

BROADBAND AND HIGH SPEED NETWORKS

4 SONET / SDH

SYNCHRONOUS OPTICAL NETWORK (SONET)

- ❑ *Synchronous Optical Network* (SONET) is a standard for optical telecommunications transport.
- ❑ SONET defines optical carrier (OC) levels and electrically equivalent synchronous transport signals (STSs) for the fiber-optic-based transmission hierarchy.
- ❑ The OC refers to the signal in its optical form. It is therefore incorrect to say that an OC-3 contains 3 OC-1s: an OC-3 can be said to contain 3 STS-1s.
- ❑ The purpose of SONET is to *transport*, *multiplex*, and *switch* digital signals representing voice, video, and data traffic to and from user's applications.

SONET AND SDH

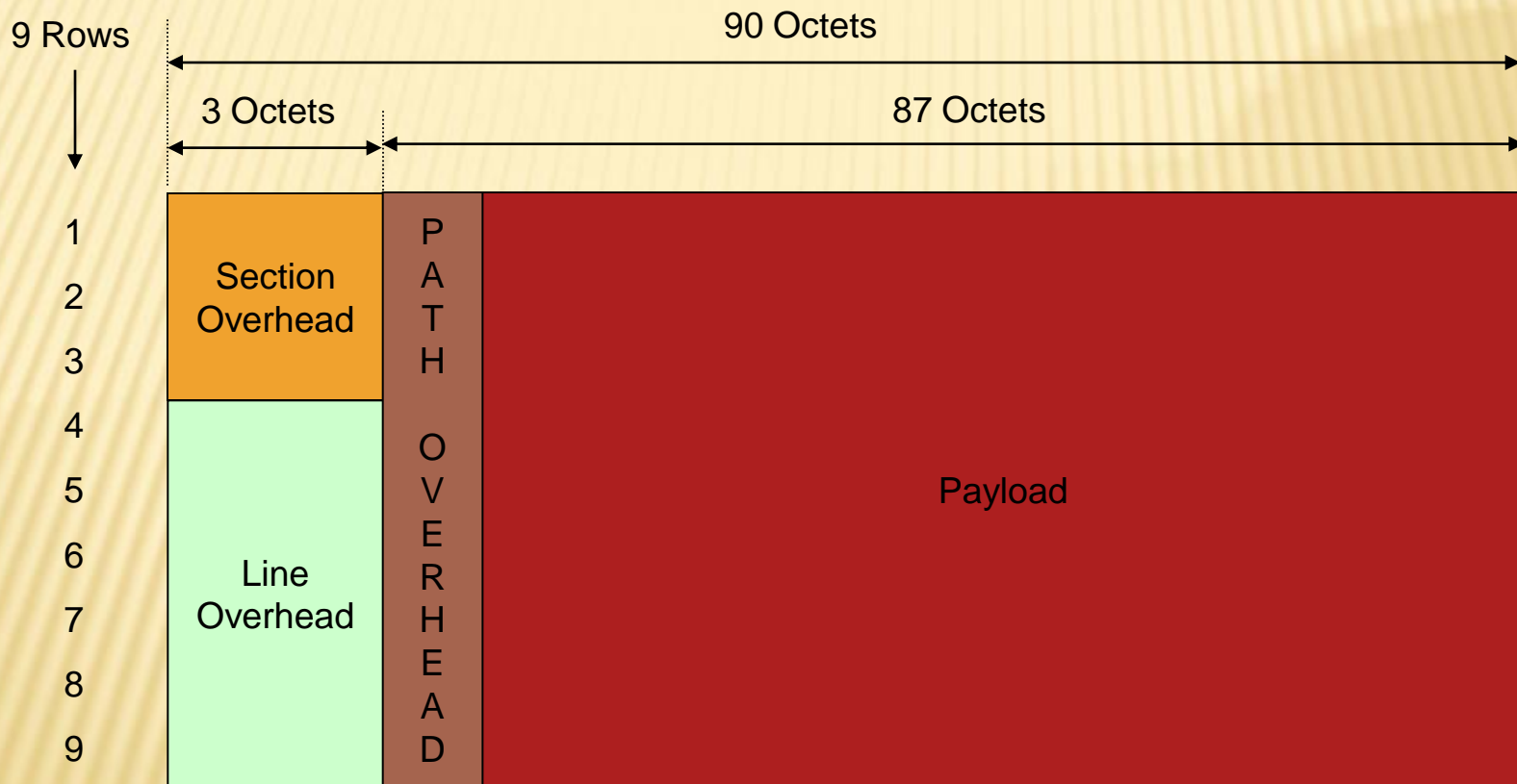
Synchronous Optical Networking (SONET) and **Synchronous Digital Hierarchy (SDH)** are standardized protocols that transfer multiple digital bit streams synchronously over optical fiber using lasers or highly coherent light from light-emitting diodes (LEDs). At low transmission rates data can also be transferred via an electrical interface. The method was developed to replace the Plesiochronous Digital Hierarchy (PDH) system for transporting large amounts of telephone calls and data traffic over the same fiber without synchronization problems.

