Optical Communications
Lecture 7

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SONET

- SONET is an acronym for Synchronous Optical Network.
- SONET is widely used in telephone network and is one of the first large scale optical transmission systems.
- Digital information is sent through optical fibers using a LED or a laser source.
- However, most of data processing, switching etc. are done electronically.
- Time-division multiplexing (TDM) is a method of transmitting and receiving independent signals over a common signal path by means of synchronized switches at each end of the transmission line so that each signal appears on the line only a fraction of time in an alternating pattern.

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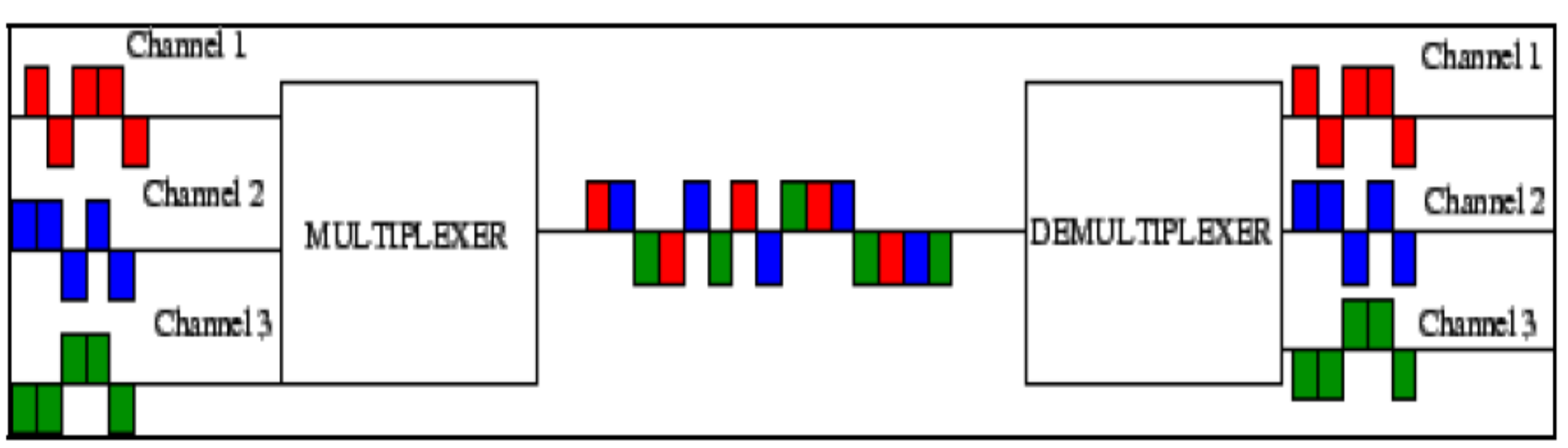
- SONET arose out of a need to find a solution of the problem of inter-operability among various vendors and technologies that existed in sixties and seventies.
- Multiplexing: In telecommunication, the phrase multiplexing is used to denote the process of combining two or more channels into a single channel.
- For instance, in encoding a video stream, we need to multiplex audio and video on single channel.
- One of the ways of doing it is known as time division multiplexing.

Time Division Multiplexing

- Example:
- Suppose we have three individual users in Mumbai who wish to send low stream data to three users in Delhi .
- Assigning physical lines for each will be expensive and such expense would grow exponentially with increasing number of users.
- If instead, we used a higher bit rate channel, we could use different time slots for the different data set.
- The figure below illustrates how this is achieved.

