

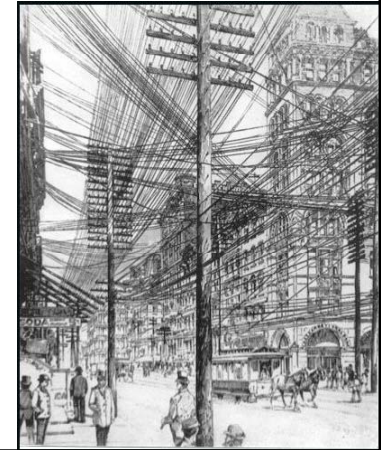
Multiplexing

COMP476
Networked Computer Systems

Many Wires

It would take millions of wires if each phone and computer required their own.

Multiplexing allows multiple channels on a single media.



The Concept of Multiplexing

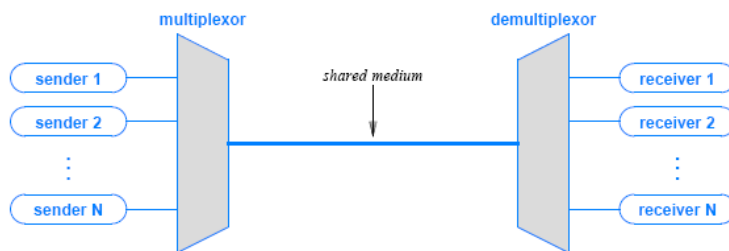


Figure 11.1 The concept of multiplexing in which independent pairs of senders and receivers share a transmission medium.

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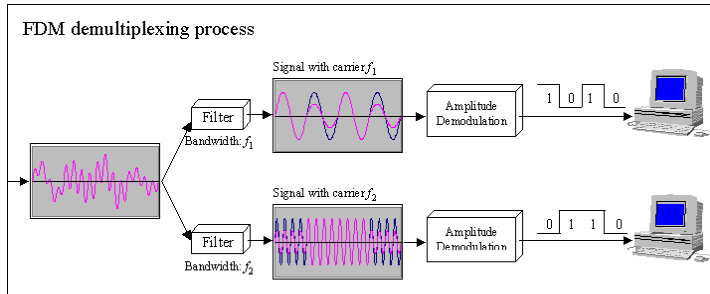
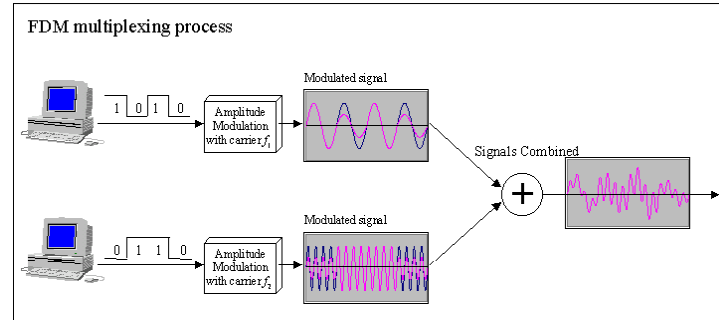
Multiplexing

The set of techniques that allows the simultaneous transmission of multiple signals across a single data link.

1. Frequency-Division Multiplexing (FDM)
2. Wavelength-Division Multiplexing (WDM)
3. Time-Division Multiplexing (TDM)
4. Code-Division Multiplexing (CDM)

Frequency-Division Multiplexing (FDM)

- Each logical channel is transmitted on a separate frequency.
- Television and radio uses FDM to broadcast many channels over the same media.
- Filters separate the multiplexed signal back into its constituent component signals



Frequency Allocation

- Different channels of information are sent on different frequencies.
- Channels may be separated to avoid cross talk

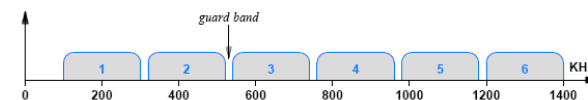


Figure 11.5 A frequency domain plot of the channel allocation from Figure 11.4 with a guard band visible between channels.

Wavelength Division Multiplexing

- Theoretically identical to Frequency Division Multiplexing.
- Used in optical systems while FDM is used in electrical systems.
- Requires more spacing between channels.

Optical WDM

- Wavelength Division Multiplexing is like sending different signals in different colors.