SYNCHRONOUS OPTICAL NETWORK (SONET)

- ❑ *Synchronous Optical Network* (SONET) is a digital transport system.
- ❑ In SONET, the base *transfer rate* is 51.84 Mbps, a 125 μsec signal, and a frame format of 9 rows by 90 columns (90 columns * 9 rows * 8 bit/byte * 8000 = 51840000 bps).
- ❑ The basic rate of SONET, known as **Synchronous Transport Signal 1 (STS-1)**, is *51.84 Mbps*.
- ❑ SONET is the standard in North America, which is permitted to be multiplexed by an integer of **three** to the European preference of *155.520 Mbps*.

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- ❑ In STS-1, the frame is 810 octets in size, while STS-3 frame is 2,430 octets in size.
 - ❑ For STS-1, the frame is transmitted as three octets of overhead, followed by 87 octets of payload. This is repeated nine times, until 810 octets have been transmitted, taking 125 μ s.
 - ❑ For STS-3, which operates three times faster than an STS-1, nine octets of overhead are transmitted, followed by 261 octets of payload. This is also repeated nine times until 2,430 octets have been transmitted, also taking 125 μ s.
 - ❑ For both SONET and SDH, this is often represented by displaying the frame graphically: as a block of 90 columns and nine rows for STS-1, and 270 columns and nine rows for STS-3.

SYNCHRONOUS OPTICAL NETWORK (SONET) STS-1 FRAME



STS-1 Envelope

OVERHEADS

The transport overhead is used for signaling and measuring transmission error rates, and is composed as follows:

- ❑ **Section overhead**

Containing information about the frame structure required by the terminal equipment.

