

## Lecture #2: Wireless Network Configurations

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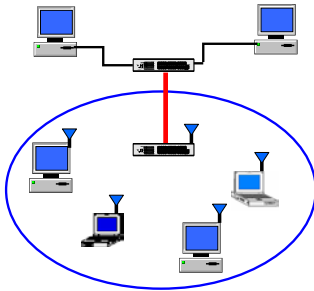
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## Outline

- Wireless LANs (WLAN)
  - Radio Waves
  - Infrared Light
  - Carrier currents (“no new wire”)
- Wireless Point-to-Point Networks
- Wireless WANs

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## Wireless LANs



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## Radio Based Wireless LANs

- Advantages
  - No line of sights
  - Propagate through obstacles
- Disadvantages
  - Interference
  - Security

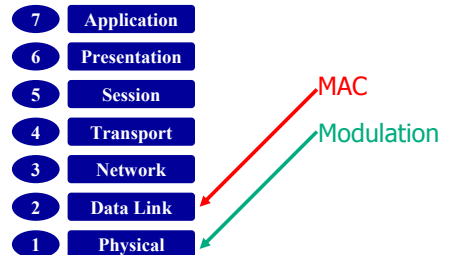
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## WLAN Operation

- Medium Access Control (MAC)
- Modulation Techniques
- Wireless LAN Topologies

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## OSI Model & Wireless LAN



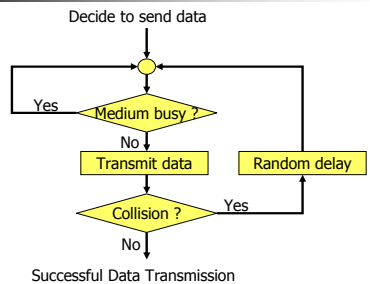
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## MAC

- Shared medium with certain agreements
  - “Protocol”
  - Share frequency and time
- Data Link Layer
- CSMA/CD
  - Ethernet

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## CSMA/CD

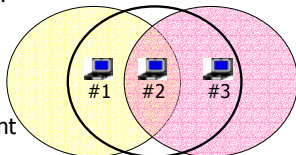


Does CSMA/CD work for Wireless LAN?

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## CSMA/CA

- Hidden terminal problem
- IEEE 802.11
  - RTS / CTS
- Error Handling
  - Acknowledgement
  - Retransmission



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## WLAN Operation

- Medium Access Control (MAC)
- Modulation Techniques
- Wireless LAN Topologies

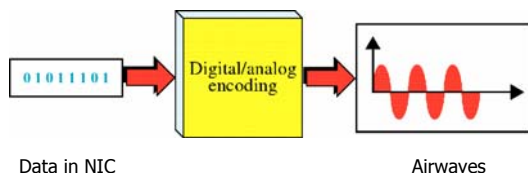
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## Modulation Techniques

- Physical Layer
- Basic transformations
- Spread Spectrum Modulation
- ISM bands

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## Digital to Analog Encoding



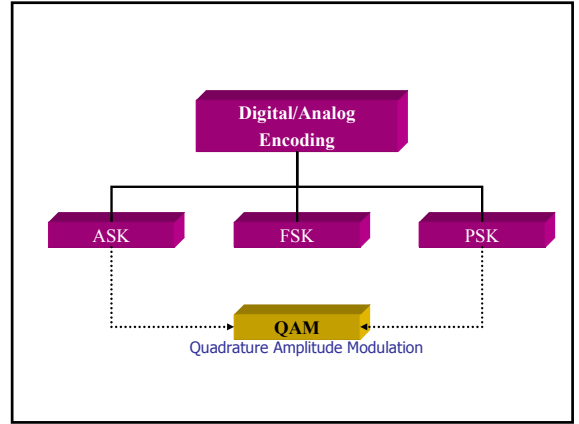
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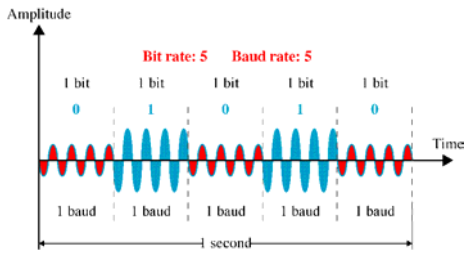
## Basic concepts

