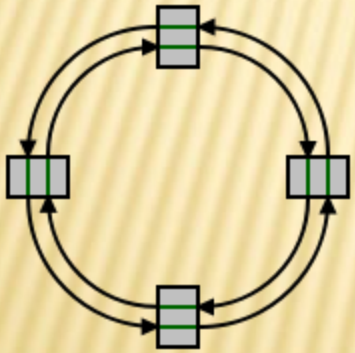
BROADBAND AND HIGH SPEED NETWORKS

4 SONET / SDH

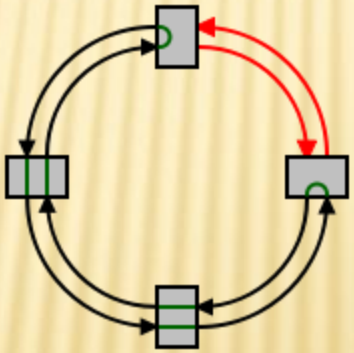
SONET TOPOLOGY

- **Self-healing ring [SHR]:**

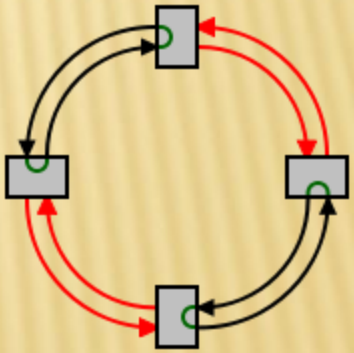
  Self-healing rings offer high levels of flexibility at low cost, the system consists of a ring of bidirectional links between a set of stations. The topology is [Dual ring of fiber optics].



A simple, SHR

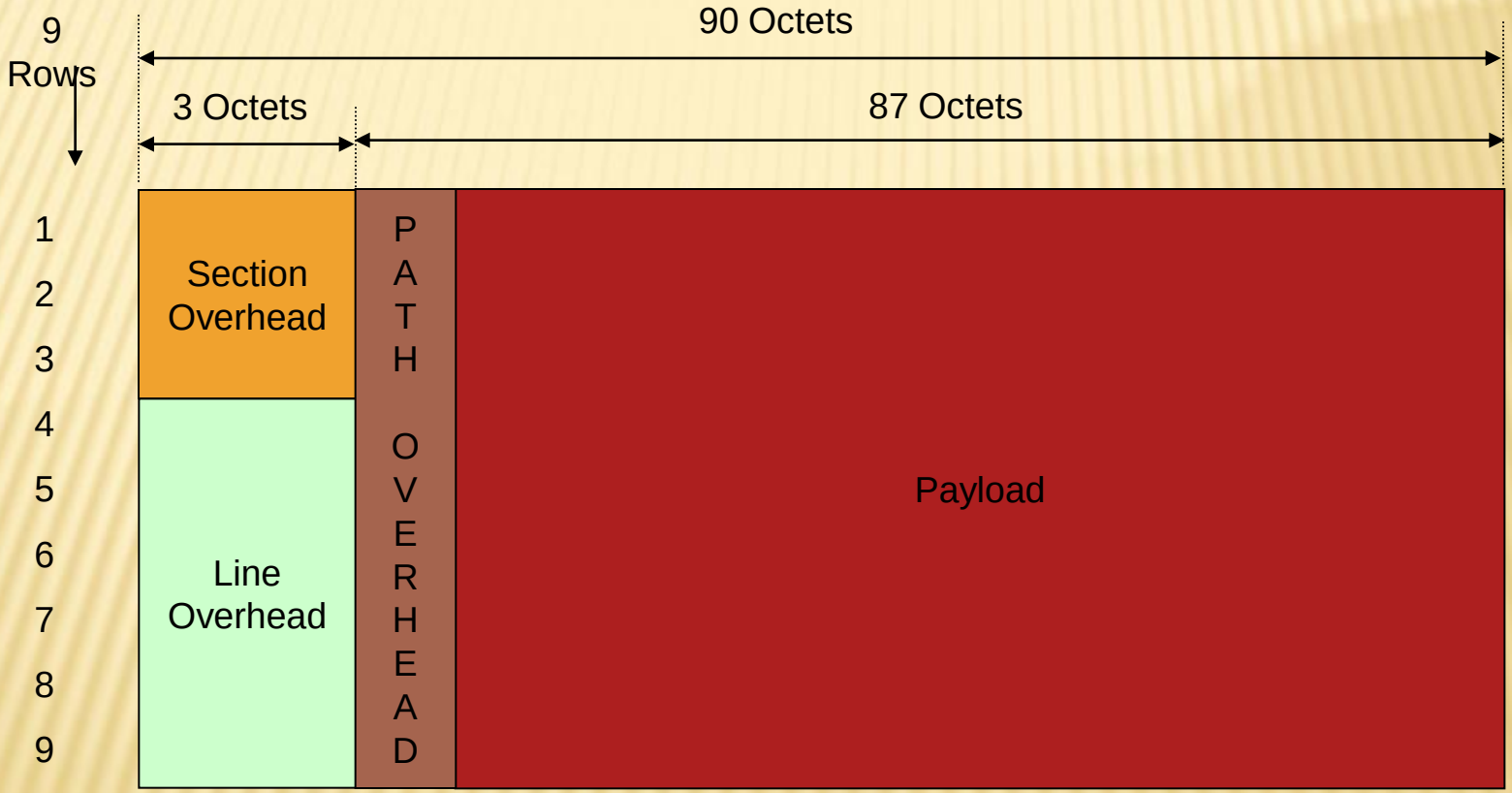


SHR with
one damaged link



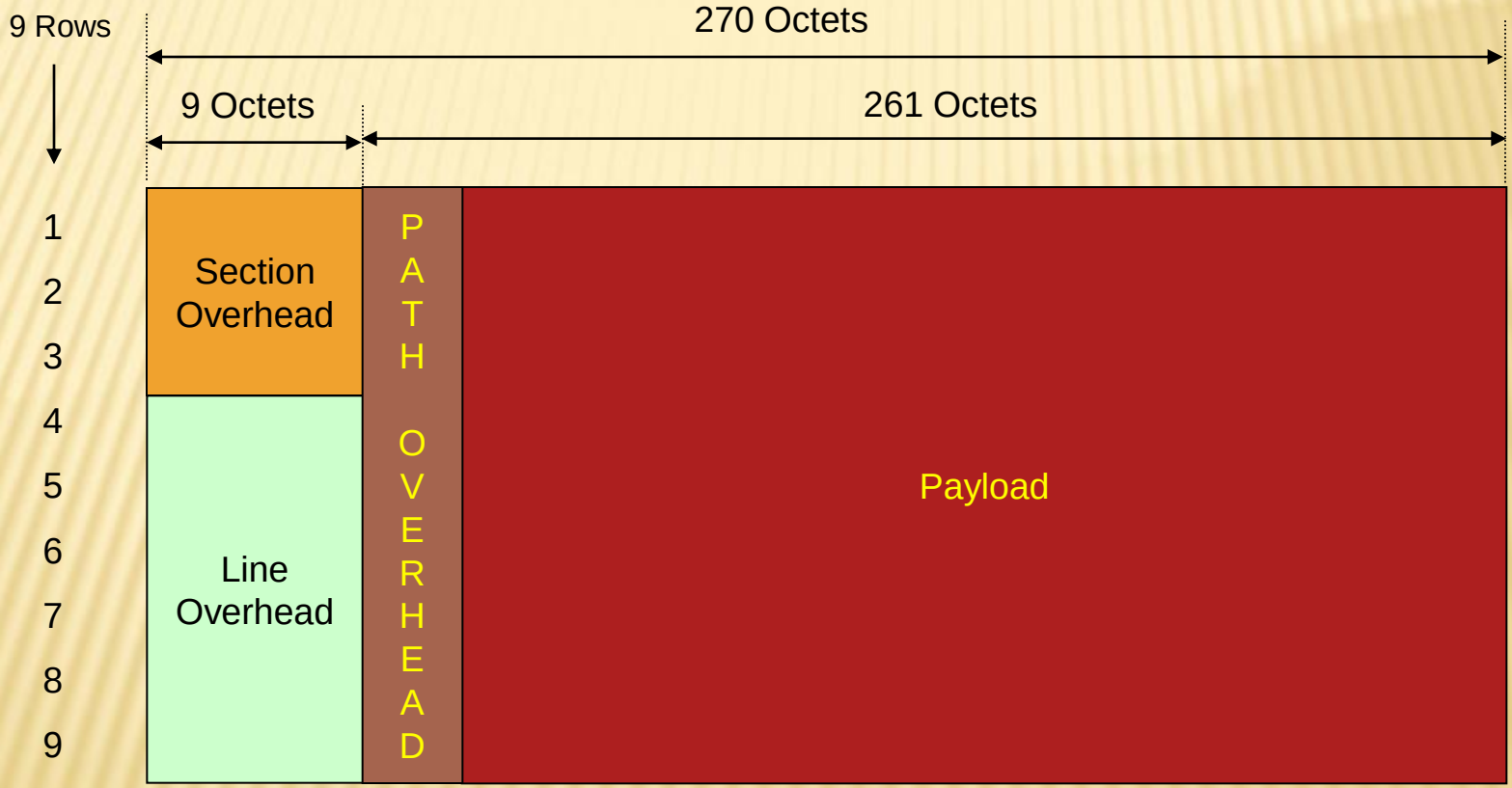
SHR with two damaged links, splitting it into two unconnected, but functional sub-rings