- ❑ **Line overhead**

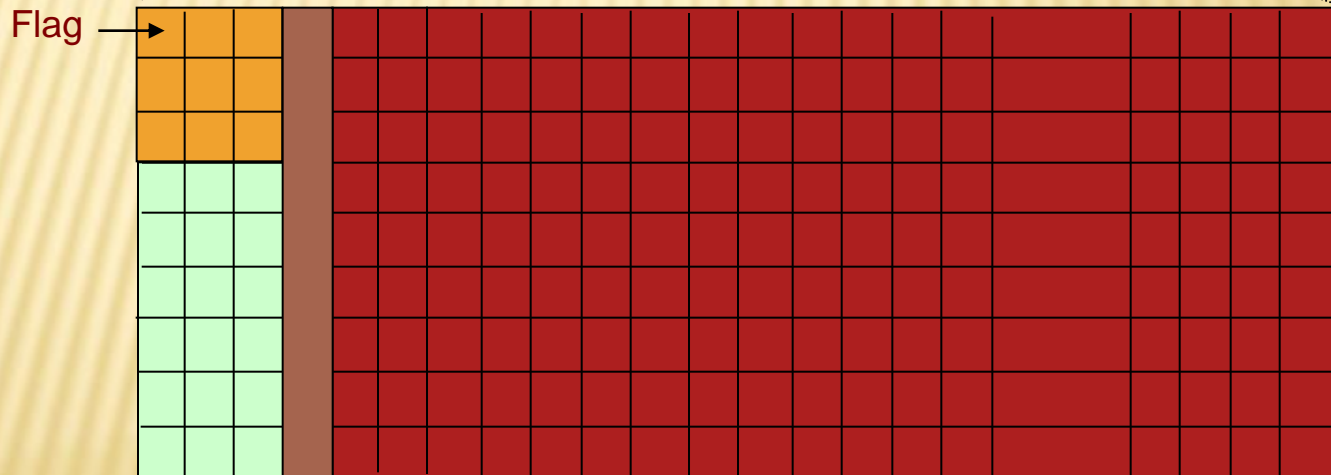
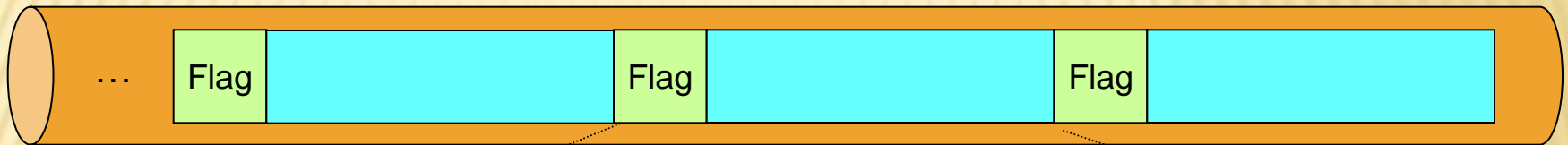
Containing information about error correction and Automatic Protection Switching messages (e.g., alarms and maintenance messages) as may be required within the network.

- ❑ **Path overhead**

Path overhead bits for performance monitoring and protection switching.

SYNCHRONOUS OPTICAL NETWORK (SONET)

Fiber Channel



STS-1 Envelope

WHAT ARE THE BENEFITS OF SONET?

- Reduction in equipment requirements and an increase in network reliability.
- Definition of a synchronous multiplexing format for carrying lower level digital signals (such as DS-1, DS-3) and a synchronous structure that greatly simplifies the interface to digital switches, digital cross-connect switches, and add-drop multiplexers
- Availability of a set of generic standards that enable products from different vendors to be connected
- Definition of a flexible architecture capable of accommodating future applications, with a variety of transmission rates

SONET

- Uses a 51.84 Mbps signal as its basic building block
 - Time-division multiplexes these basic signals into higher-speed signals
 - STS-n : (Electrical) *Synchronous Transport Signal level n* and Higher-level signals are integer multiples of STS -1.
- ✘ OC-n : *Optical Carrier Signal level n* (Various STS input streams are multiplexed), where n represents multiplexing integer.
- The lowest level or base signal is referred to as STS -1 i.e. (Synchronous Transport Signal level -1) which operates at 51.840Mbps.
- Three STS-1 signals can be multiplexed together to create STS-3 signal (155.52 Mbps) which represent the electrical signal of OC-3

FRAME TRANSMISSION

STS	OC	Rate (Mbps)	SPE (Mbps)	User (Mbps)
STS-1	OC-1	51.84	50.12	49.536
STS-3	OC-3	155.52	150.336	148.608
STS-9	OC-9	466.56	451.008	445.824
STS-12	OC-12	622.08	601.344	594.432
STS-18	OC-18	933.12	902.016	891.648
STS-24	OC-24	1244.16	1202.688	1188.864
STS-36	OC-36	1866.23	1804.032	1783.296
STS-48	OC-48	2488.32	2405.376	2377.728
STS-192	OC-192	9953.28	9621.604	9510.912

