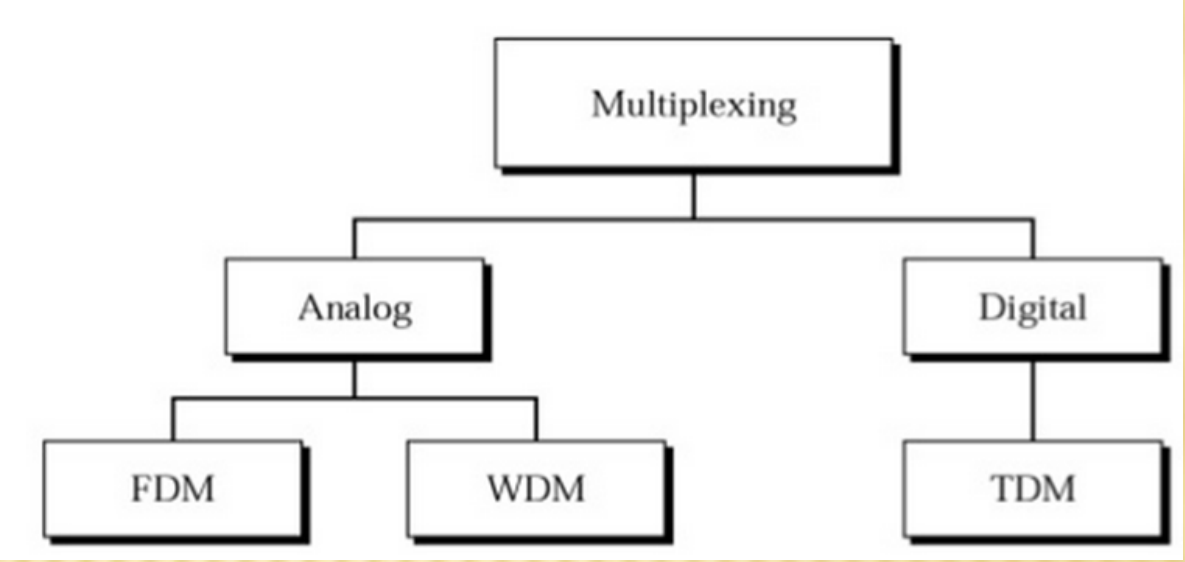
# BROADBAND AND HIGH SPEED NETWORKS

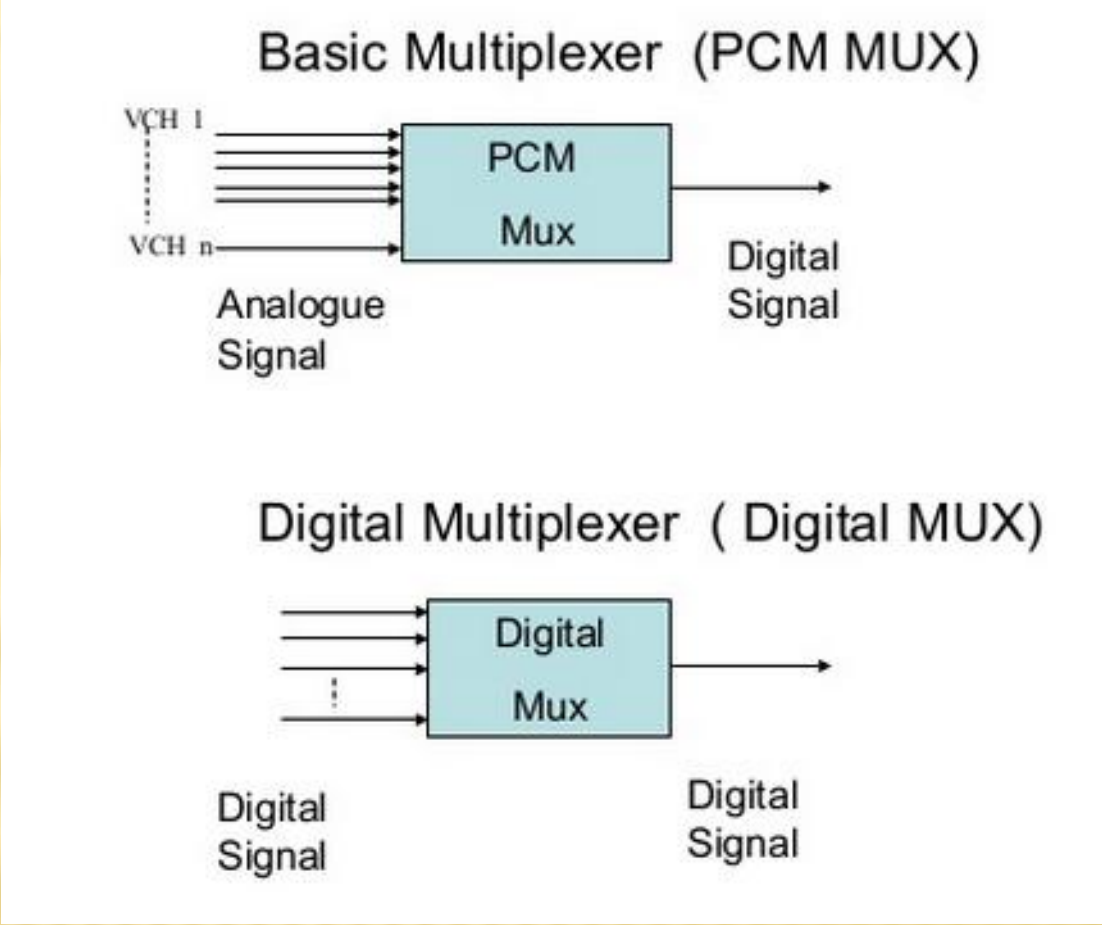
# 4 Carriers

# INTRODUCTION TO MUTIPLEXING

**Multiplexing** is the set of techniques that allows the simultaneous transmission of multiple signals across a single data link