SONET ENVELOPES



STS-1 Envelope

SONET ENVELOPES

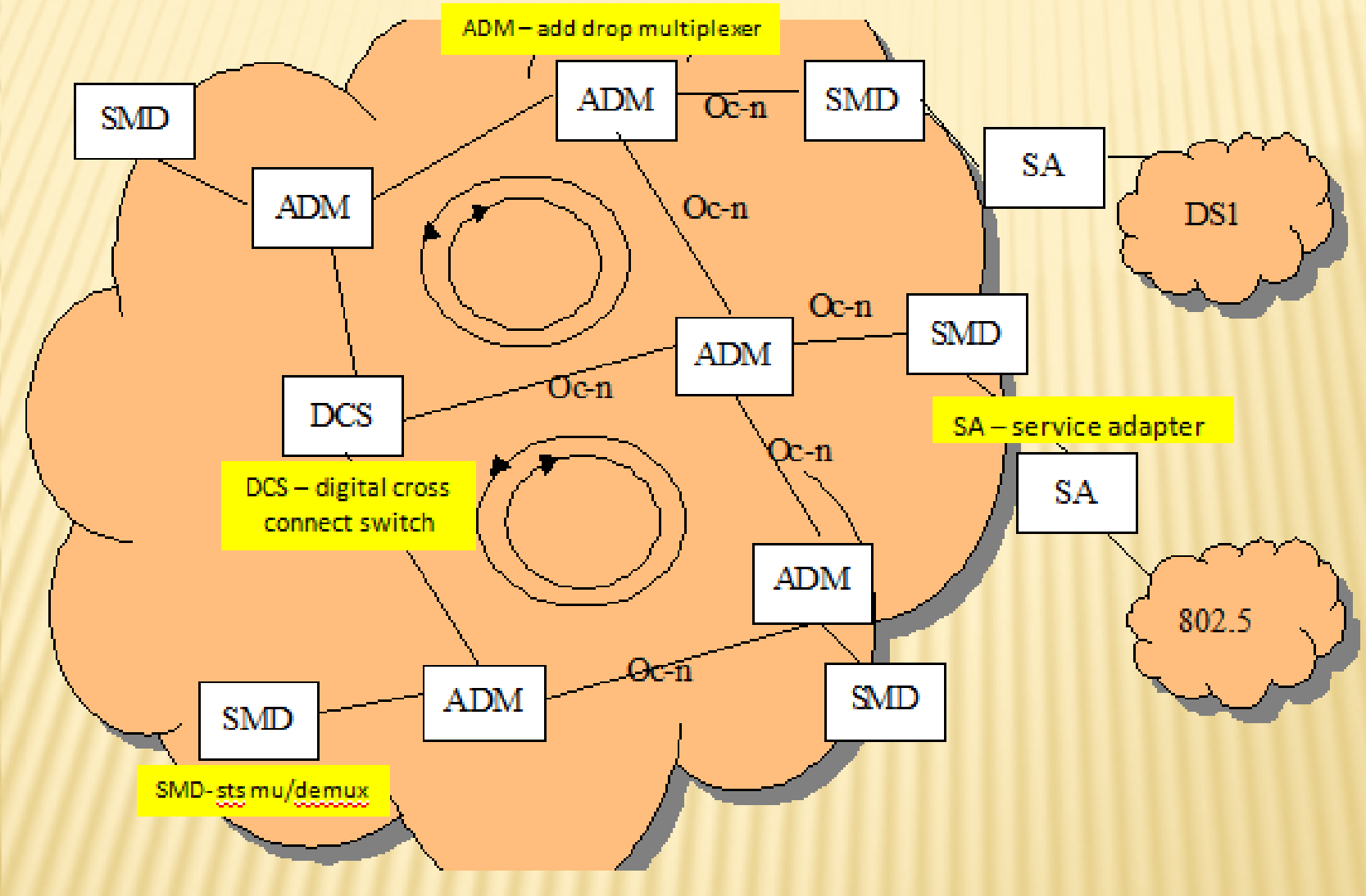


STS-3 Envelope

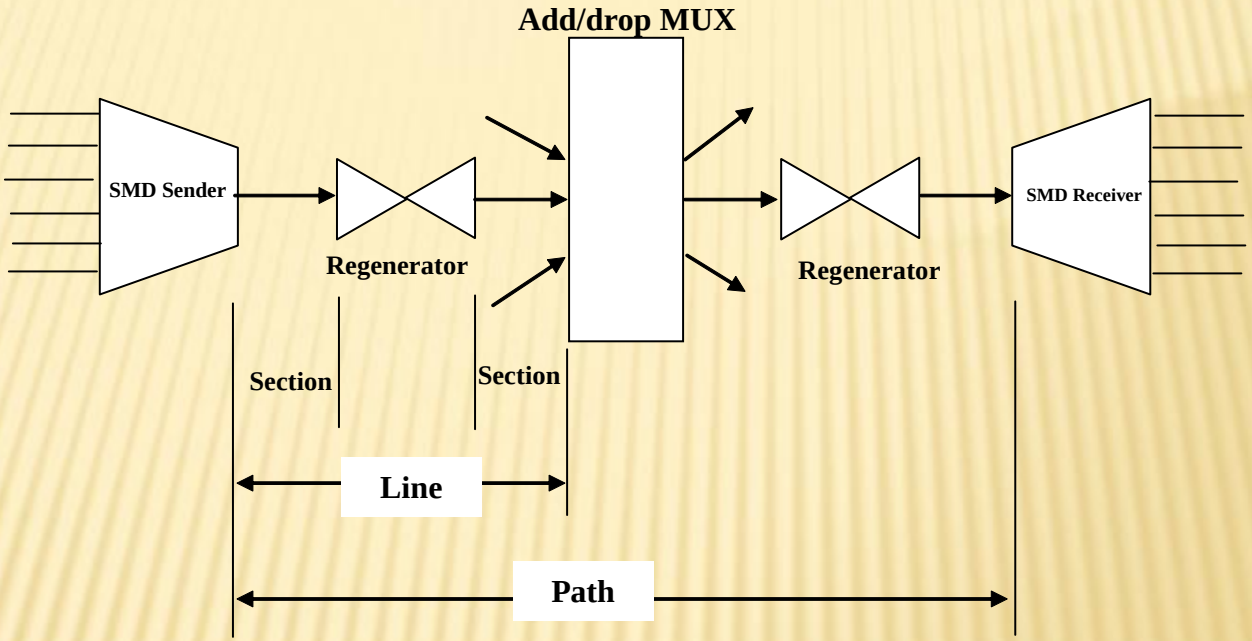
SONET/SDH DATA RATES

SONET		SDH Optical	Data Rate (Mbps)		
Electrical	**Optical**		**Envelope**	**SPE**	**User**
STS-1	OC-1		51.840	50.112	49.536
STS-3	OC-3	STM-1	155.520	150.336	148.608
STS-9	OC-9	STM-3	466.560	451.008	445.824
STS-12	OC-12	STM-4	622.080	601.344	549.432
STS-18	OC-18	STM-6	933.120	902.016	891.648
STS-24	OC-24	STM-8	1244.160	1202.688	1188.864
STS-36	OC-36	STM-12	1866.240	1804.032	1783.296
STS-48	OC-48	STM-16	2488.320	2405.376	2377.728
STS-192	OC-192	STM-64	9953.280	9621.504	9510.912

SONET TOPOLOGY



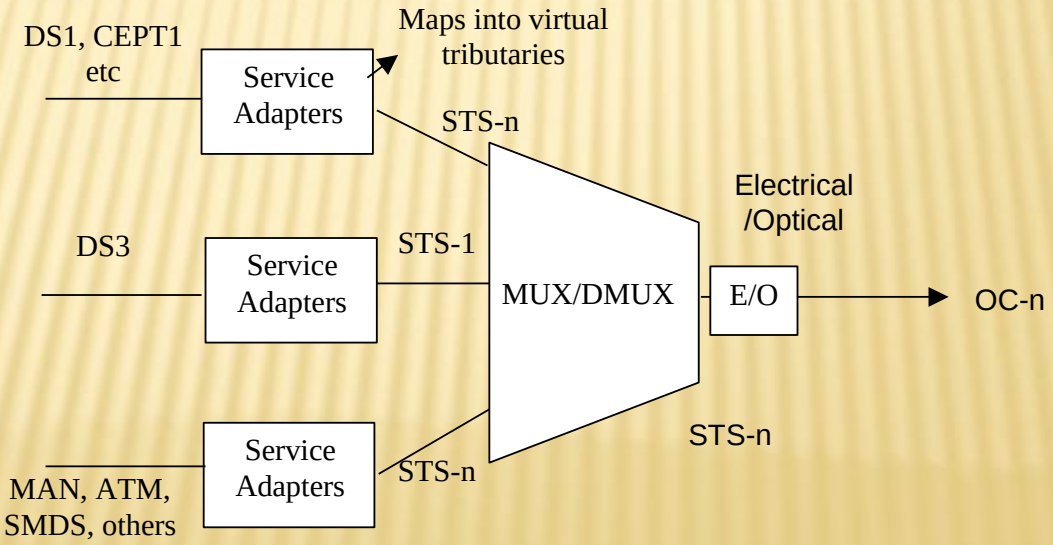
SONET CONFIGURATION



- Section
  - Connects two neighboring devices
- Line
  - Connects two multiplexers (STS , Add/Drop)
- Path
  - Connects two STS Mux/demux

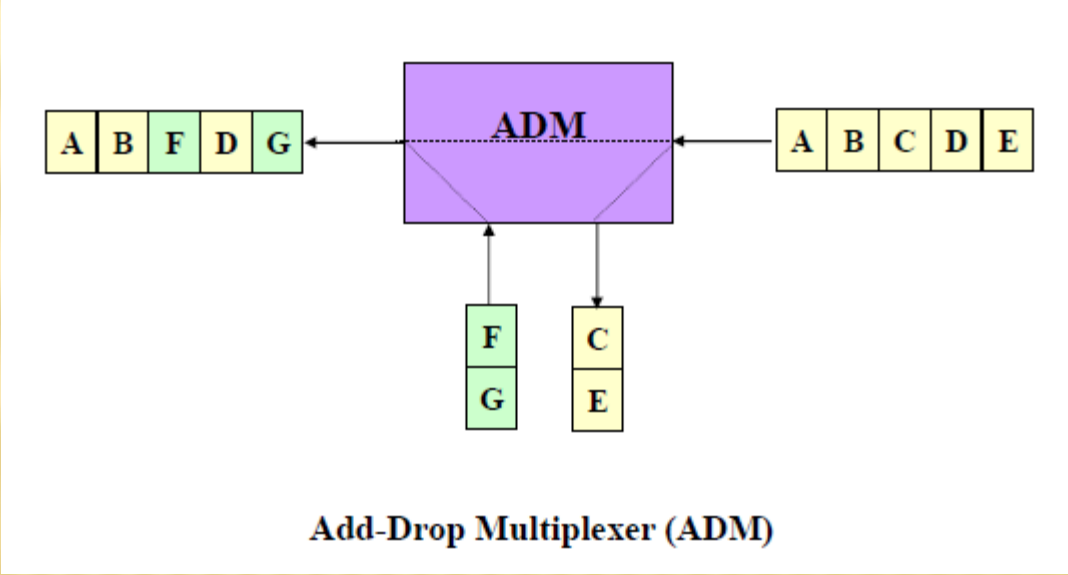
SONET DEVICES

- STS [Multiplexer/De-multiplexer] SMD
  - Multiplexes and de-multiplexes signals from multiple sources
  - Path terminating equipment
  - Maps user payload into standard frame
  - Header goes end-to-end as part of Synchronous Payload Envelope - SPE



SONET DEVICES