STS : Synchronous Transport Signal

OC : Optical Carrier

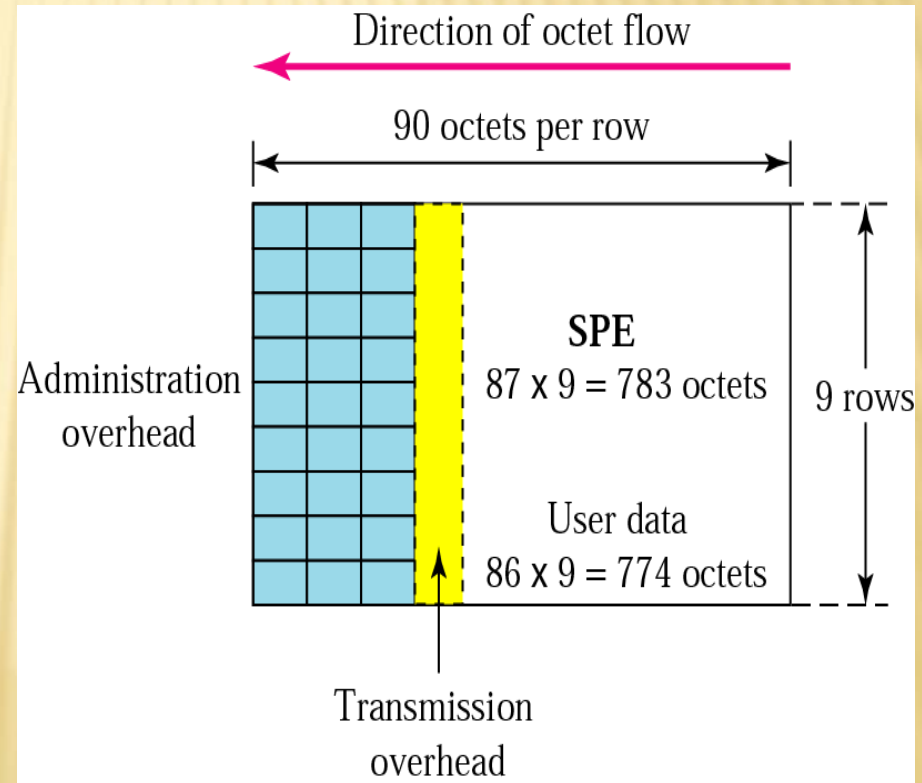
SPE : synchronous Payload Envelope

FRAME FORMAT STRUCTURE

■ In general, the frame can be divided into two main areas: **transport overhead** and the **synchronous payload envelope (SPE)**.

■ The synchronous payload envelope can also be divided into two parts: the STS **path overhead (POH)** and the **payload**.