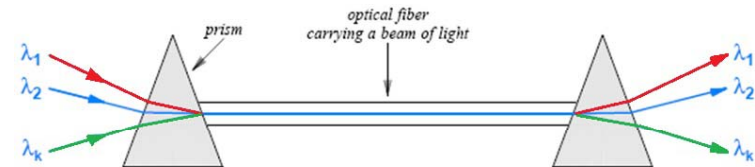


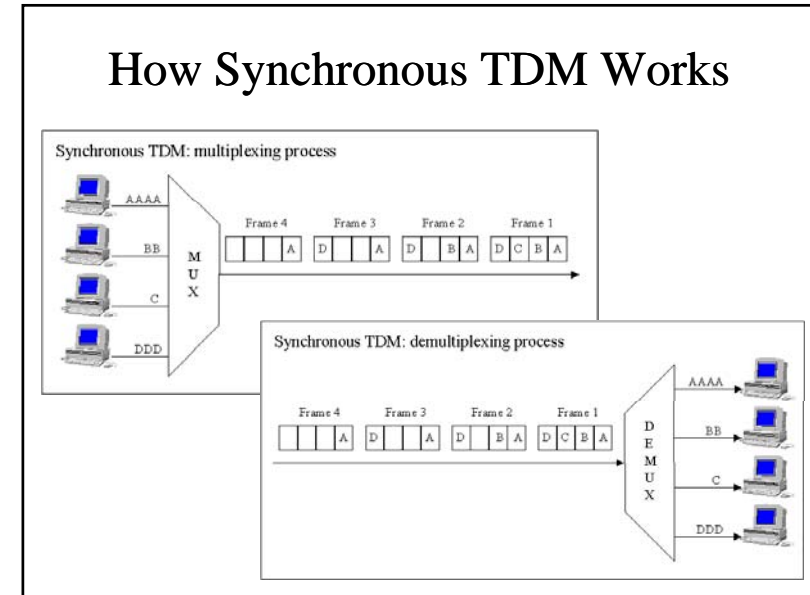
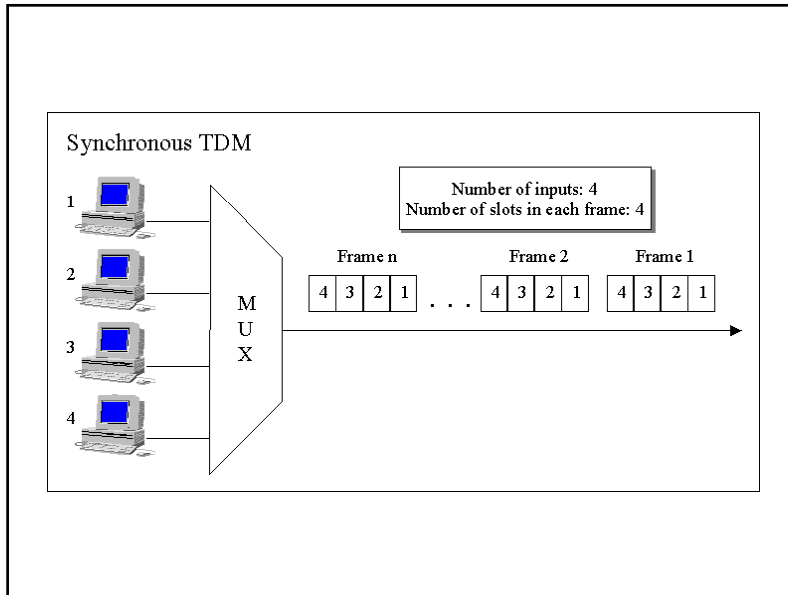
Figure 11.7 Illustration of prisms used to combine and separate wavelengths of light in wavelength division multiplexing technologies.

Time-Division Multiplexing (TDM)

- Multiple transmissions can occupy a single link by subdividing them and interleaving the portions
- We refer to TDM as a “round robin” use of a channel
- TDM can be implemented in two ways:
 1. Synchronous TDM
 2. Asynchronous TDM

Synchronous TDM

- The multiplexer allocates exactly the same time slot to each device at all times, whether or not a device has anything to transmit
- A frame consists of one complete cycle of time slots. Thus the number of slots in frame is equal to the number of inputs.

