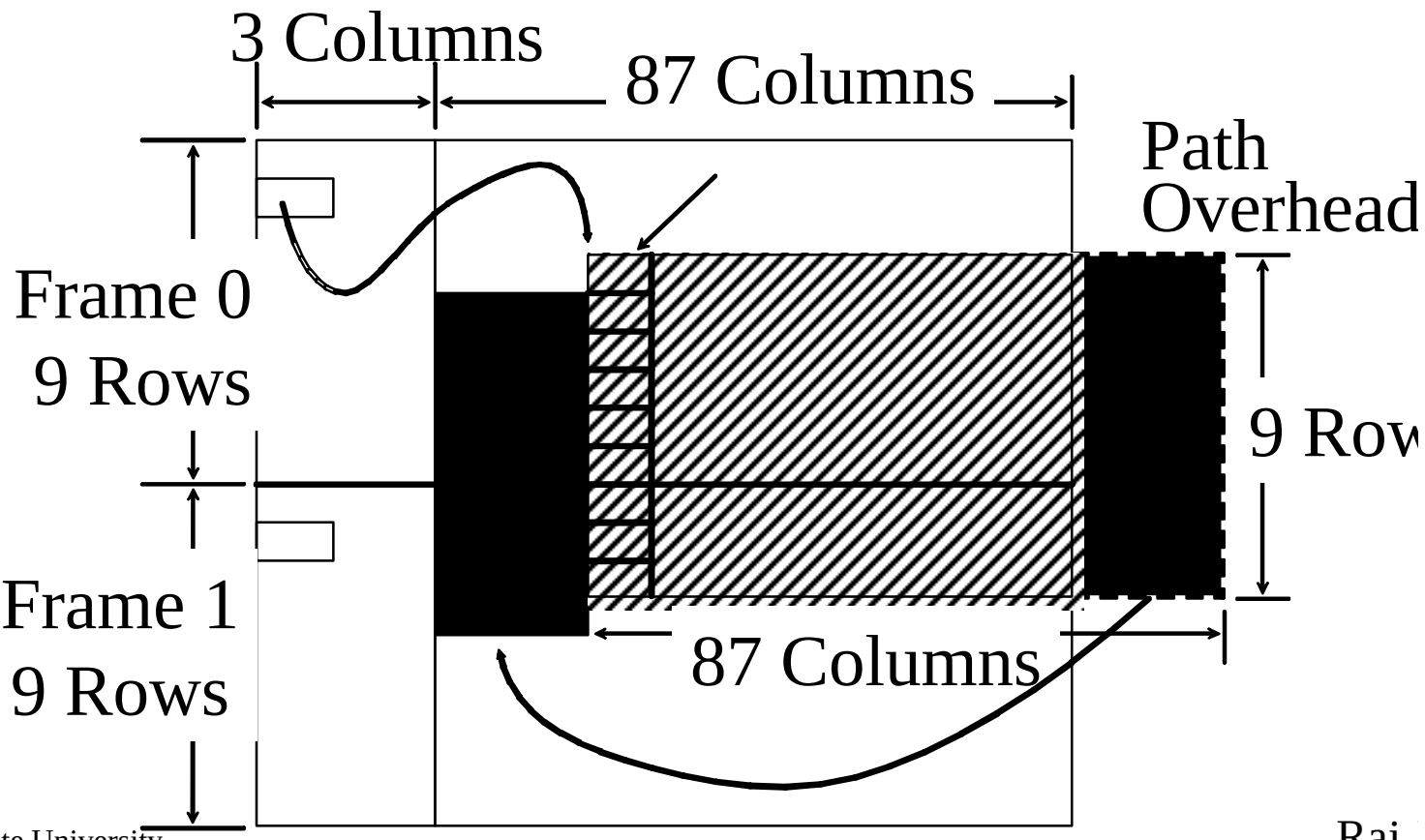
STS-3c Frame Format

2430 Bytes/125 ms = 155.54 Mbps



ocation of SPE in STS-1

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



crambling: Introduction

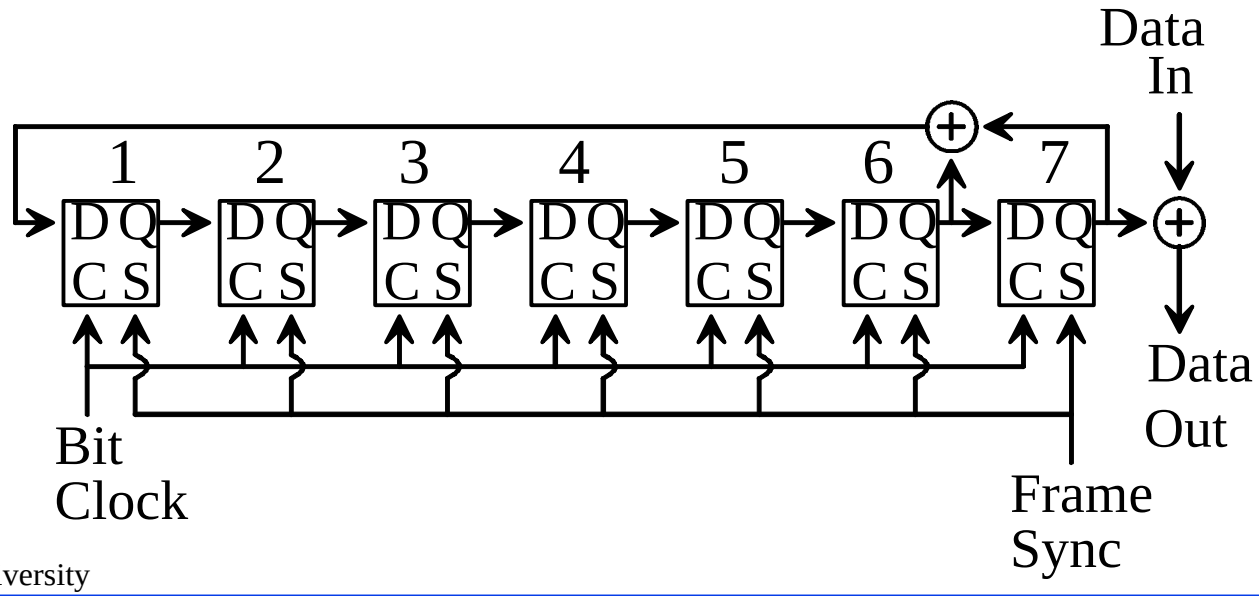
o Methods:

Add random sequence

Divide by a number and send quotient. Similar to Cl

th implemented by shift-registers.

Analyzed using polynomials. $1+x^6+x^7$



Scrambling (Cont)

Set-Reset Synchronous scrambler:

Add a fixed random bit pattern.

Need to tell where to start adding