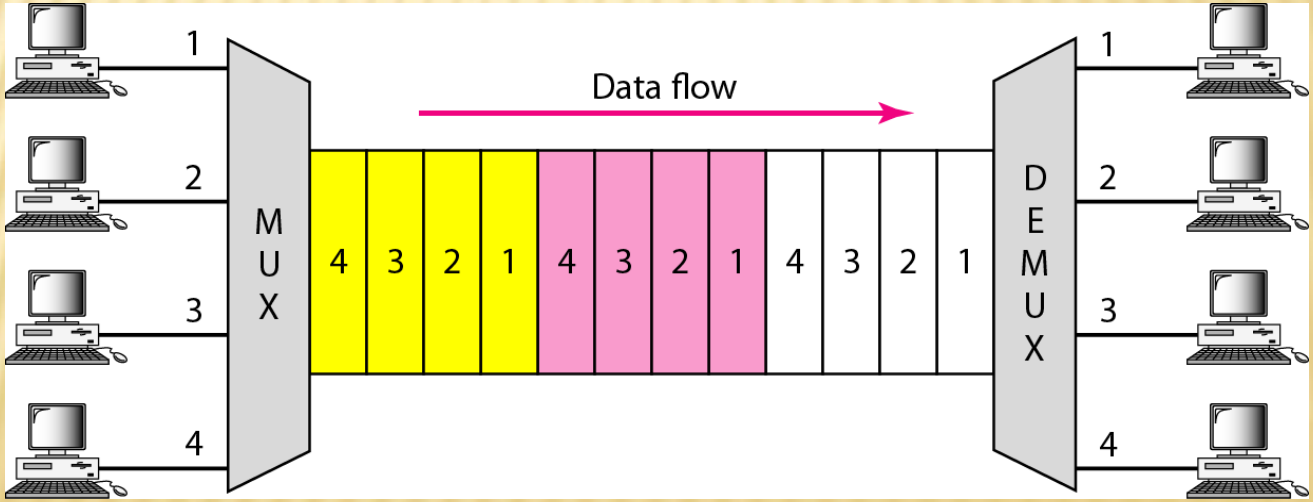
# INTRODUCTION TO DIGITAL MUTIPLEXING



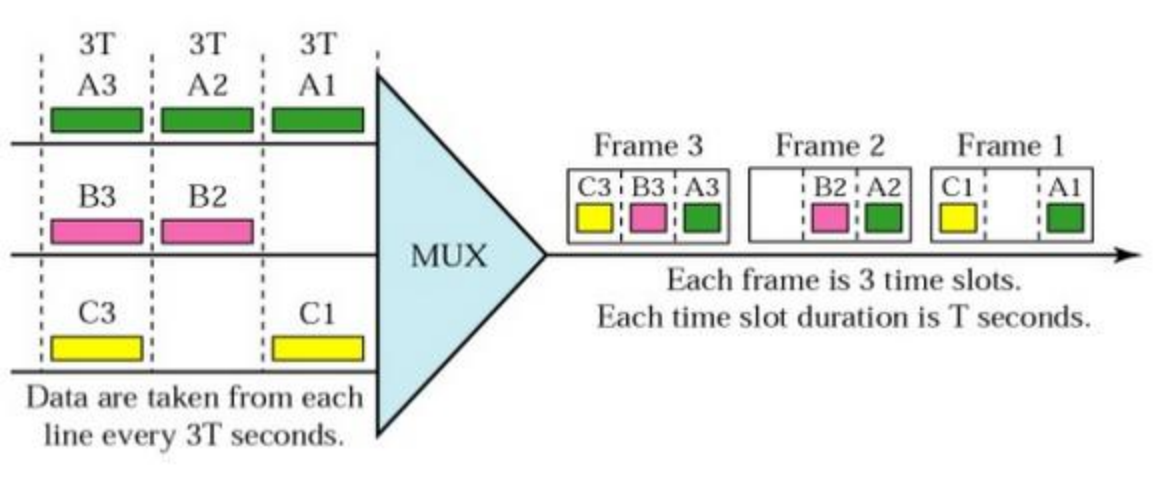
# DIGITAL MULTIPLEXING (TDM)

**TDM (Time-Division Multiplexing) is a digital process that can be applied when the data rate capacity of the transmission medium is greater than the data rate required by the sending and receiving device.**

**TDM is a digital multiplexing technique for combining several low-rate channels into one high-rate one.**



# TDM




**In TDM, the data rate of the link is n times faster, and the unit duration is n times shorter**

# INTERLEAVING

**It is the process that a single data bit or byte from an I/O port is released to the input of Multiplexer or output of multiplexer by a clock pulse.**

**Types of Interleaving :**

- **Bit by Bit Interleaving**

  **It is much simpler because it is independent of frame structure and also requires less memory capacity.**

- **Word by Word Interleaving**

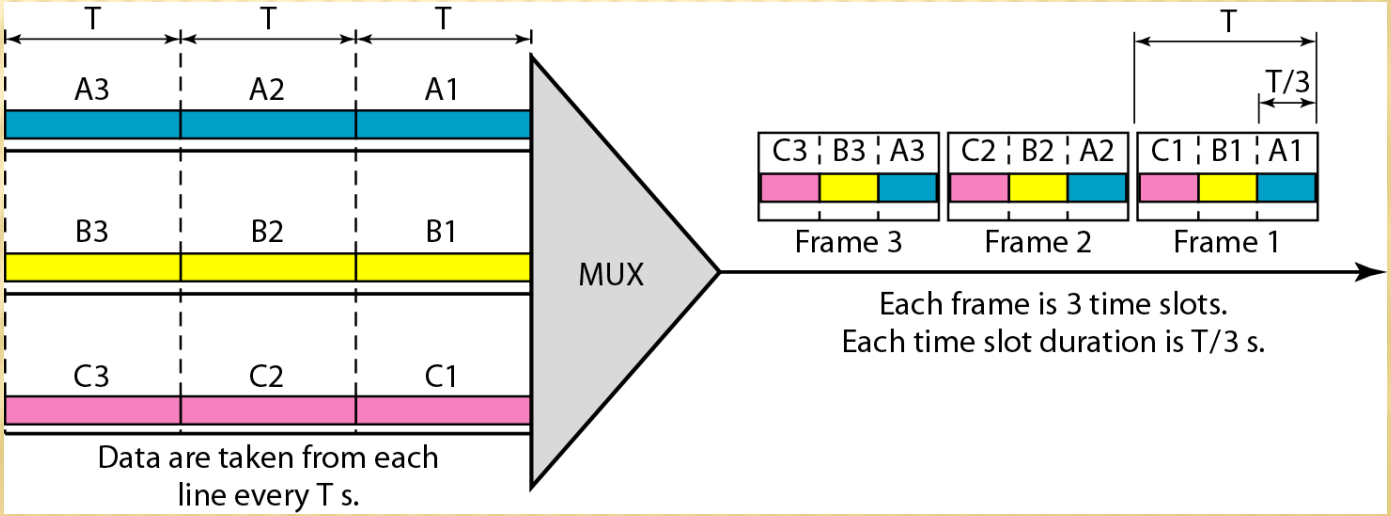
  **It sets some chains on the frame structure of the channels and requires a greater amount of memory capacity.**

# WAYS OF TDM

- TDM can be implemented in two ways
  - Synchronous TDM
  - Asynchronous TDM

# SYNCHRONOUS DIGITAL MULTIPLEXER

- Synchronous digital multiplexer have channels with the same clock frequency, and they are all synchronized to a master clock.
- T-1 and ISDN telephone lines are common examples of synchronous time division multiplexing.