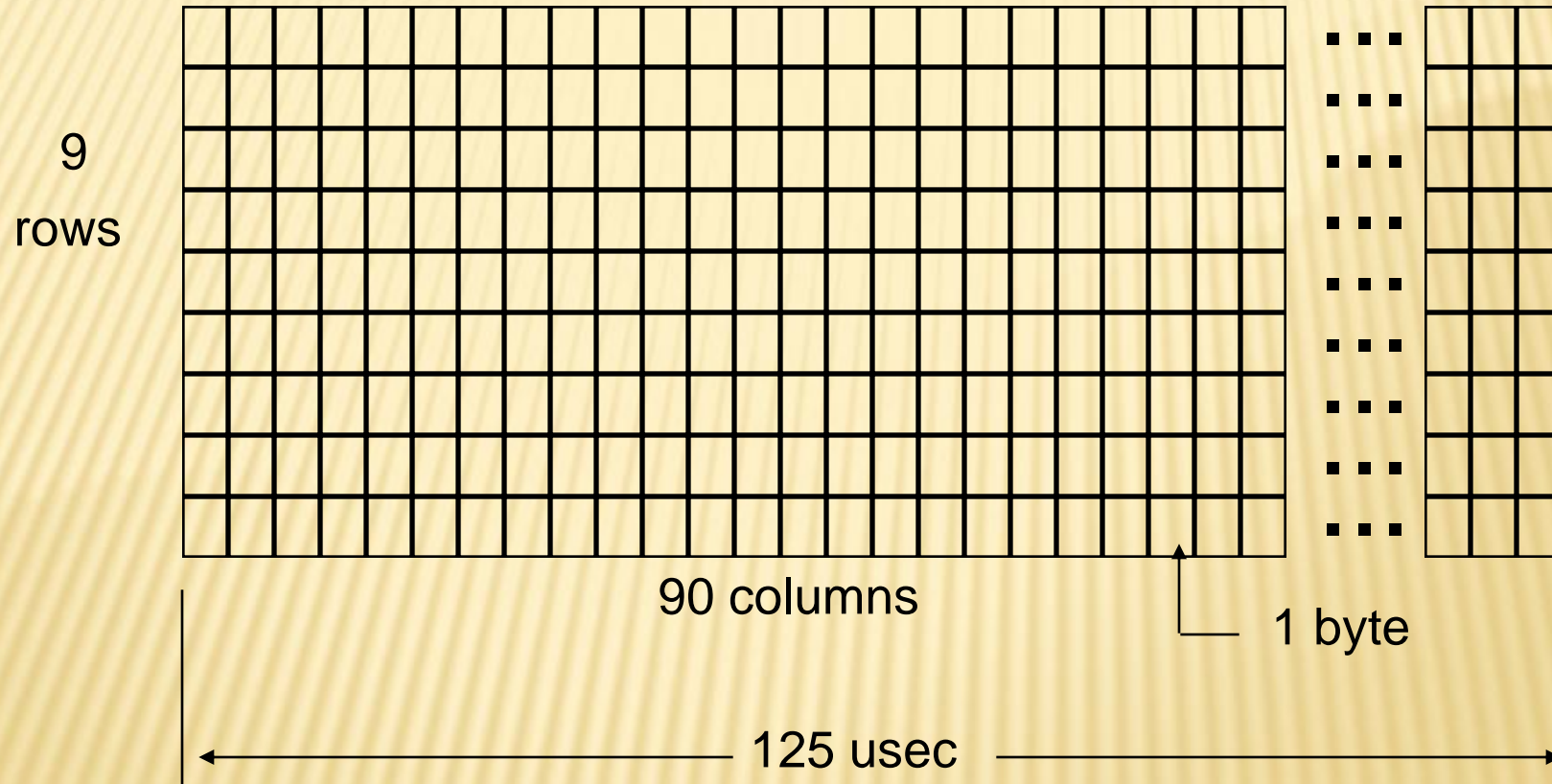
The payload is the traffic being transported and routed over the SONET network. Once the payload is multiplexed into the synchronous payload envelope, it can be transported and switched through SONET.



SONET FRAMING STRUCTURE

- ✘ Basic module is STS-1 (Synchronous Transport Signal, Level 1), corresponds to 51.84 Mbps
- ✘ Frame structure: 9 rows of 90 columns of 8-bit bytes
- ✘ 8000 frames/sec (125 usec/frame)