- Add /Drop Multiplexer ADM
  - Adds/removes signals from different sources.
  - Uses header address information to identify stream and remove
  - Line terminating Equipment
  - Performs multiplexing, synchronization.



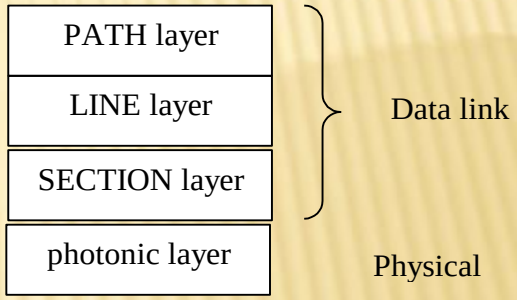
Add-Drop Multiplexer (ADM)

SONET DEVICES

- Regenerator
  - Repeater – Improves signal quality
  - Operations – Frame alignment, scrambling and error monitoring
  - Section terminating equipment

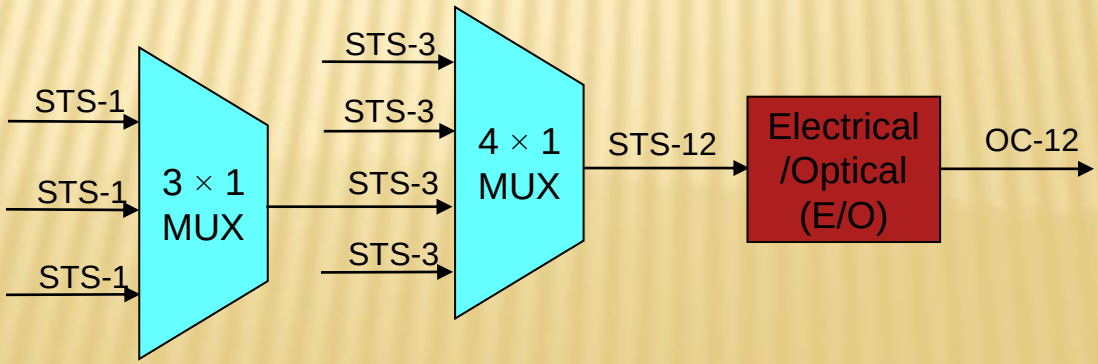
SONET LAYERS

- Section layer
  - Frames – identifies beginning of frame
  - Scrambling – introducing 1's to derive clock
  - Error monitoring – section level
  - Adds 9 bytes to header – frame size 810 bytes
  - Provided at all devices
- Line layer
  - Locates partial payload – virtual tributaries
  - Provides frequency justification
    - To adjust to clocking from different systems
  - Adds 18 bytes to header
  - Provided at the STS Mux and Add/Drop Mux
- Path layer
  - Converts to optical signals and back to electromagnetic
  - Adds 9 bytes to header - is part of SPE
  - Defines the payload being carried
  - End-to-end path control
  - Support virtual tributaries
  - Provided at the STS Mux