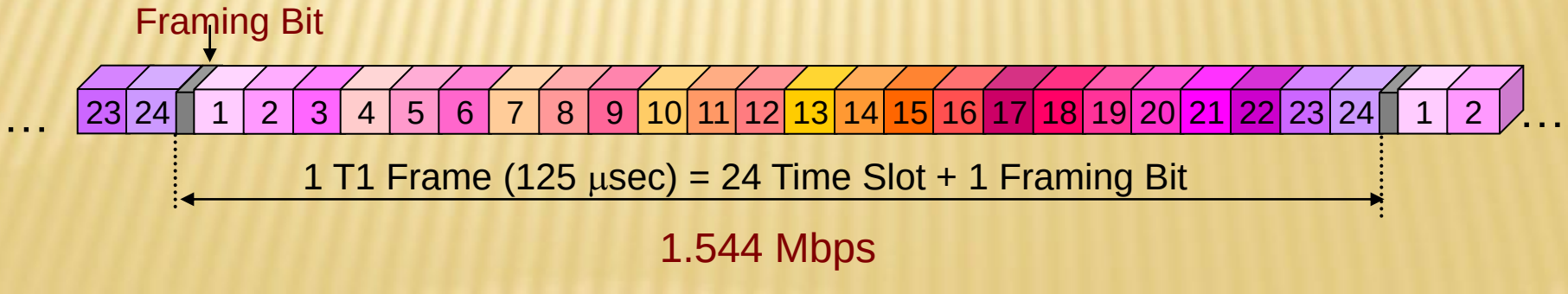


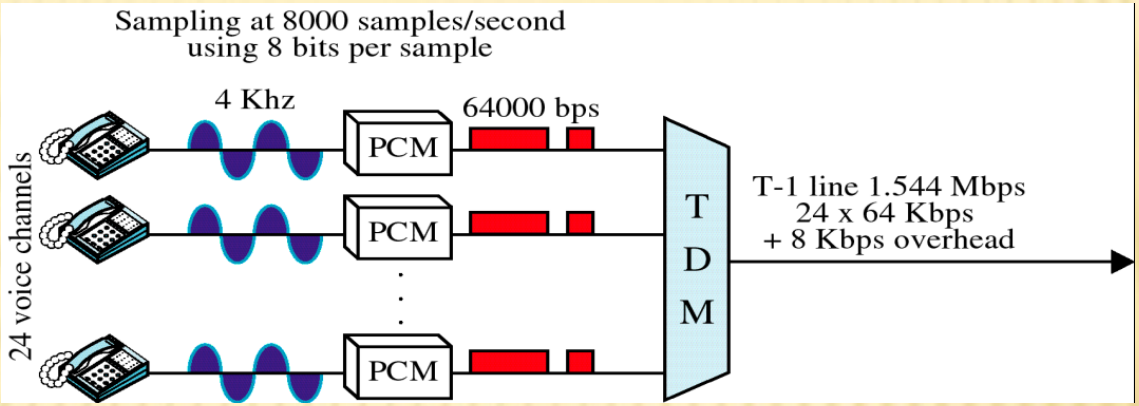
# T1 DIGITAL CARRIER SYSTEM

- North American Telephone standards Recognized by ITU-T Recommendation G.733
- The T1 (1.54 Mbps) multiplexor stream is a continuous series of frames of both digitized data and voice channels.
- Each channel contains an 8 bit PCM code and is sampled at 8000 times per second.
- The T1 carrier consists of 24 voice channels multiplexed together. Usually, the analog signals are sampled with the resulting analog stream being fed to the codec. Each of the 24 channels gets to insert 8-bit into the output stream.
- A frame length = 24*8 = 192 data bits + 1 extra bit for framing

  = 193 bits / 125 μsec

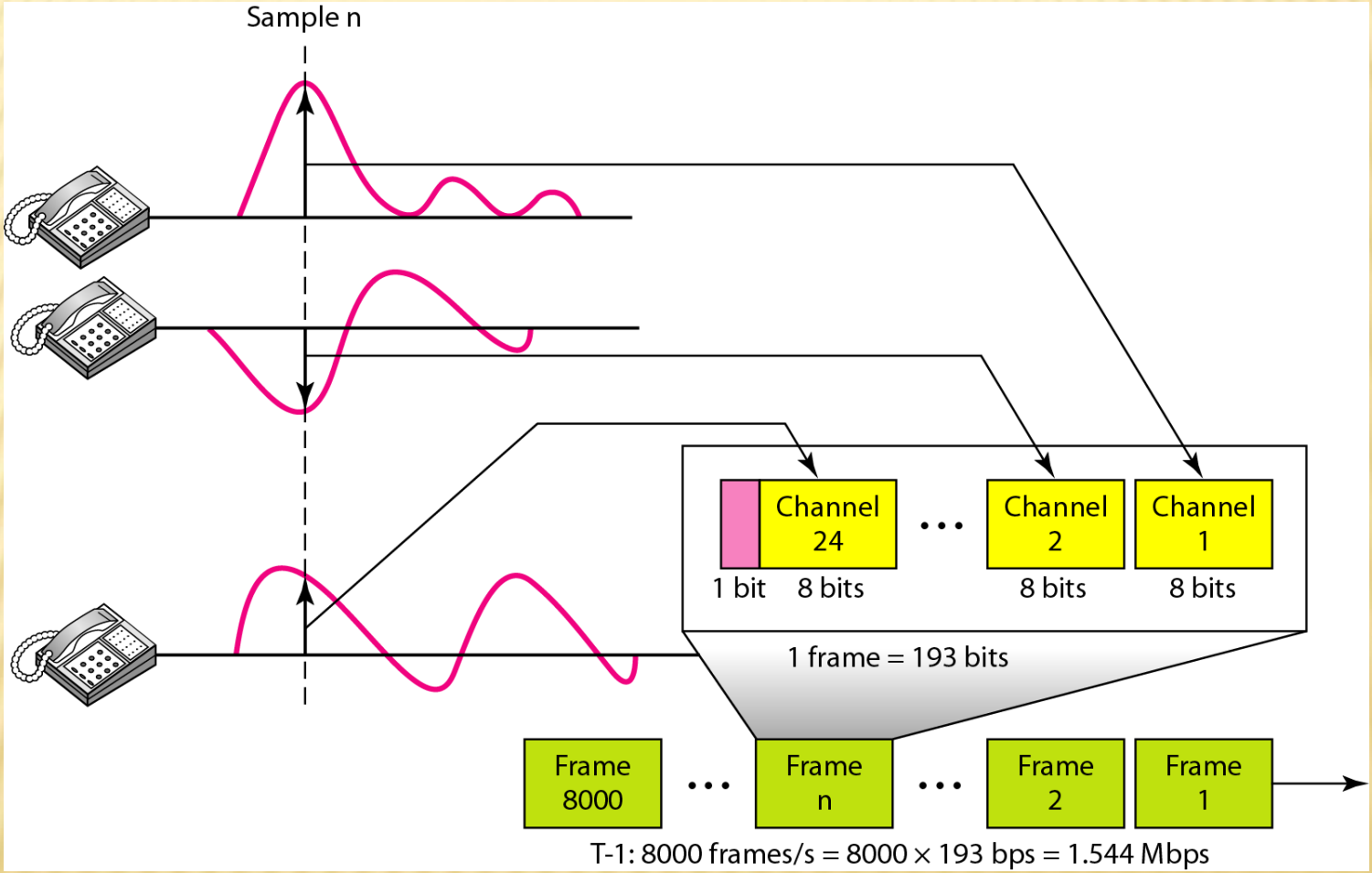
  This is gives data rate = 1.544 Mbps
- Frame synchronization in T1 link uses the extra bit at the start of each frame which alternates between 1 and 0 for consecutive frames.






- A digital carrier system is a communications system that uses digital pulse rather than analog signals to encode information.

# T-1 FRAME STRUCTURE



# T1 DIGITAL CARRIER SYSTEM

- The multiplexer has 24 independent inputs and one time-division multiplexed output. The 24 PCM output signals are sequentially selected and connected through the multiplexer to the transmission line.
- A transmitting portion of a Channel digitally encodes the 24 analog channels, adds signaling information into each channel, and multiplexes the digital stream onto the transmission medium.