STS-1 FRAMING STRUCTURE

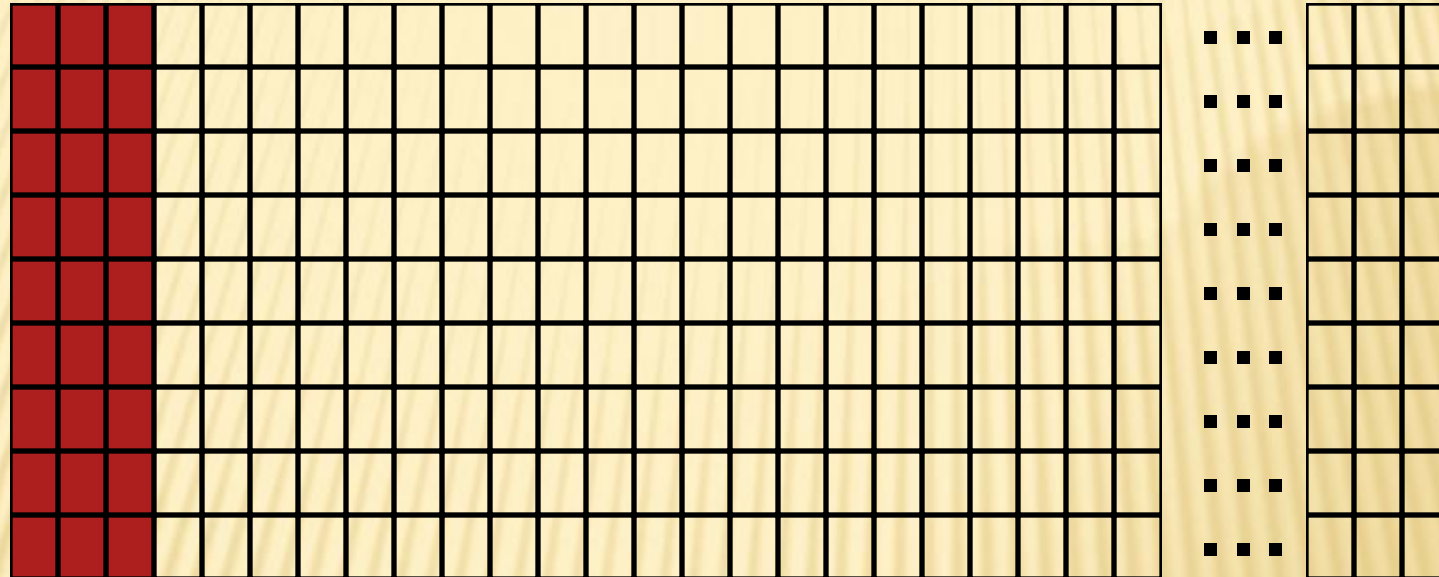


STS-1 FRAMING

- Bytes are transmitted one row at a time, from left to right
- Note: 1 byte/frame = 64 kbps
- First three columns of STS-1 frame are for section overhead and line overhead
- Remaining 87 columns are for the Synchronous Payload Envelope (SPE)

STS-1 FRAMING (CONT'D)

90 columns



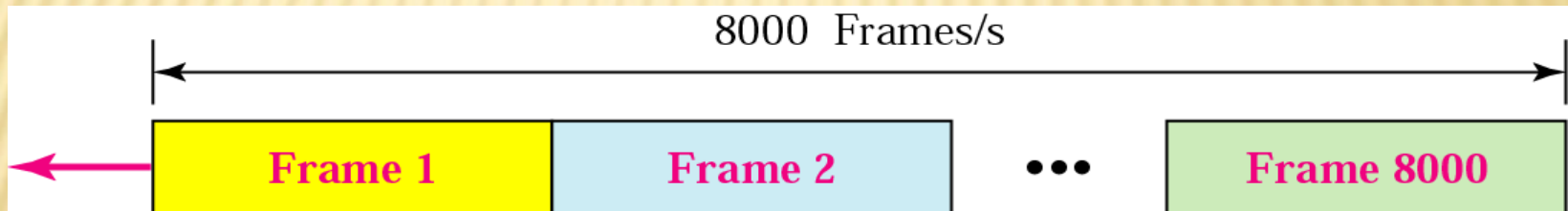
9
rows

↑
Section and
Line Overhead
(3 columns)

↑
Synchronous Payload
Envelope (SPE)
(87 columns)

STS-1

- **STS-1** is a specific sequence of 810 bytes (6,480 bits), which includes various overhead bytes and an envelope capacity for transporting payloads. It can be depicted as a 90-column by 9-row structure. With a frame length of 125 us (8,000 frames per second), STS-1 has a bit rate of 51.840 Mbps. The order of transmission of bytes is row-by-row from top to bottom and from left to right (most significant bit first).



$$\text{Raw rate} = 8000 \text{ frames/s} \times 9 \times 90 \times 8 = 51,840,000 \text{ bps}$$

$$\text{SPE rate} = 8000 \text{ frames/s} \times 9 \times 87 \times 8 = 50,112,000 \text{ bps}$$

$$\text{User rate} = 8000 \text{ frames/s} \times 9 \times 86 \times 8 = 49,536,000 \text{ bps}$$