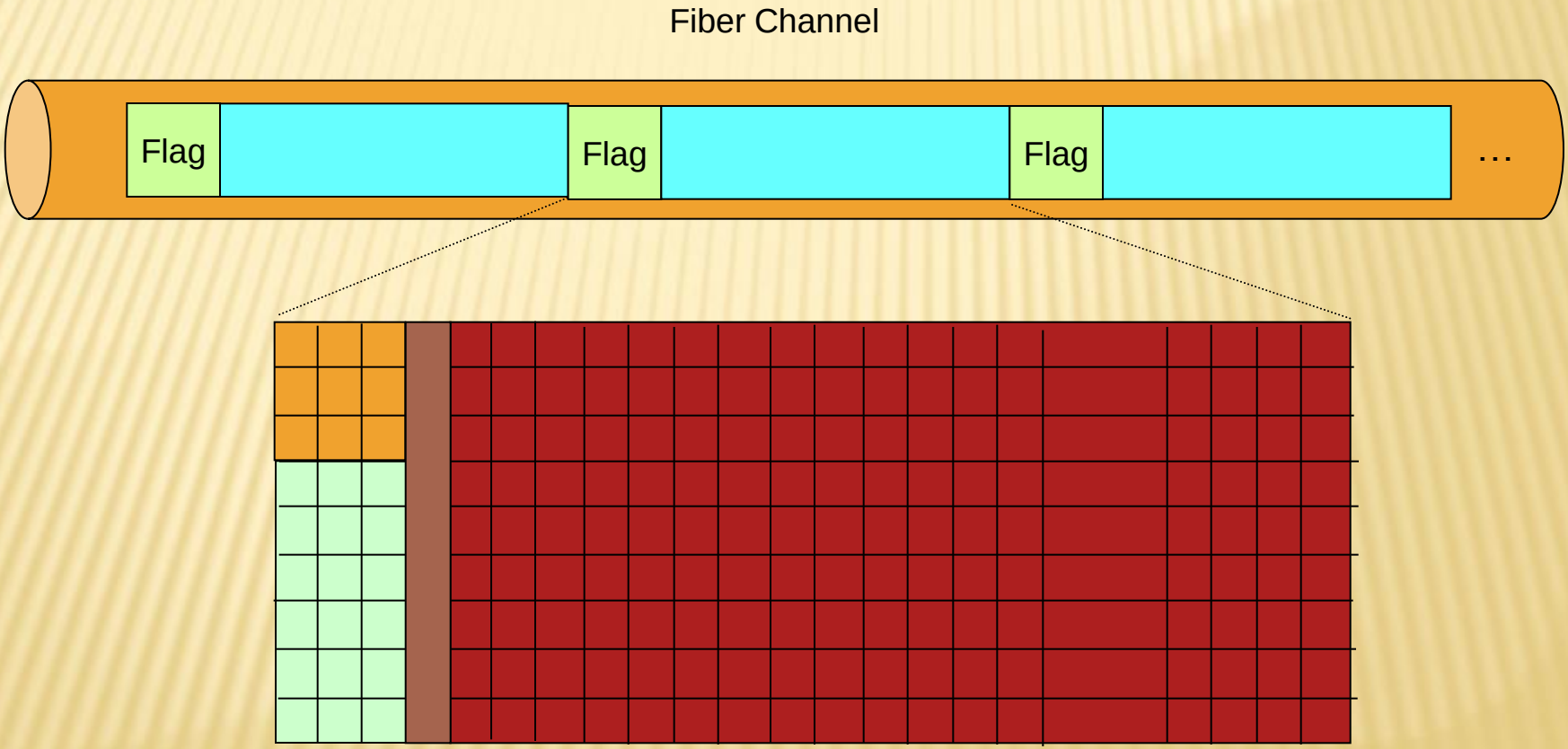


SONET MULTIPLEXING

- The purpose of the *service adapter* is to map the different signals, ranging from DS1 to ATM cells, into synchronous transport signal-1 (STS-1) envelops or its multiples.
- The multiplexing of multiple data streams is called *tributaries (channels)*.
- Lower speed signals (such as DS1 and E1) are first multiplexed into *virtual tributaries* (VTs) or *virtual containers* (VCs), which are sub-STS-1 payload.
- The purpose of the VT/VC is to keep the various payloads organized within the SONET envelop.
- Several STS-1s can be multiplexed together to form an STS-*n* signal.
- These signals are sent to an *electrical/optical (E/O)* converter where a conversion is made to an optical carrier-*n* (OC-*n*) optical signal.
- Finally, all traffic is transported through SONET in synchronous envelopes.