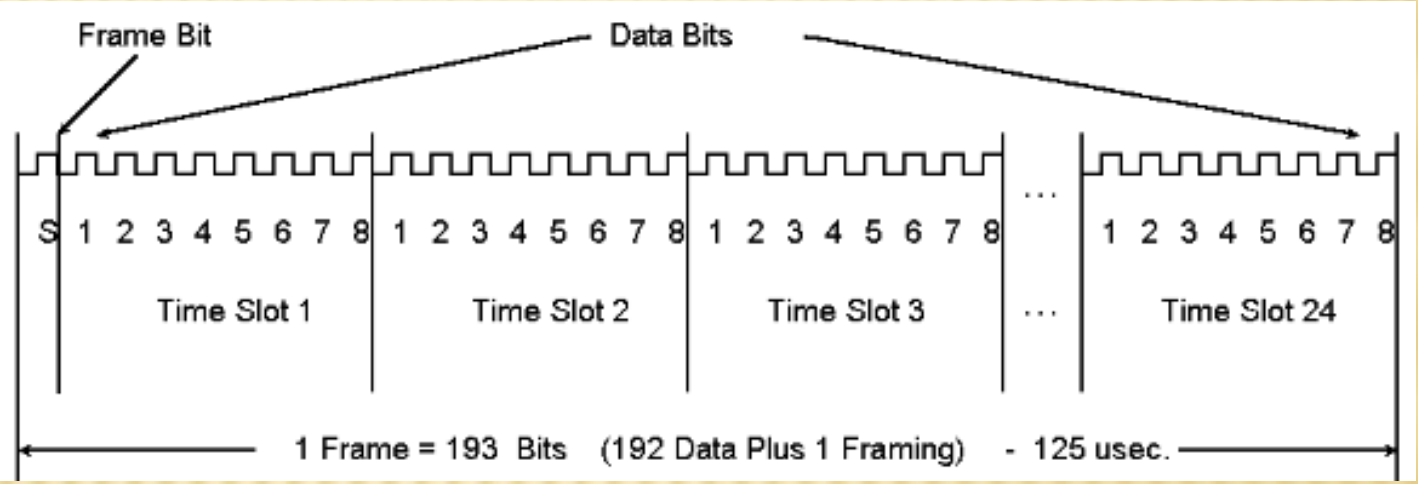
The line speed is calculated as:

$$\frac{24 \text{ channels}}{\text{frame}} \times \frac{8 \text{ bits}}{\text{channel}} = 192 \text{ bits/frame}$$

$$\frac{192 \text{ bits/frame}}{\text{frame}} \times \frac{8000 \text{ frames}}{\text{second}} = 1.536 \text{ Mbps}$$

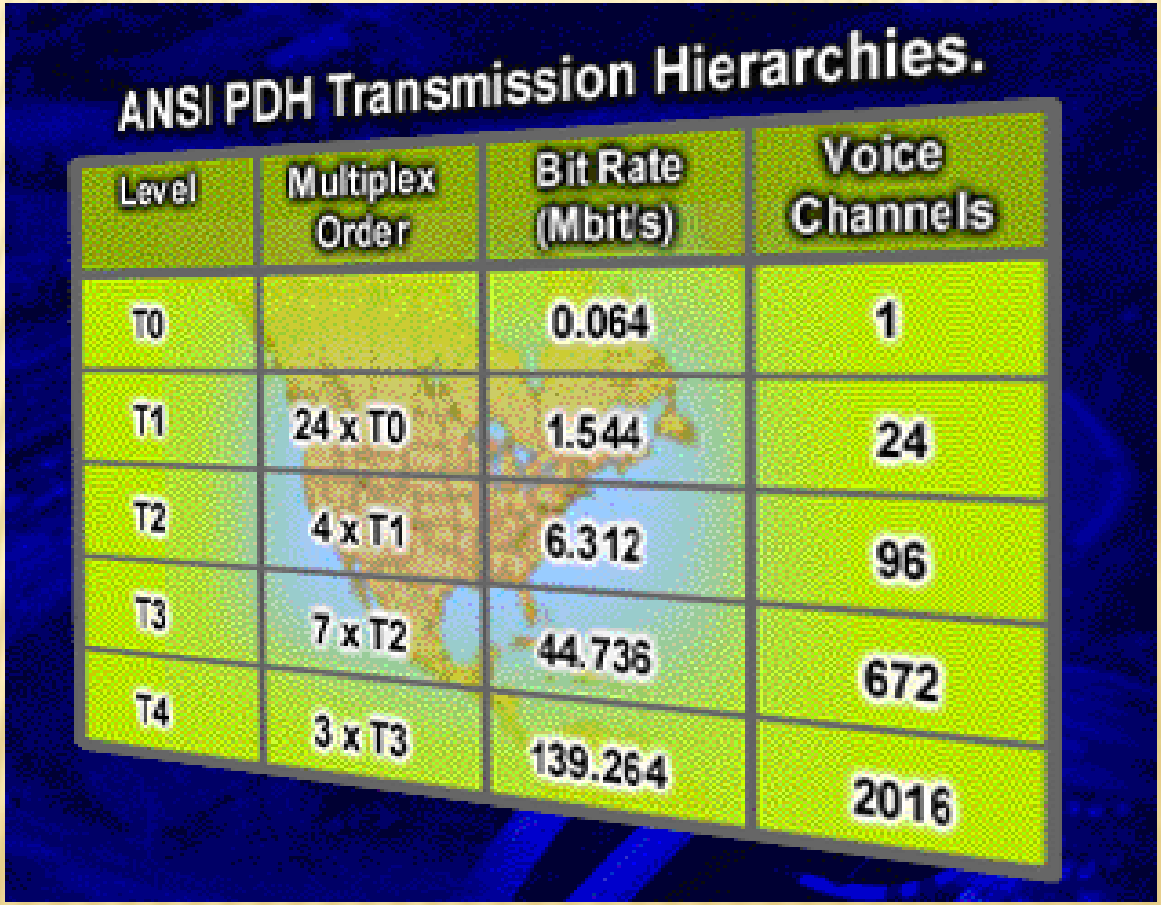
Each of the 24 channels contains an eight-bit PCM code and is sampled 8000 times a second. Each channel is sampled at the same rate, but may not be at the same time.

- Later, an additional bit called the framing bit is added to each frame. The framing bit occurs once per frame and is recovered at the receiver and its main purpose is to maintain frame and sample synchronization between TDM transmitter and receiver.




- As a result of this extra bit, each frame now contains 193 bits and the line speed for a T1 digital carrier system is 1.544 Mbps. { 193 bits × 8000 frames = 1.544 Mbps} .