⇒ Need to synchronize.

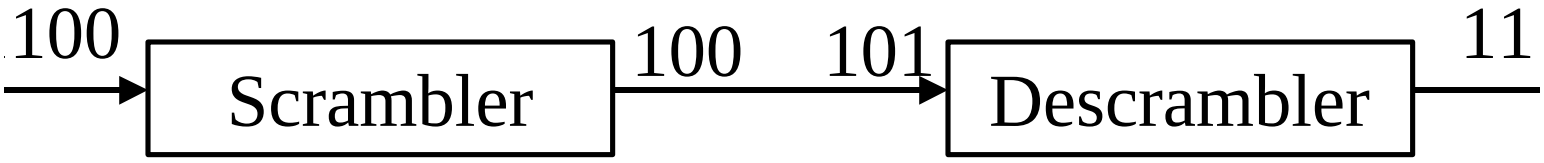
Self-synchronous scrambler: Divide by a fixed numl

No need for synchronization.

Errors multiply.

Example: Send 12 using divider 3 ⇒ Send 4.

1-bit error ⇒ Received 5 ⇒ 15 ⇒ 2-bit error in data



Scrambling

SONET uses NRZ coding.

1 = Light On, 0 = Light Off.

Too many 1's or 0's ⇒ Loss of bit clocking informa

All bytes (except some overhead bytes) are scramble

Polynomial $1 + x^6 + x^7$ with a seed of 1111111 is us
o 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 o
1's.