SONET ENVELOPES



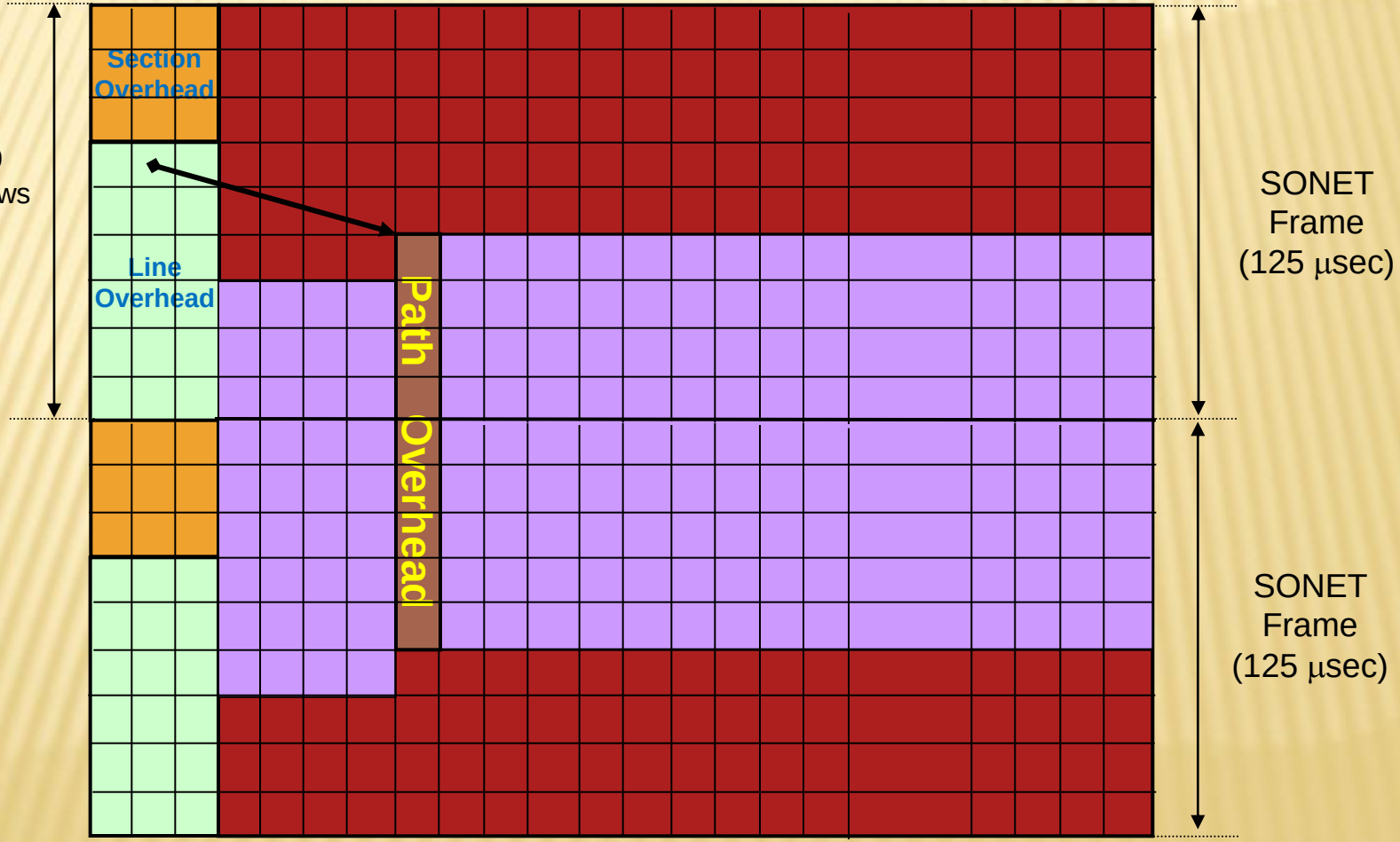
SONET ENVELOPES

- The *first three columns* are reserved for system management information.
- The *first three rows* contain the *section overhead* which generated and checked at the start and end of each section.
- the *next six* contain the *line overhead* which generated and checked at the start and end of each line.
- The remaining 87 columns are used for *user data* which called the **SPE** (**synchronous Payload Envelope**) does not always begin in row1, column 4. The SPE can begin anywhere within the frame.
- The *87 columns* hold 87 × 8 × 9 × 8000 = *50.112 Mbps*.
- A *pointer* to the first byte is contained in the first row of the *line overhead*.
- The first column of the SPE is the *path overhead* (i.e., header for the end-to-end path sublayer protocol).

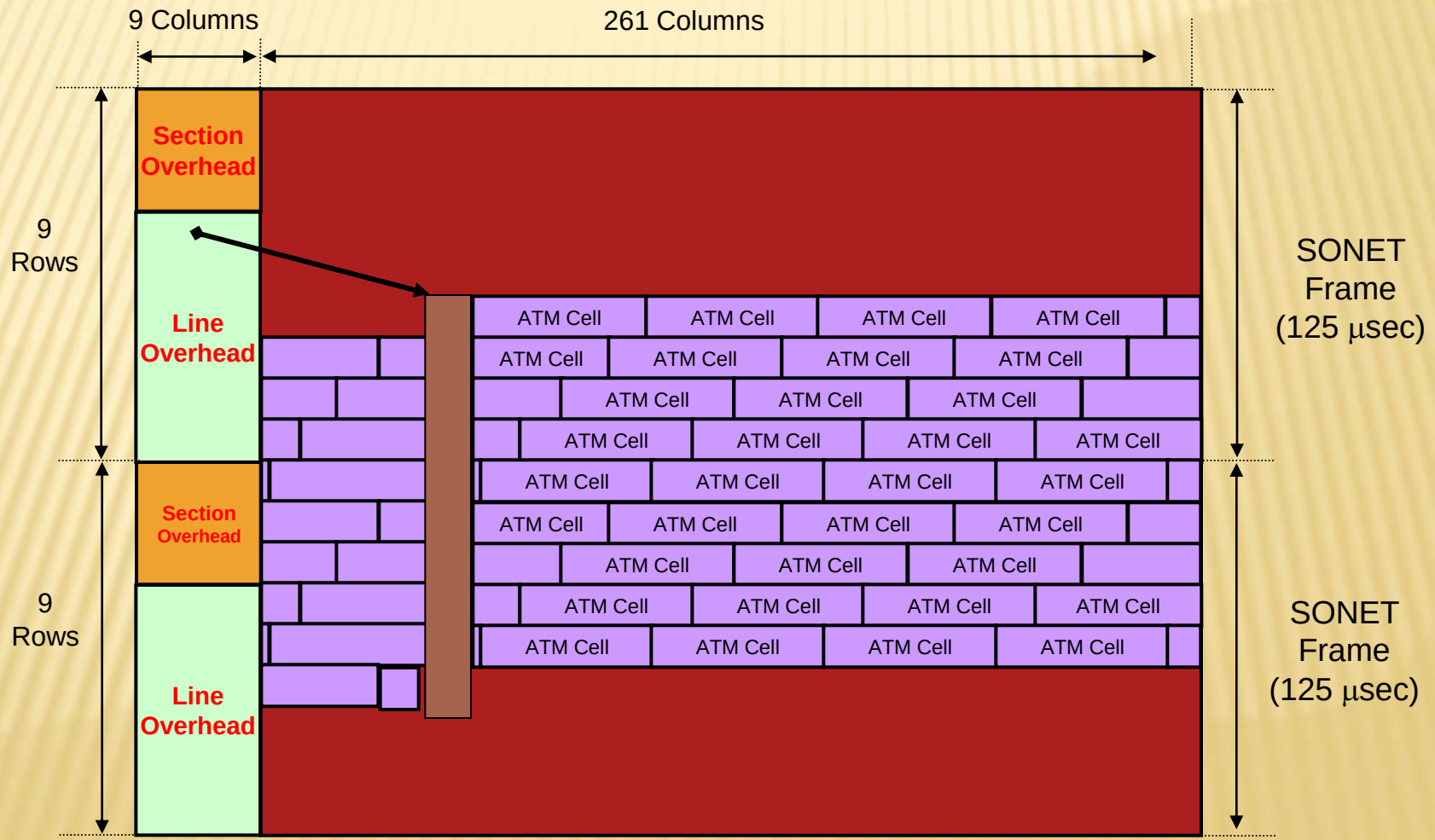
SONET ENVELOPES

- The SPE can begin anywhere within the SONET frame, and even to span two frames.
- If a payload arrives at the source while a *dummy SONET frame* is being constructed, it can be inserted into the current frame, instead of being held until the start of the next one.
- This feature is also useful when the payload does not fit exactly in one frame.
- When a source generates a sequence of *53-byte ATM cells*, the first row of the *line overhead* can point to the start of the first cell, to provide *synchronization*.

