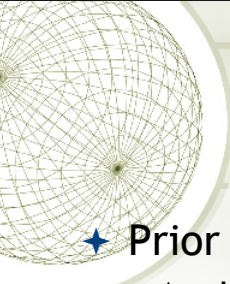




# *Transmission Techniques*

Info 341 Networking and Distributed Applications

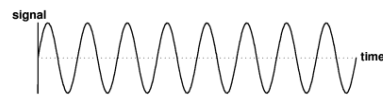


# *Basic Data Transmission Characteristics*

- ★ Prior chapters/lectures mentioned
  - ◆ Analog signaling
    - ◆ Use analog wave forms to transmit data
  - ◆ Digital signaling
    - ◆ Use of discrete square waves for transmission
- ★ How are these used?

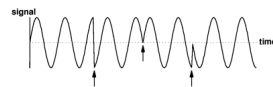
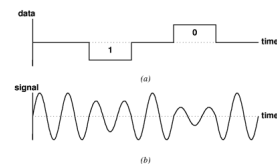
## Carrier Transmission

- ★ Long distance transmission uses a carrier
  - ✦ Carrier - oscillates at a known rate and amplitude
  - ✦ Data is encoded into the carrier wave through modulation of the carrier wave



## Basic Carrier Encoding

- ★ Three common approaches
  - ✦ Frequency Modulation (FM)
  - ✦ Amplitude Modulation (AM)
  - ✦ Phase Shift



## Frequency Modulation

- ★ Frequency of the carrier wave is modulated

Carrier

Modulating Wave

Modulated Result

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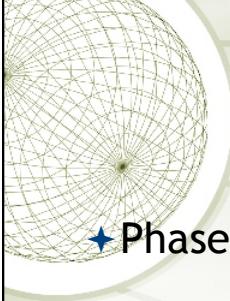
## Amplitude Modulation

- ★ Carrier amplitude is modulated

CARRIER SIGNAL

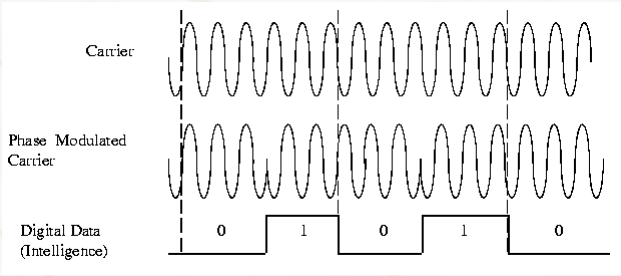
MODULATING SIGNAL

MODULATED SIGNAL



## Phase Shift Modulation

- ★ Phase shift determines values

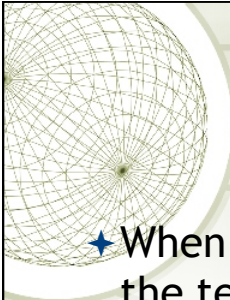


Carrier

Phase Modulated Carrier

Digital Data (Intelligence)

0 1 0 1 0

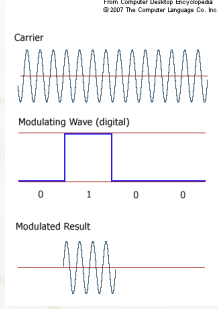


## Shift Keying

- ★ When the modulation is digital then the term Shift Keying is used instead of modulation
  - ★ Amplitude Shift Keying (ASK)
  - ★ Frequency Shift Keying (FSK)
  - ★ Phase Shift Keying (PSK)

## Amplitude Shift Keying

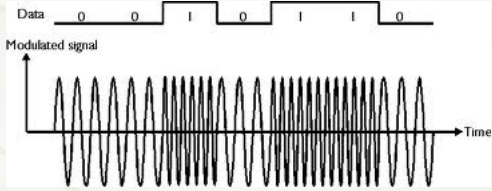
- ★ Digital data directly modifies carrier



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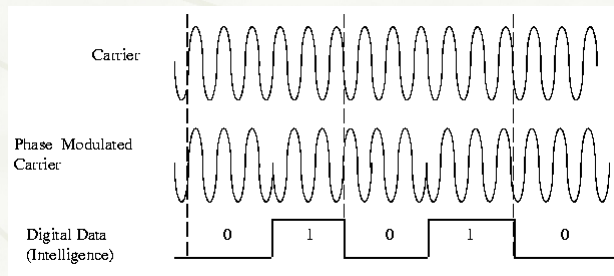
## Frequency Shift Keying