Time Division Multiplexing



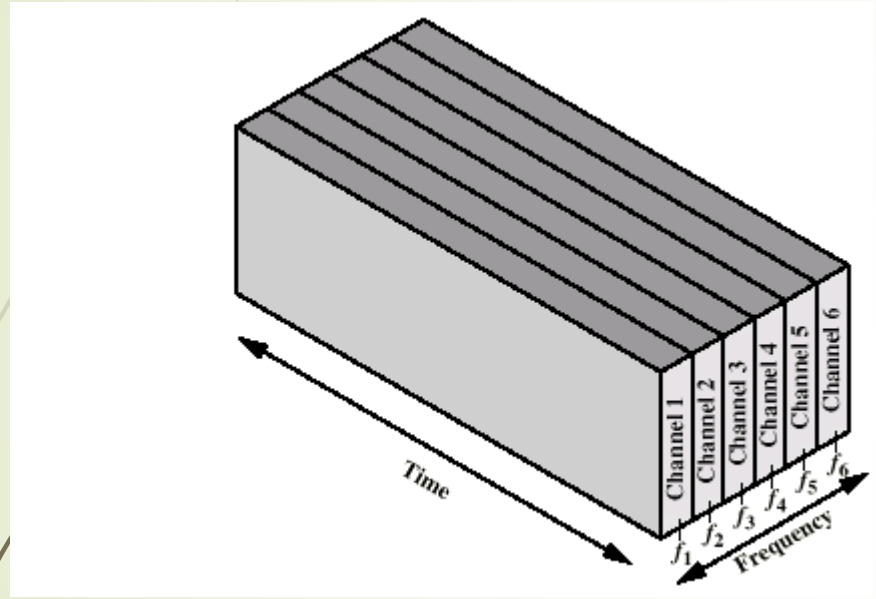
Time Division Multiplexing

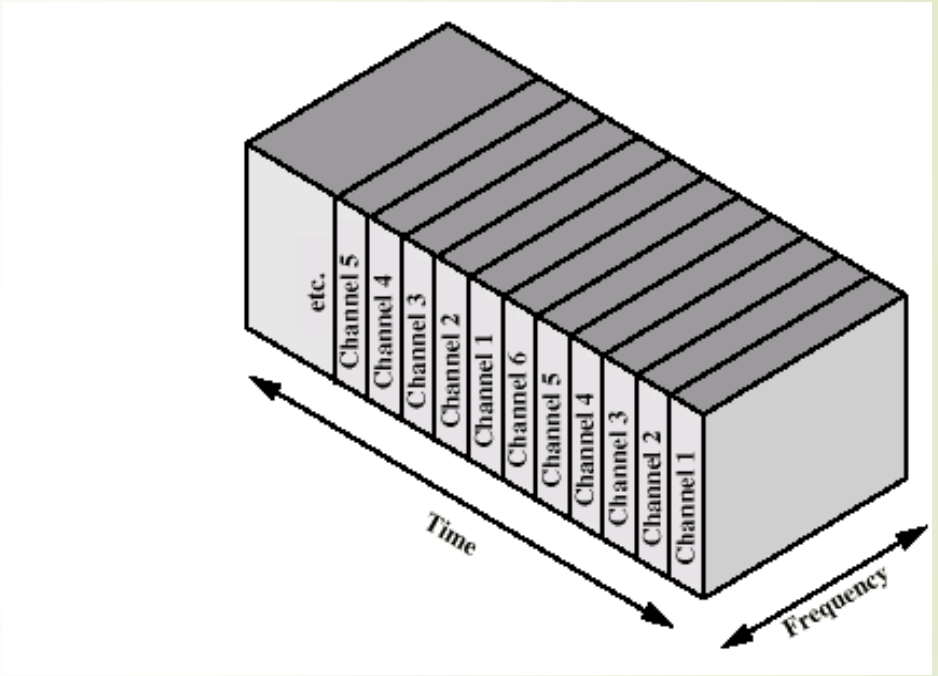
- In sixties, the International Telecommunication Union (ITU) defined what is now known as a T-1 carrier.
- The analog voice data was digitized by sampling at a rate which is twice that of the maximum frequency component in the signal. This is known as **Pulse Code Modulation(PCM).**
- The T-1 standard was an universal agreement on a sampling rate of 8 kHz and a channel rate of 64 kilo-bit per second. The single voice channel is known as DS-0 signal (DS= Digital Signal).

Time Division Multiplexing

- Thus, if we return back to the example of three users, with each transmitting at a rate of 64 kbps.
- we could transmit them as a sequential stream of data over a single channel capable of transmitting at 192 Kbit/sec.

Time Division Multiplexing





- With FDM, each channel continuously gets a fraction of the bandwidth.
- With TDM, each channel gets all of the bandwidth periodically during brief intervals of time.

Synchronous Time Division Multiplexing

- Data rate of medium exceeds data rate of digital signals to be transmitted.
- Multiple digital signals interleaved in time.
- Interleaving can be at: bit level; blocks of bytes level; or larger quantities level.
- Time slots pre-assigned to sources and fixed.
- Time slots allocated even if no data.
- Time slots do not have to be evenly distributed amongst sources -> TDM can handle source with different data rate.

Principle of SONET/SDH

- In a synchronous device the clock transitions occur precisely at the same rate.
- All signal transitions are fixed with reference to a very accurate atomic clock called **Primary Reference Clock (PRC).**
- The advantage of a synchronous system is that multiple signals can be stacked without any need for bit stuffing.
- In SDH, data from different sources are multiplexed in a way that the channels have fixed locations with respect to the framing byte.
- As the location is fixed, it is not necessary to de-multiplex while dropping a single channel from the stream.