STS-1 SONET ENVELOPES



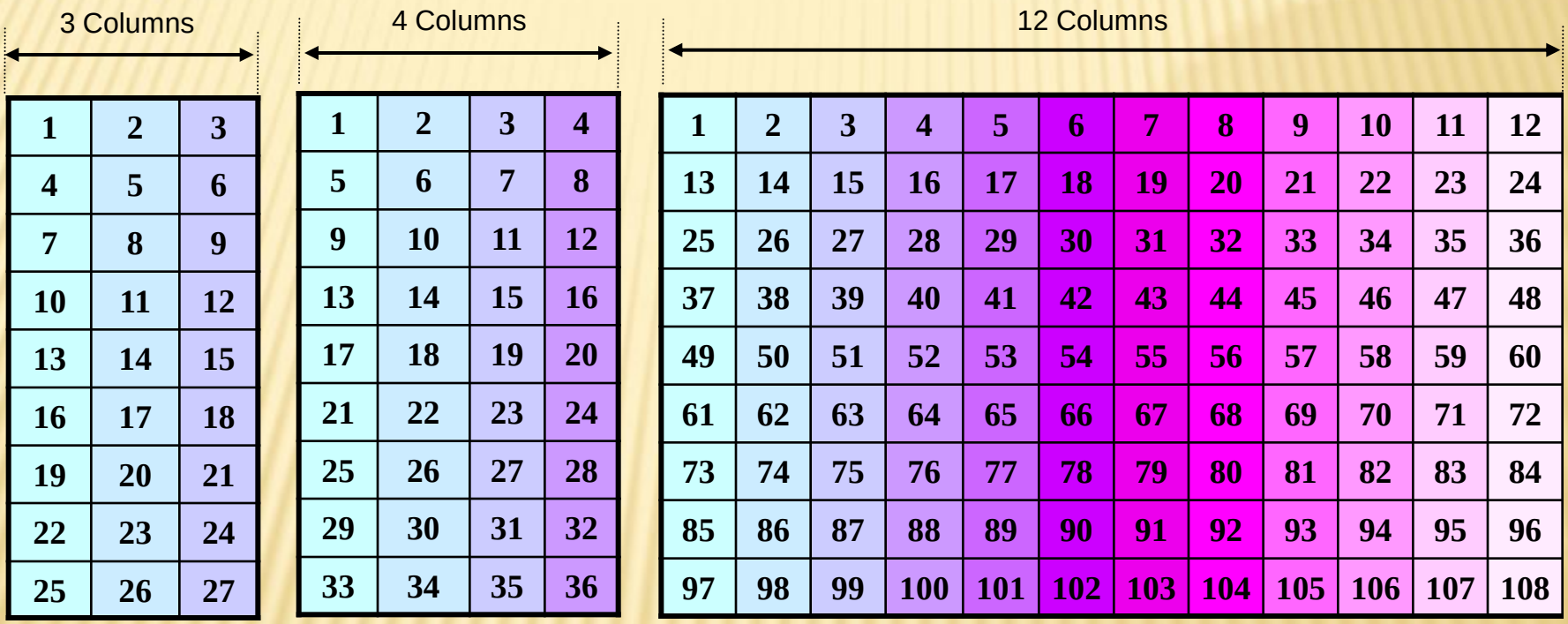
SONET ENVELOPES



SONET ENVELOPES

- The *section*, *line*, and *path overheads* contain a large amount of bytes for *operation*, *administration*, and *maintenance*.
- Other bytes are used for *framing*, *parity*, *error monitoring*, *IDs*, *clocking*, *synchronization*, and other functions.

VIRTUAL TRIBUTARIES



1	2	3
4	5	6
7	8	9
10	11	12
13	14	15
16	17	18
19	20	21
22	23	24
25	26	27

1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16
17	18	19	20
21	22	23	24
25	26	27	28
29	30	31	32
33	34	35	36

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72
73	74	75	76	77	78	79	80	81	82	83	84
85	86	87	88	89	90	91	92	93	94	95	96
97	98	99	100	101	102	103	104	105	106	107	108