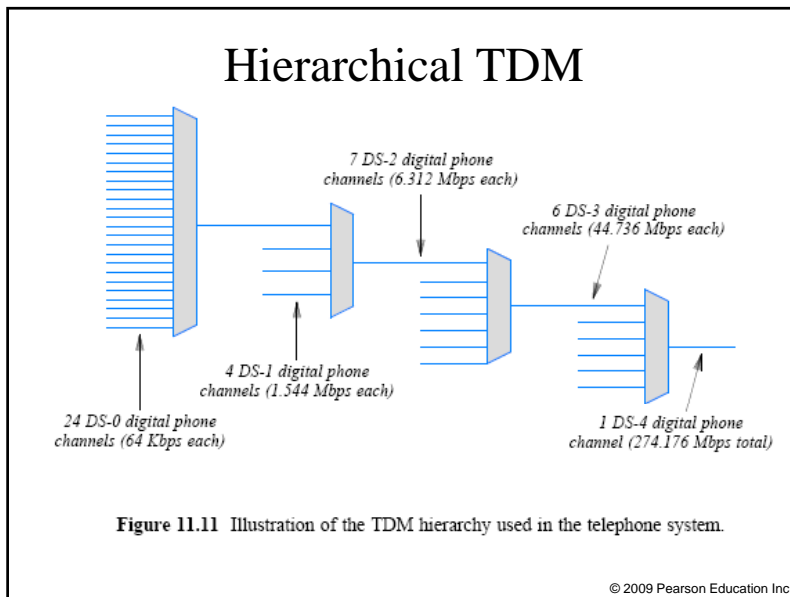
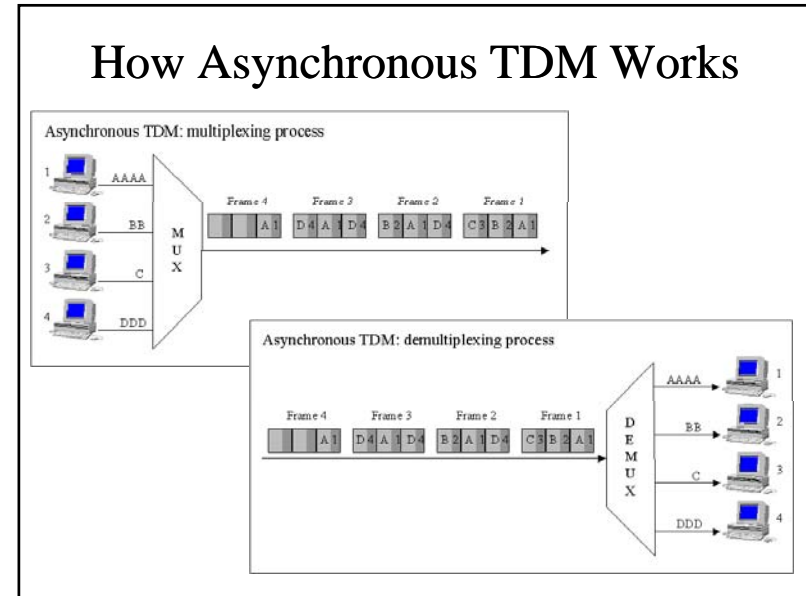
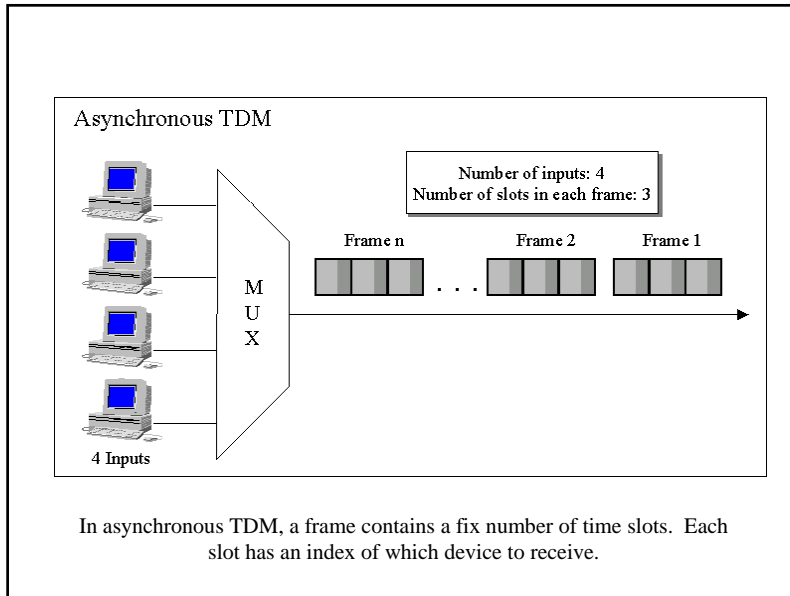