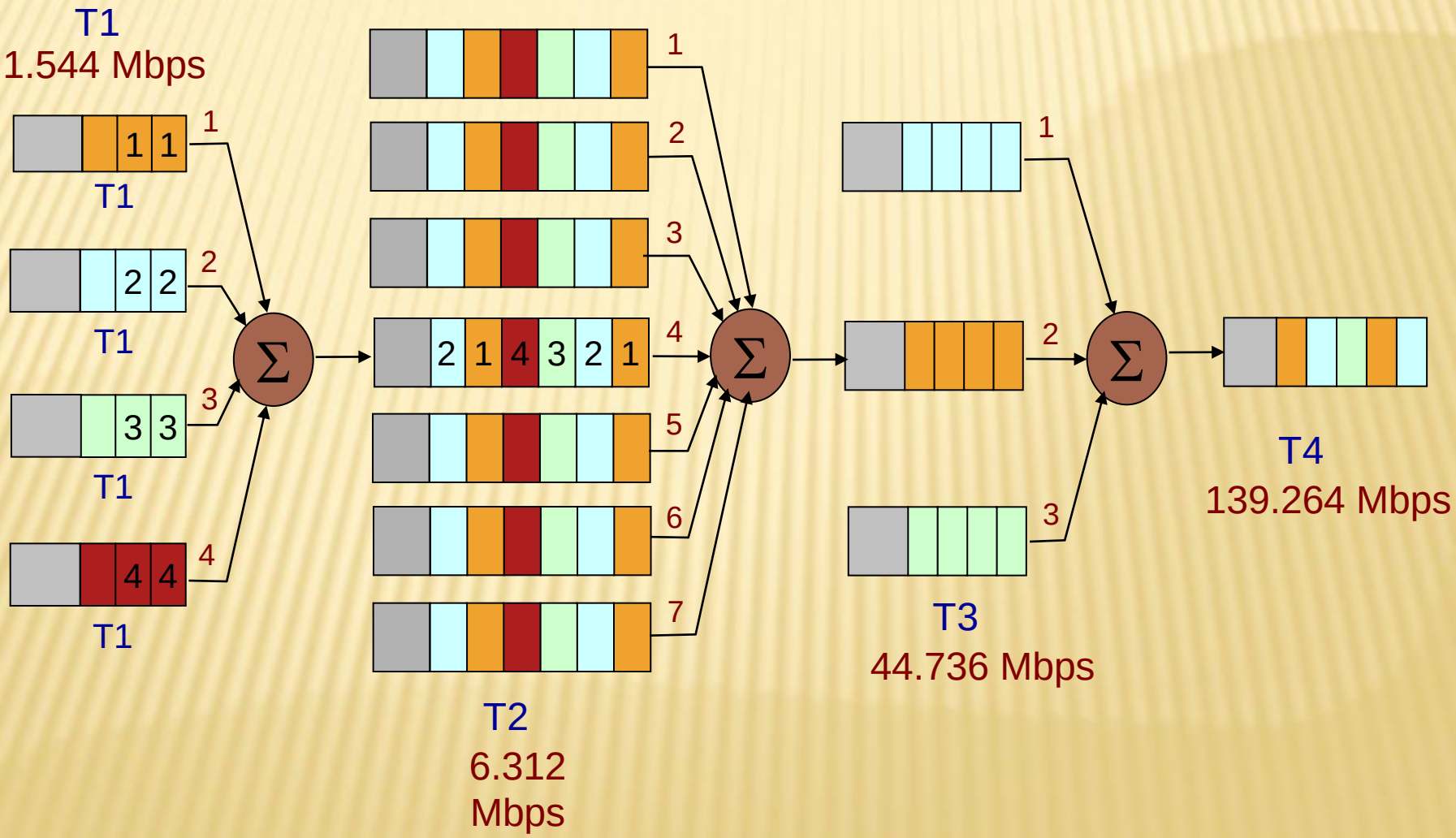
# PDH TRANSMISSION HIERARCHIES



# T1 CARRIER SYSTEMS

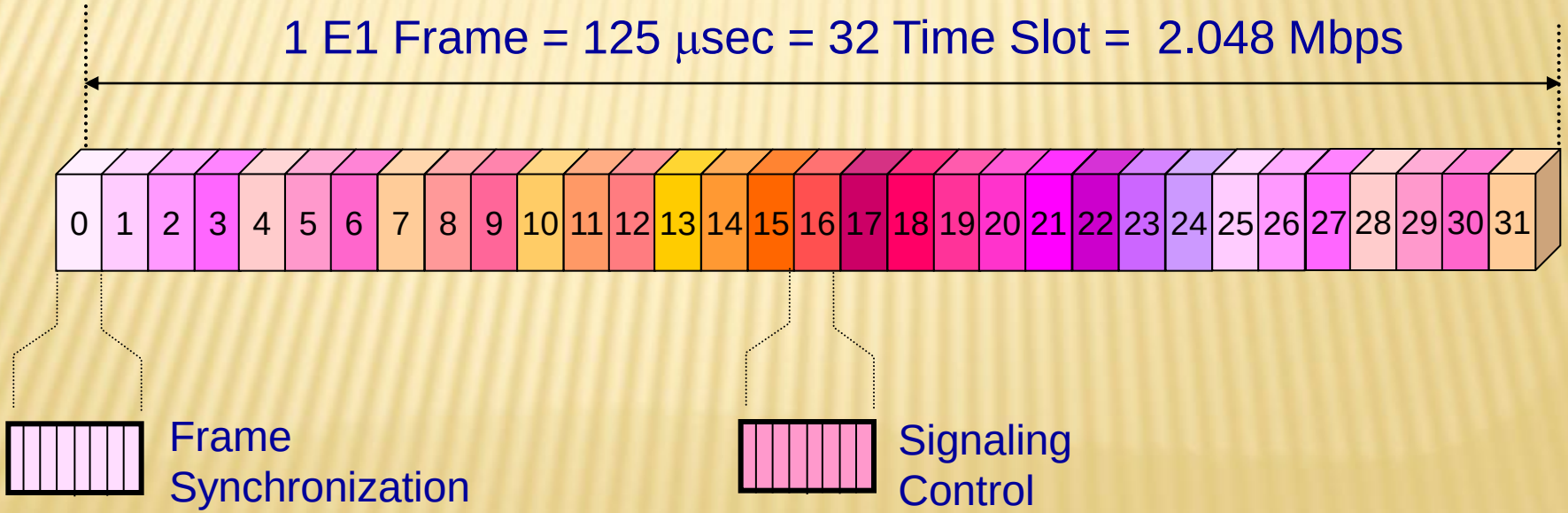
- T1 carrier systems were designed to combine PCM and TDM techniques for the transmission of 24 64-kbps channels with each channel capable of carrying digitally encoded voice band telephone signals or data. The transmission bit rate (line speed) for a T1 carrier is 1.544 Mbps.
- T2 carriers time-division multiplex 96 64-kbps voice or data channels into a single 6.312 Mbps data signal for transmission over twisted-pair copper wire up to 500 miles over a special LOCAP (low capacitance) metallic cable.
- Higher transmission rates make clock synchronization even more critical.
- T3 carriers time-division multiplex 672 64-kbps voice or data channels for transmission over a single 3A-RDS coaxial cable. The transmission bit rate is 44.736 Mbps and coding technique used with T3 carriers is binary three zero substitution (B3ZS).