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- The basic signal of SONET is synchronous transport signal, called **STS-1** which operates at 51.84 Mbit/sec.
- After conversion to optical signals, STS-1 is known as optical carrier, or OC-1.
- The higher level signals are multiples of STS-1 signal and operate at multiples of base frequency.
- Thus STS-3 (or its optical equivalent OC-3) operates at a bit rate of 155.52 Mbps interleaving frames from three STS-1 signals.

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The hierarchy for SONET/SDH is shown in the following table.

SONET	SDH	Optical	(Mbps)
STS-1	-	OC-1	51.84
STS-3	STM-1	OC-3	155.52
STS-12	STM-4	OC-12	622.08
STS-48	STM-16	OC-48	2488.32
STS-192	STM-64	OC-192	9953.28
STS-768	STM-256	OC-768	~40 Gbps

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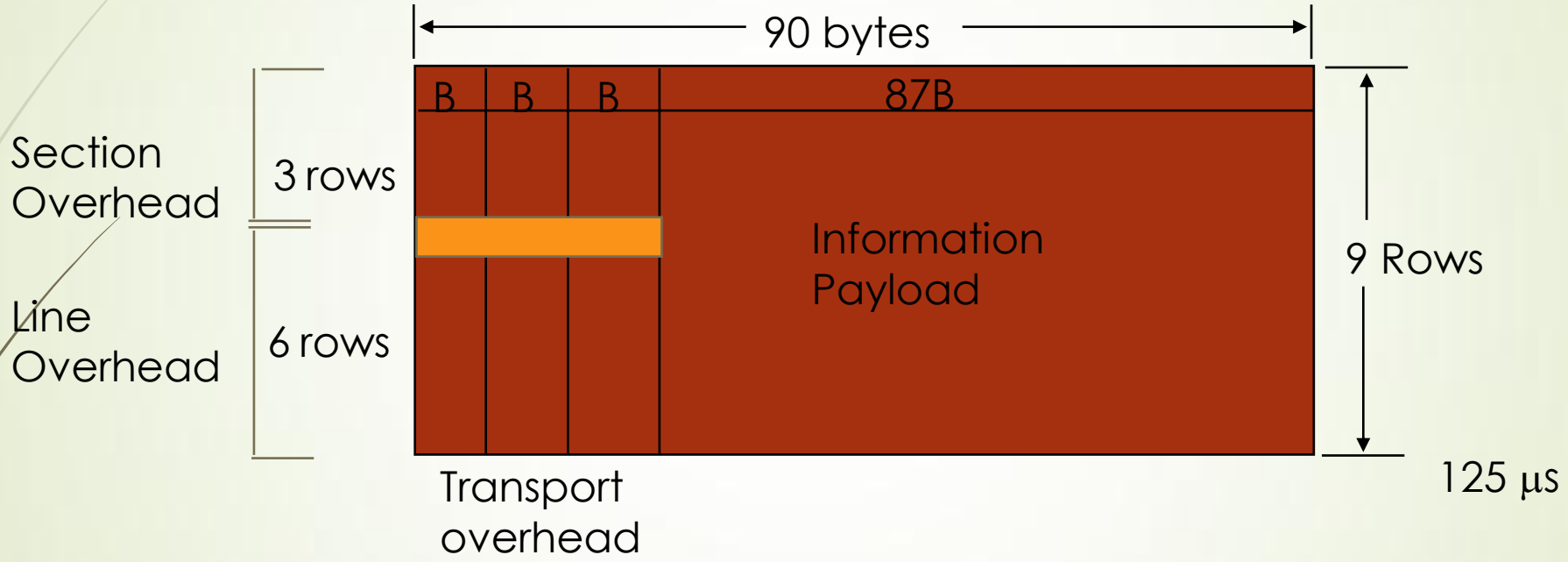
- Each rate is an exact multiple of the lower rate ensuring that the hierarchy is synchronous.
- The network hierarchy is organized in a master-slave relationship with the lower level nodes receiving time signal from the higher level nodes.
- All clock level can be traced back to the primary reference clock (PRC), which is very stable.

FRAMES IN SONET

- As the bit rate of information is moving at very fast rate, a convention has to be applied so that distinct digital channels that have been multiplexed together can be distinguished.
- SONET uses the concept of **framing** to achieve this.
- A framing bit can be thought of as a pointer or an address. As the line is moving fast, it would be easy to skew it a little to left or to right and the information would then get out of sequence.
- The extra bit of information creates a locator for the system.

SONET STS-1 Frame Format



SONET STS-1 Frame Format

- Section overhead is used to provide framing, error monitoring, and other section-related management functions.
- Line overhead is used to provide synchronization and multiplexing for the path layer, as well as protection-switching capacity.
- The first two bytes of the line overhead are used as a pointer that indicates the byte within the information payload where the SPE begins.