Asynchronous TDM (or statistical time-division multiplexing)

- Each slot in a frame is **not** dedicated to the fix device
- The number of slots in a frame is not necessary to be equal to the number of input devices. More than one slot in a frame can be allocated for an input device.
- Allows maximum utilization of the link. It allows a number of lower speed input lines to be multiplexed to a single higher speed line

Headers

- With synchronous TDM, the receiver knows which slot belongs to which device by virtue of its position in the frame
- With asynchronous TDM, a header must be added to each slot to identify which device is to receive the information
- The header uses some of the transmission time



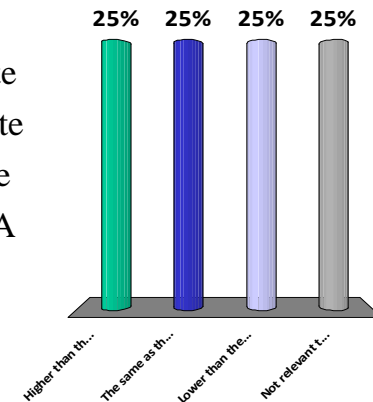
- ## Code Division Multiplexing
- Sends many signals or “chips” per bit.
 - Each sender uses a unique pattern of chips.
 - May use multiple frequencies for spread spectrum communication.
 - Common with wireless systems, particularly cell phones

Pros and Cons of CDMA

- CDMA does not require any coordination between the senders
- Spread spectrum communication is hard to jam and resistant to noise
- Spread spectrum uses more bandwidth
- Sending multiple chips per bit slows the bit rate.

Is the Baud rate of CDMA

1. Higher than the bit rate
2. The same as the bit rate
3. Lower than the bit rate
4. Not relevant to CDMA



Historical Fact

Actress Hedy Lamarr and composer George Antheil received a patent in 1942 for a spread spectrum communication system

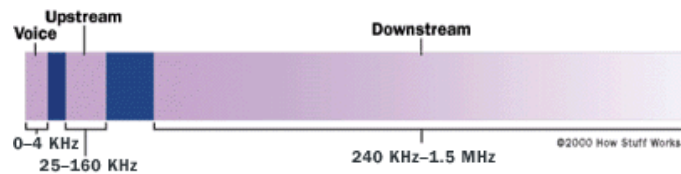


ADSL

- Asymmetric Digital Subscriber Line (ADSL or just DSL) provides a means of transmitting high speed data to homes.
- The system is asymmetric because the transmission rate is different for upload and download.
- Not every phone line can support ADSL. You must be within 18,000 feet of the central office with good wires.

ADSL Multiplexing

- The phone line is frequency division multiplexed to provide a channel for analog POTS, digital up link and down link.
- The central office modulates the data signals to the proper frequencies.



ADSL Installation and Splitters

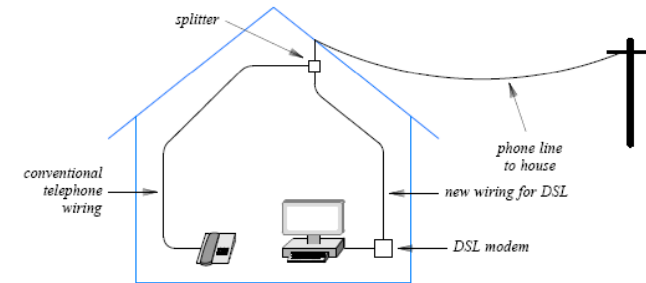


Figure 12.6 Illustration of a splitter and the wiring used with ADSL.

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Cable Modems

- Television cable systems are designed for high frequencies and bandwidth
- A traditional television channel is 6 MHz
- Cable modems modulate the digital signal to a specified frequency
- Statistical multiplexing is used to separate multiple users

Speed Comparison

- ADSL provides up to 8.5 Mbps downstream and 576 Kbps upstream
- ADSL adapts to the quality of the line based on its signal to noise ratio
- Cable can support up to 52 Mbps downstream and 512 Kbps upstream
- Statistical multiplexing splits the data rate among multiple customers