# ANSI PDH TRANSMISSION HIERARCHIES



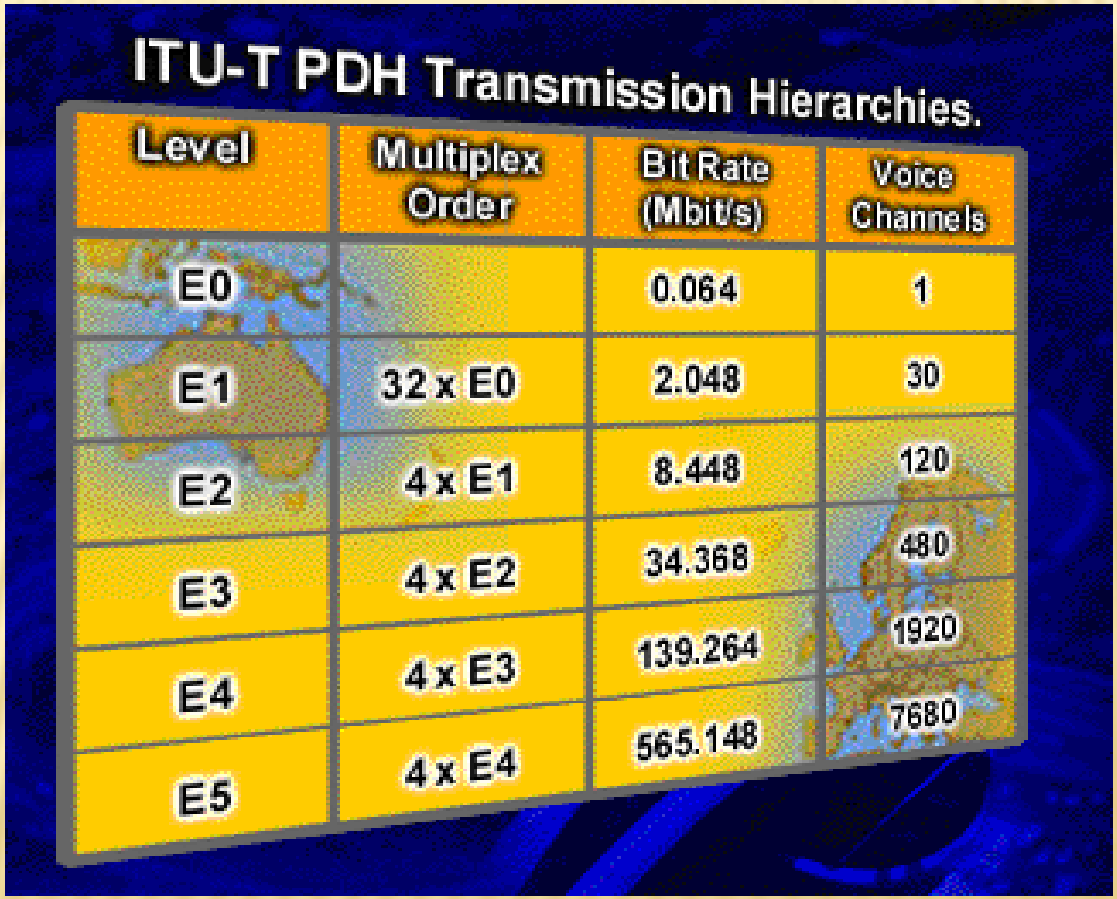
# E1 CARRIER

- ITU-T recommends for a PCM carrier at 2.048 Mbps called **E1 Carrier**.
- This carrier has 32 of 8-bit data samples, yielding 256 bits every 125 μsec.
- This gives the gross data rate of **2.048 Mbps**.
- (30) channels are used for information and (2) channels are used for signaling.
- Outside North America and Japan, the E1 carrier is widely used.




Time Slots 1-15, 17-31

# ITU-T PDH Transmission Hierarchies



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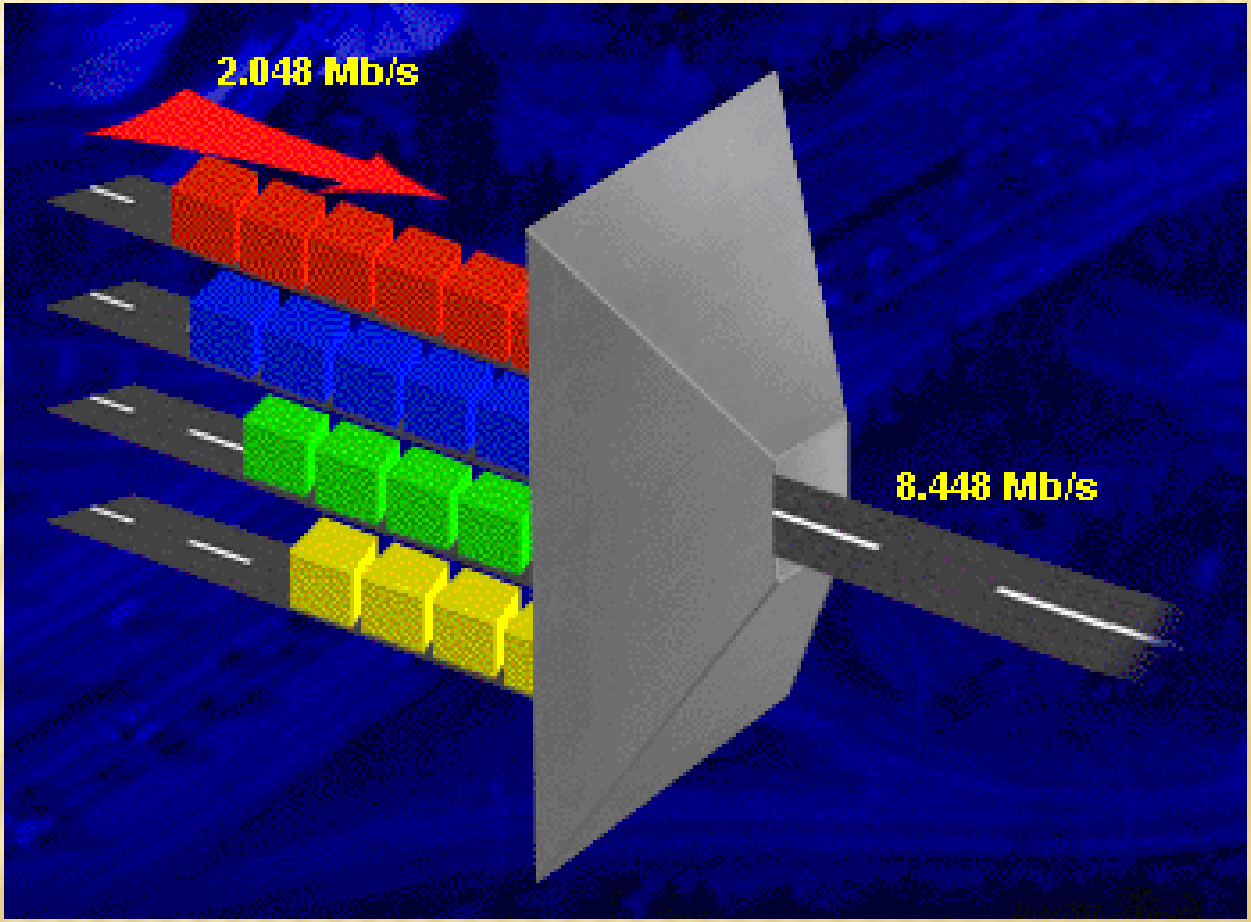