Automatic Protection Switching

100 ms or more is “loss of signal”

2.3 ms or less is not “loss of signal”

In-between is up to implementations

Most implementations use 13-27 ms

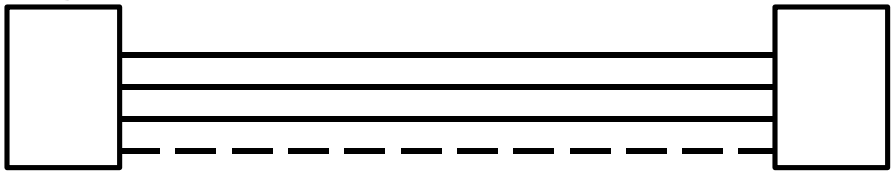
⇒ Higher speed lines ⇒ maintain sync for more bits

APS allows switching circuits on fault

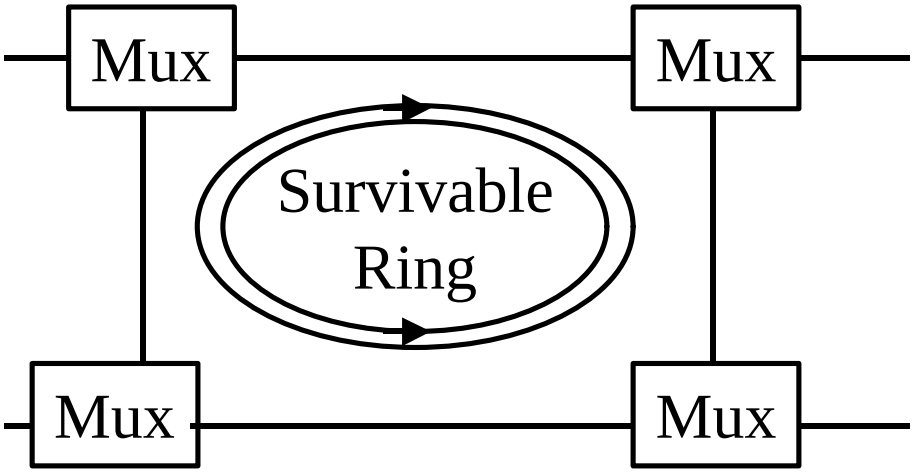
May take up to 50 ms to complete

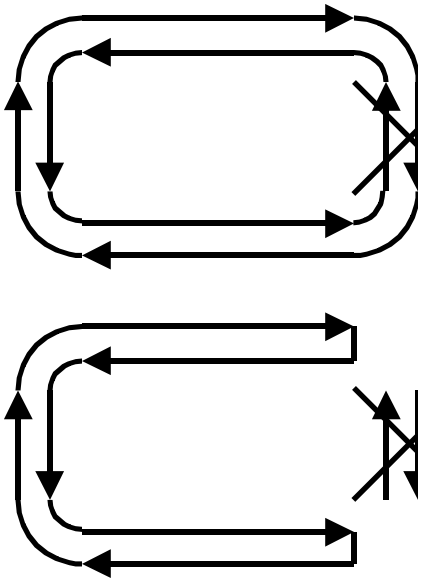
Wastes entire links as standby.

Protection by routers works faster than by SONET



SONET Topology





Two fibers: Working + Protection

On a fault, faulty cable is isolated and ring heals itse

Four Fibers: Two working + Two protection

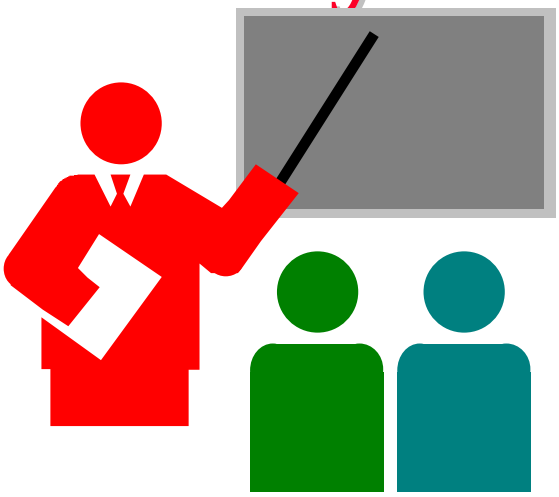
⇒ Bi-directional operation

⇒ Traffic sent over shortest path

SONET vs SDH

- ANSI vs ITU-T
- Bits 5,6 of SPE/VC pointer are different [RFC2171]
- Synchronous payload envelope (SPE) vs Virtual Container (VC)
- Network element vs Network node interface
- Section vs regenerator section
- Link vs multiplex section

Summary



- SONET
- SDH
- STS-n, STM-n
- STS-3c

Homework

Read Chapter 8 of Black's Emerging Technologies, 2nd Ed.

Additional References

Chapter 9 of FDDI Handbook by Raj Jain