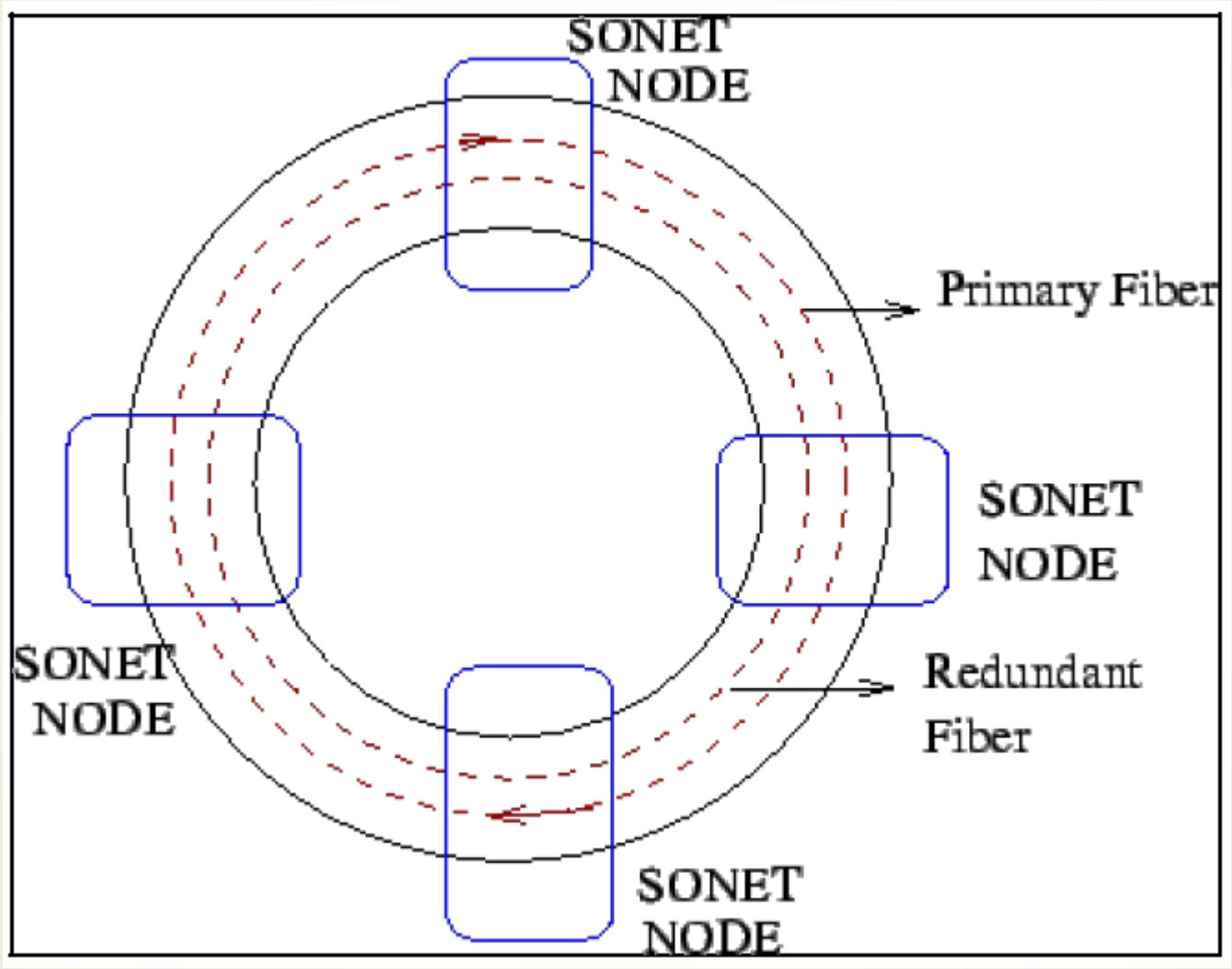
SONET STS-1 Frame Format

- 9 rows by 90 columns – 810 octets in the frame.
- Frame is transmitted from left to right, by row.
- Frames are transmitted 8,000 times per second, every 125 μseconds.
- STS-1 bit rate is therefore 51.84 Mbps (810 octets x 8,000 times per second x 8 bits per octet).
- This lowest level SONET signal is called a Synchronous
- Transport Signal, level 1 (STS-1).

SONET Topology

- SONET and SDH standards specify that the network topology be in the form of a ring.
- The ring contains fiber redundancies which allow traffic both unidirectional and bidirectional.
- In case of an accidental snapping of a fiber, the multiplexers can reroute the traffic along an alternate path using redundant fibers.

SONET Topology



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