- ★ Digital data modifies carrier frequency



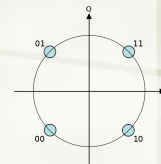
## Phase Shift Keying

- ★ You might remember this from earlier
- ★ Technically it was a 2-PSK encoding

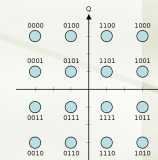


## Multiple Encoding

- ★ More phase shifts, more encoding
- ★ 4 PSK
- ★ Expressed on a constellation diagram





- ★ Quadrature Amplitude Modulation (QAM)
- ★ 16-QAM uses both phase shifting and amplitude modulation



## Modems

- ★ Traditionally over phone lines
  - ✦ Use a limited range of frequencies
  - ✦ Baud rates kept increasing
  - ✦ V.32 9600 bps 32QAM
  - ✦ V.32bis 14,400 bps 128QAM



## Multiplexing

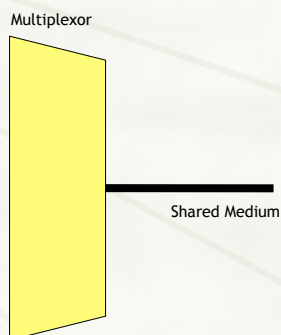
- ★ Four important types
  - ✦ Frequency Division Multiplexing (FDM)
    - ✦ Wavelength Division Multiplexing
  - ✦ Time Division Multiplexing (TDM)
  - ✦ Code Division Multiplexing (CDM)

## *Frequency Division*

- ★ Each frequency is a carrier frequency (or frequency range - a band)
  - ✦ Often allocate some space between bands
- ★ Use one (or more) bands per sender/receiver
  - ✦ What is the advantage of using more than one?

## *Multiplexor*

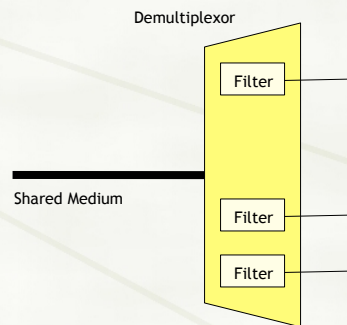
- ★ Multiplexor combines incoming frequencies





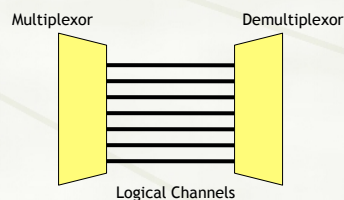
## Demultiplexor

- ★ Demultiplexor must separate the individual carrier frequencies (filters)



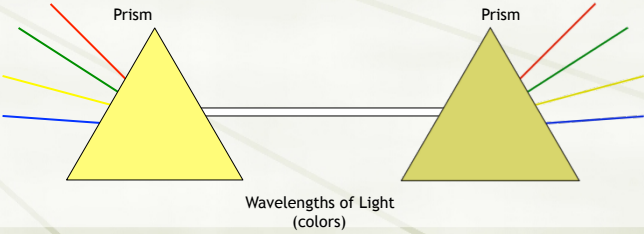
## Frequency Division

- ★ Logically each carrier is a separate channel - but all are on one shared medium



## *Wavelength Division*


- ★ Change medium to light (fiber optics)
- ★ Change Mux/Demux to prisms



Wavelengths of Light  
(colors)

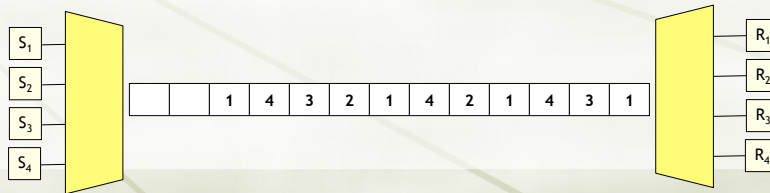
## *Time Division Multiplexing*

- ★ Add a clock, with regular ticks
- ★ Allocate a specific time slot to each channel
- ★ Strict round-robin allocation



## Time Division Multiplexing

- ★ Bandwidth gets wasted when a sender has nothing to send
- ★ Solution is Statistical TDM
  - ✦ In round-robin if sender has no data, pick next sender



## Code Division Multiplexing

- ★ Math (vector space) solution
- ★ Each sender has a unique ID
  - ✦ ID is a vector, each and every vector/ID pair is orthogonal (dot product is zero)
- ★ Senders can send data on the same channel and data can be recovered
- ★ Extremely low latency for sending
- ★ Large IDs computationally expensive