VT1.5

$27 \times 8 \times 8000 = 1.728$ Mbps

VT2

$36 \times 8 \times 8000 = 2.304$ Mbps

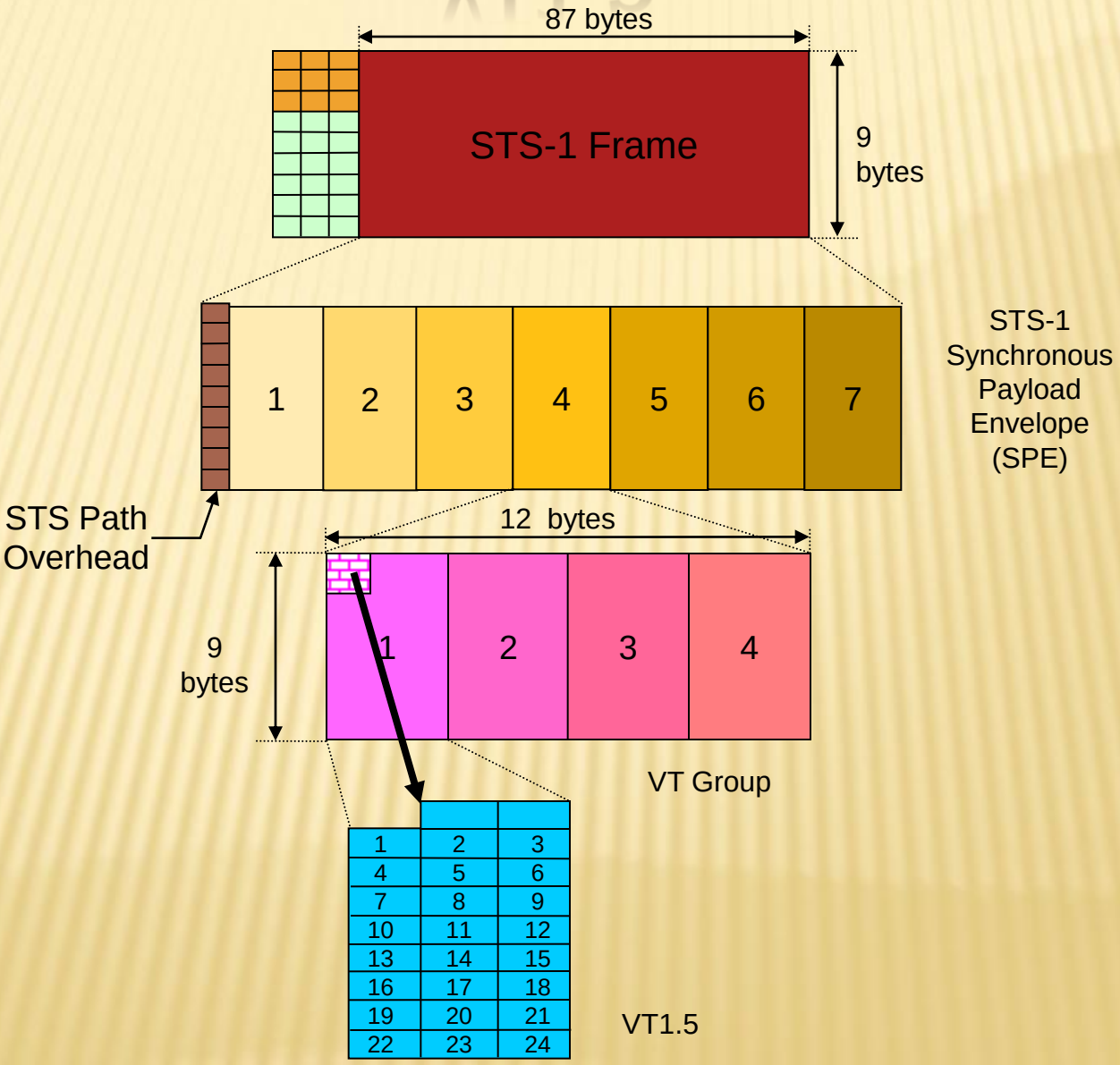
VT6

$108 \times 8 \times 8000 = 6.912$ Mbps

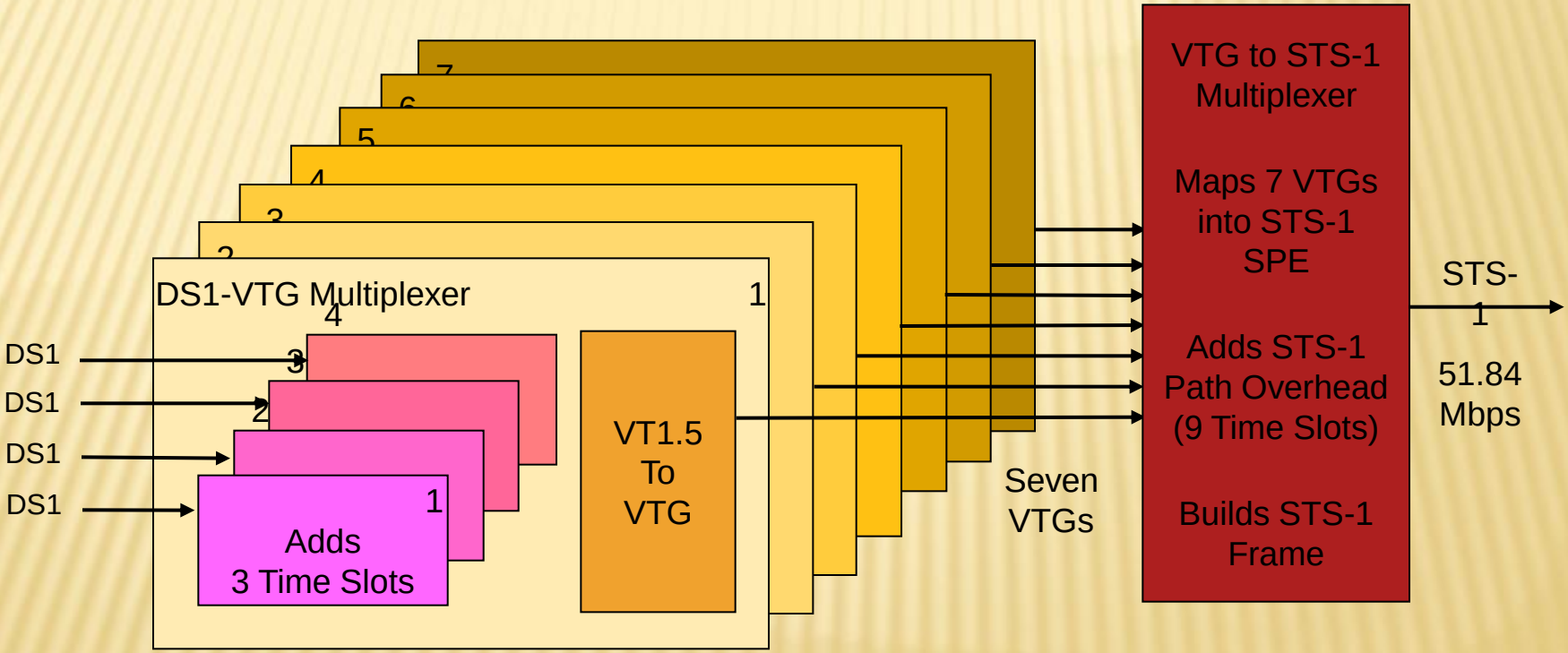
VIRTUAL TRIBUTARY 1.5 (VT1.5)

- The VT1.5 signal occupies *three columns* and *nine rows*.
- The user traffic consists of 24 octets in accordance with a T1 24 slot frame.
- The remaining 3 octets are used for SONET control.
- VT group (VTG) supports 4 VT1.5 to occupy 12 columns.
- The bit rate of each VT1.5 is 1.728 Mbps.
- The full rate of T1 is 1.544 Mbps
  - (24 × 8 × 8000 = 1536000 Mbps + 8000 occurrences of the 193rd bit = 1.544 Mbps).
- The 193rd bit is not used in the VT.
- The bit rate of VT1.5 is derived from:
  - (24 × 8 × 8000 = 1536000 Mbps) + (3 × 8 × 8000) = 1.728 Mbps.

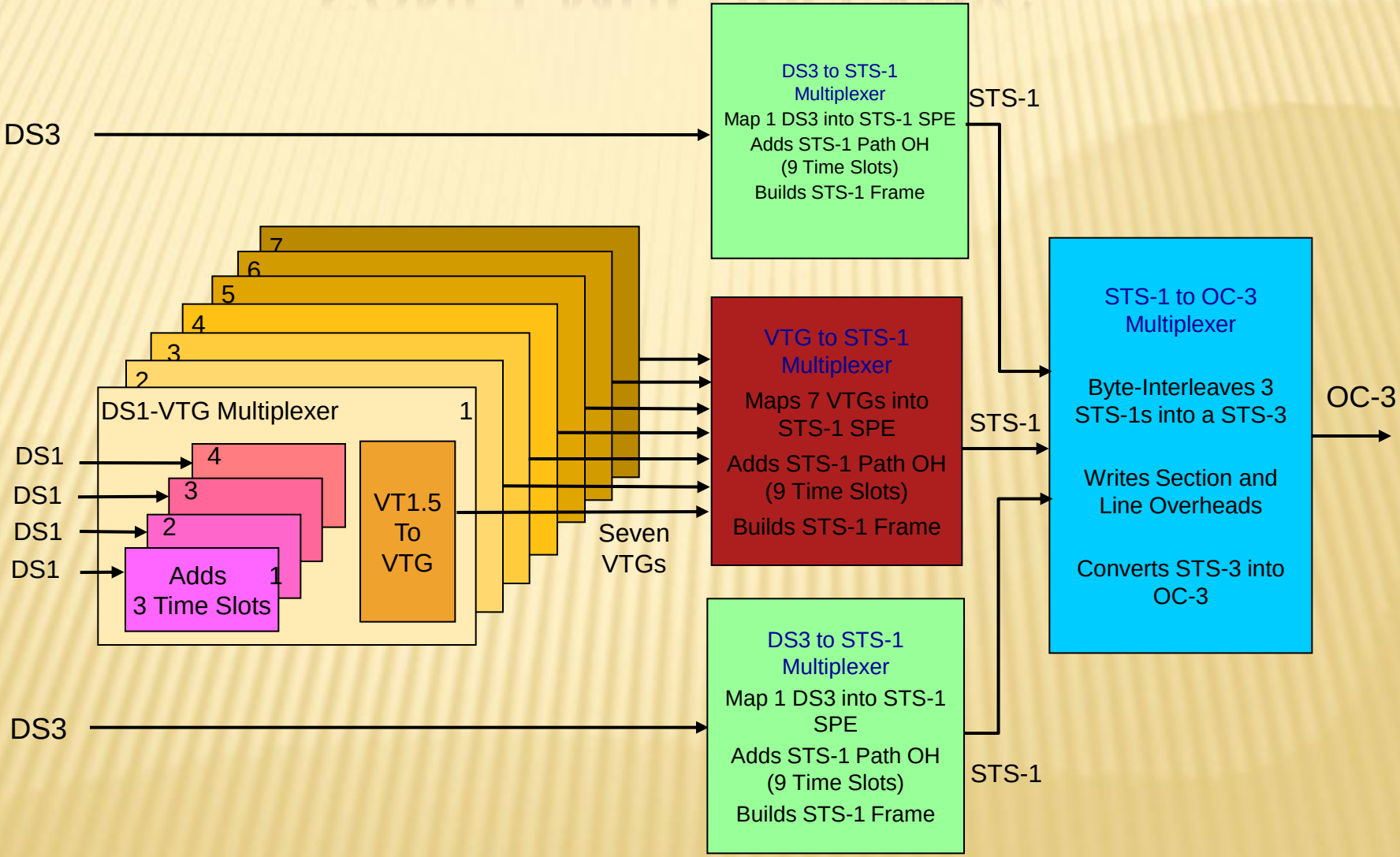
VT1.5


87 bytes
STS-1 Frame
9
bytes
1
2
3
4
5
6
7
STS-1
Synchronous
Payload
Envelope
(SPE)
STS Path
Overhead
12 bytes
9
bytes
1
2
3
4
VT Group
1 2 3
4 5 6
7 8 9
10 11 12
13 14 15
16 17 18
19 20 21
22 23 24
VT1.5