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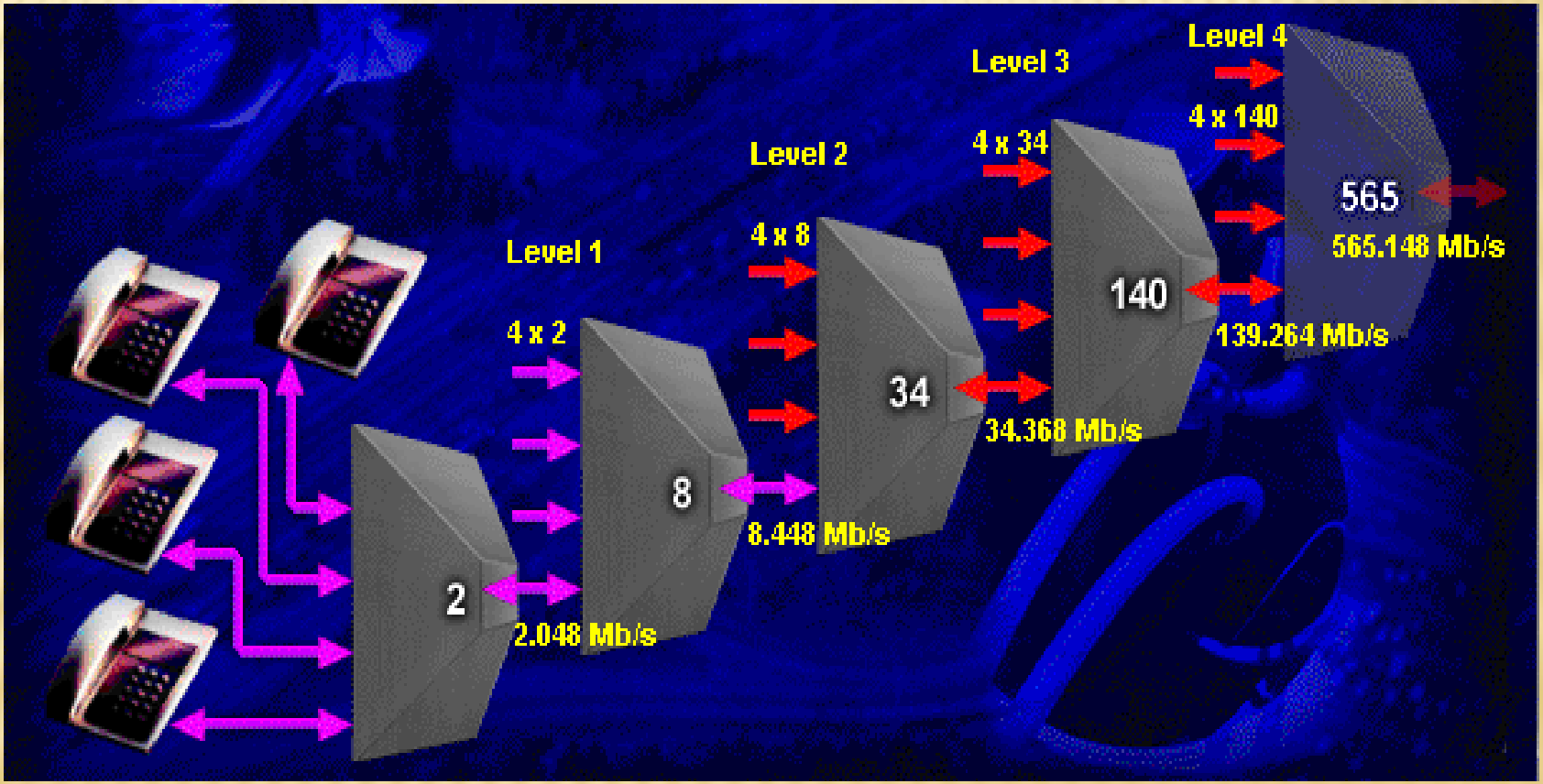
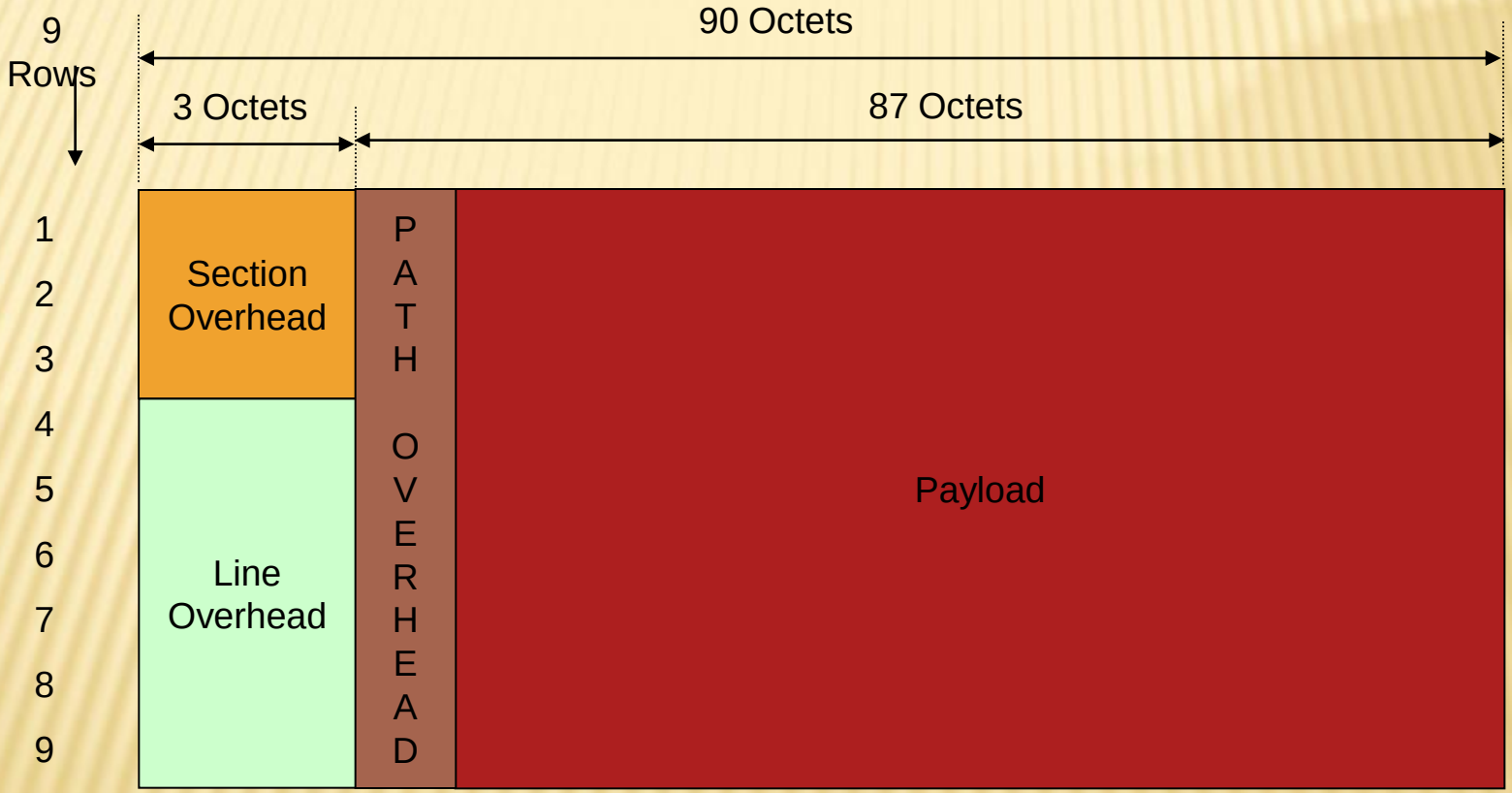


# SYNCHRONOUS OPTICAL NETWORK (SONET)

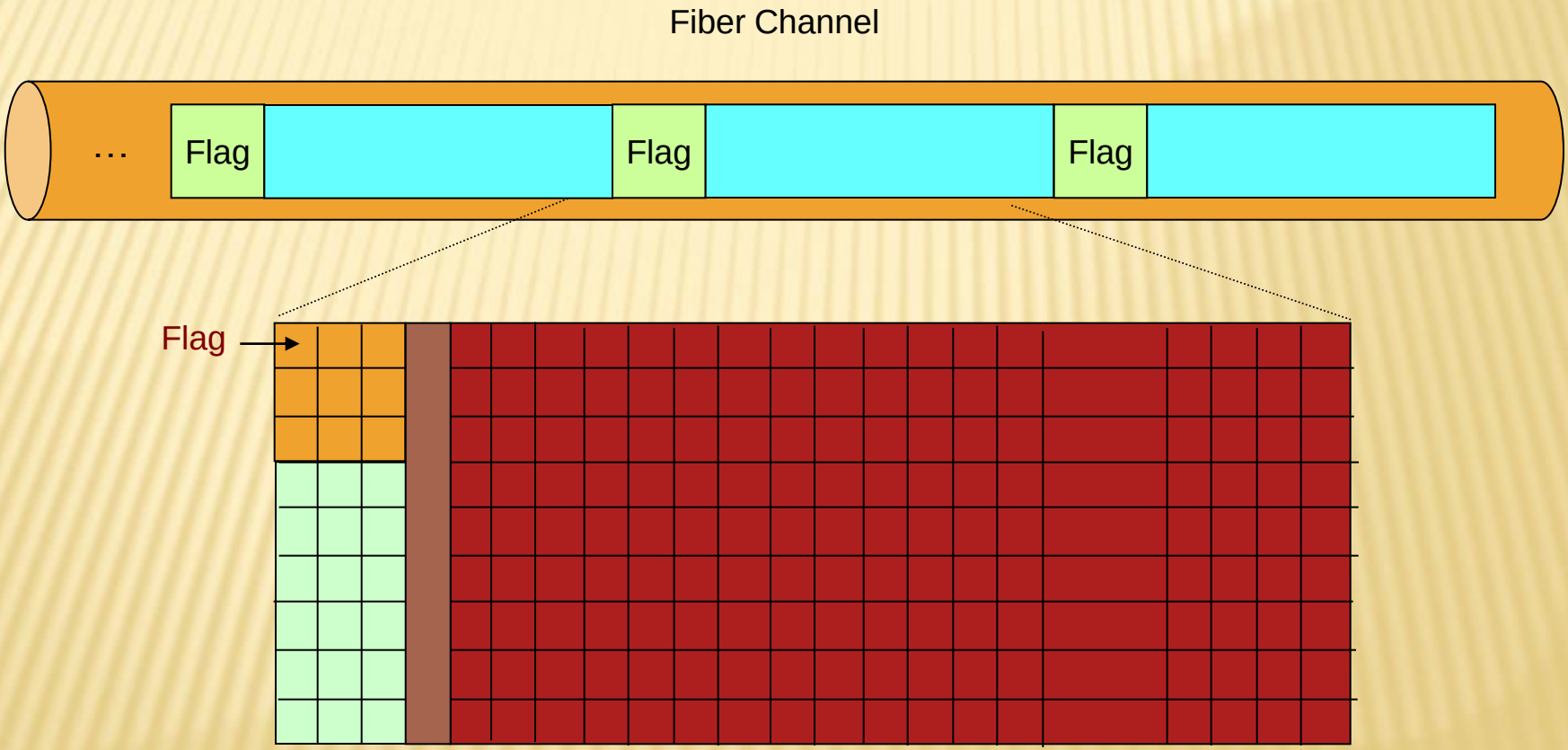
- *Synchronous Optical Network* (SONET) is a digital transport system.
- In SONET, the base *transfer rate* is 51.84 Mbps, a 125 μsec signal, and a frame format of 9 rows by 90 columns (90 columns * 9 rows * 8 bit/byte * 8000 = 51840000 bps.
- The basic rate of SONET, known as **Synchronous Transport 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*.

# SYNCHRONOUS OPTICAL NETWORK (SONET)




STS-1 Envelope

# SYNCHRONOUS OPTICAL NETWORK (SONET)




STS-1 Envelope

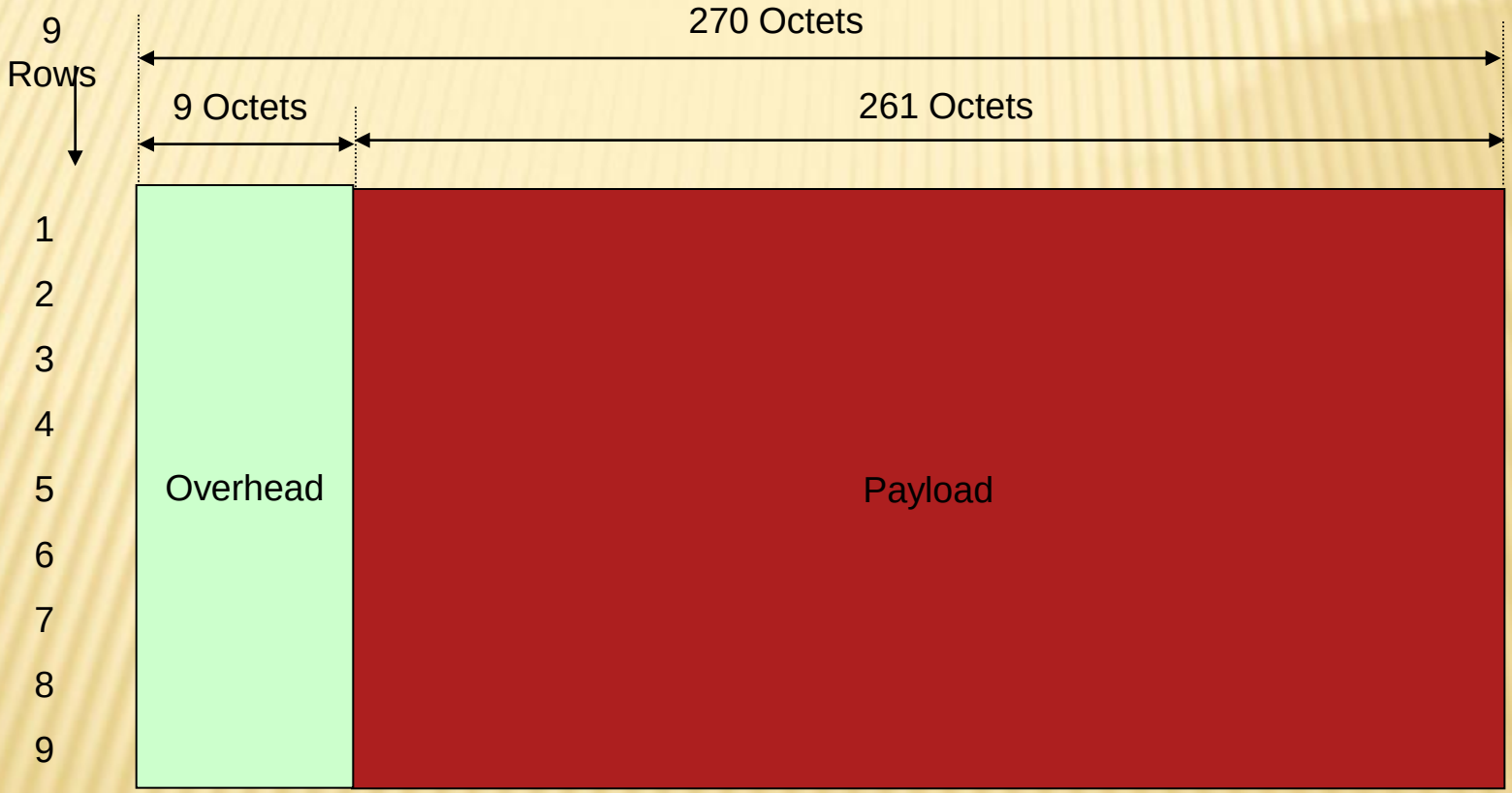
# SYNCHRONOUS DIGITAL HIERARCHY (SDH)

- In SDH, the base *transfer rate* is 155.52 Mbps, a 125 μsec signal, and a frame format of 9 rows by 270 columns (270 columns * 9 rows * 8 bit/byte * 8000 = 155520000 bps.

- The basic rate of SDH, known as **Synchronous Transport Module 1 (STM-1),** is 155.52 Mbps.

- SDH is a European Standard and was developed by ITU-T.

# SYNCHRONOUS DIGITAL HIERARCHY (SDH)




SDH Envelope