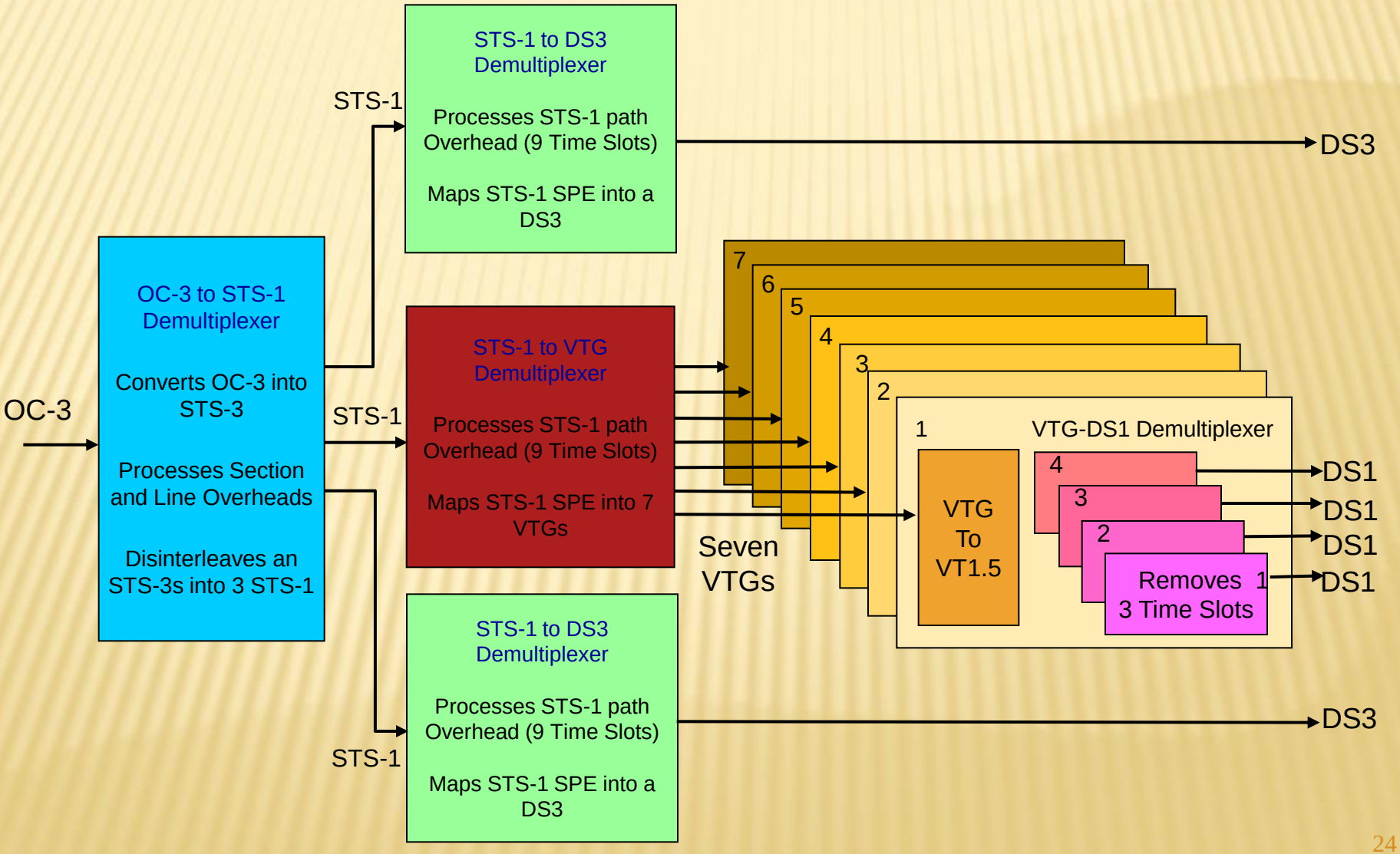
SONET MULTIPLEXING



SONET MULTIPLEXING



SONET DEMULTIPLEXING



VIRTUAL TRIBUTARY 2 (VT2)

- The VT2 signal occupies *four columns* and *nine rows*.
- The user traffic consists of 32 octets in accordance with a E1 32 slot frame.
- The remaining 4 octets are used for SONET control.
- A VT group (VTG) supports 3 VT2 to occupy 12 columns.
- The bit rate of each VT2 is 2.304 Mbps.
- The full rate of E1 is 2.048 Mbps
  (32 × 8 × 8000 = 2048000 Mbps).
- The bit rate of VT2 is derived from:
  (4 × 9) × 8 × 8000 = 2304000 Mbps.

VIRTUAL TRIBUTARIES

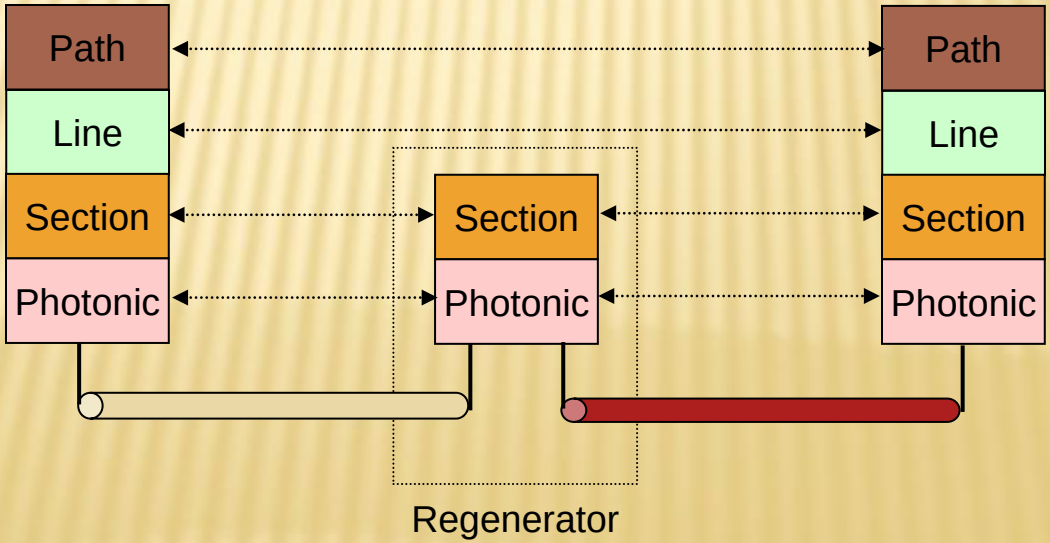
VT Type	Number in a VT Group (VTG)	Signal Standard	Signal Rate (Mbps)	Number Bytes	Number Columns
1.5	4	DS-1 (T1)	1.544	27	3
2	3	CEPT-1 (E1)	2.048	36	4
3	2	DS-1C	3.152	54	6
6	1	DS-2	6.312	108	12

SONET LAYERS

- The SONET physical layer is divided into 4 sublayers:
  - **Photonic Sublayer:**
    - It is the lowest sublayer.
    - It is concerned with specifying the physical properties of light and fiber to be used.
    - It is responsible for converting the electrical signal to an optical signal, and then regenerating the optical signal as it carried through the network.
- The remaining sublayers correspond to the sections, lines, and paths.
  - **Section Sublayer:**
    - It handles a single point-to-point fiber run.
    - It generates a standard frame at one end and processes it at the other end of the fiber.
    - Sections can start and end at repeater.

- **Line Sublayer:**
  - It concerns with multiplexing multiple tributaries onto a single line and demultiplexing them at the other end.
  - When a multiplexer puts out bits on a fiber, it is expect them to arrive at the next multiplexer unchanged, no matter how many repeaters are used in between.
  - The protocol in the line sublayer is between two multiplexers and deals with issues such as how many inputs are being multiplexed and how.
- **Path Sublayer:**
  - The path sublayer and protocol deal with end-to-end issues.

- In accordance with the OSI model, traffic to be transmitted through the network is passed through the *ATM layer* to the *path layer*.
- A *path header* is attached to the traffic.
- The traffic is passed to the *line sublayer*, which adds a *line header*, performs certain actions and passes the traffic to the *section sublayer*.
- The *section sublayer* adds a *section header* to the traffic, performs certain actions and passes the traffic to the *photonic sublayer*.
- The photonic sublayer adds no header; but it encodes the bits, places a synchronization flag in front of them, and transmit them onto the channel.
- At the *receiving machine* the process is reversed, each layer strips off its respective header and uses it to determine what actions that layer is to take.



SONET LAYERS