- **Carrier signal (carrier frequency)**
  - High frequency as a basis for information
  - Sender and receiver agree on the frequency
  - Digital data is modulated (shift keying) on the carrier by modifying carrier characteristics
- **3 characteristics of carrier signal**
  - Amplitude
  - Frequency
  - Phase

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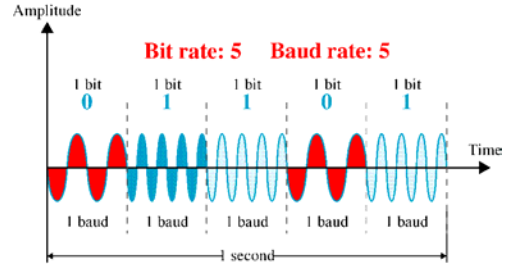
## Amplitude Shift Keying (ASK)



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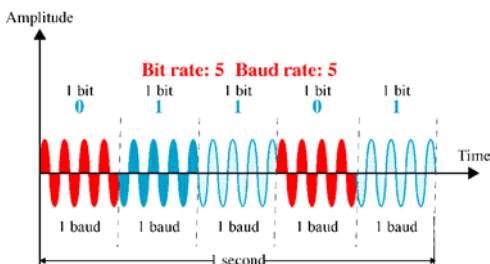
## Frequency Shift Keying (FSK)



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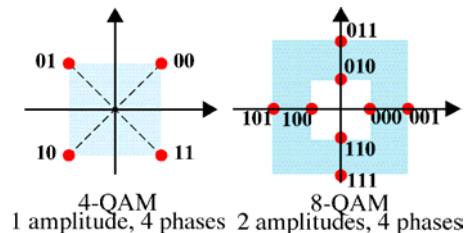
## Phase Shift Keying (PSK)



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## Quadrature Amplitude Modulation (QAM)



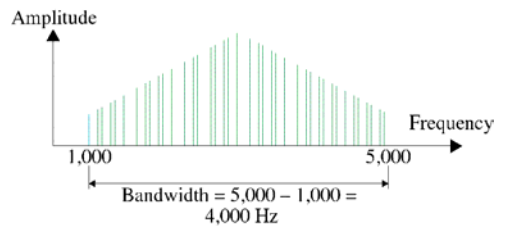
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## Frequency Spectrum and Bandwidth

- Frequency Spectrum of a signal
  - Collection of all the component frequencies of the signal
- Bandwidth of a signal
  - The width of the frequency spectrum

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## Bandwidth



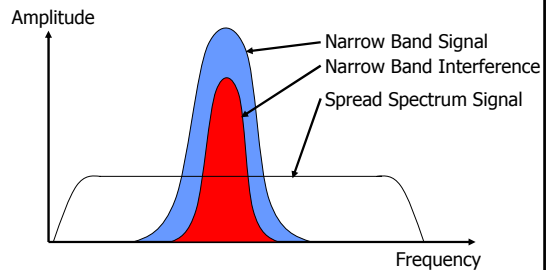
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## Spread Spectrum Modulation

- Modulation:
  - Conversion process from data in NIC to radio waves
- Narrow Band Modulation:
  - Concentrate all Tx power within a narrow band
  - Frequency Spacing
  - TV, AM/FM radio
- Spread Spectrum:
  - A signal's power over a wider band of frequencies
  - Less susceptible to noise
  - Trade-off between BW and Signal-to-Noise Ratio (process gain)

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## Spread Spectrum Modulation



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## Spread Spectrum Modulation

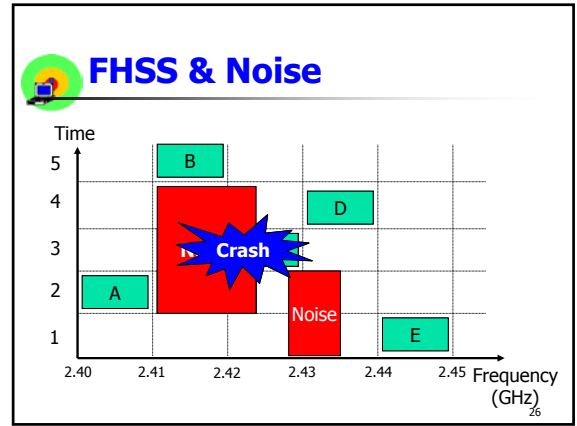
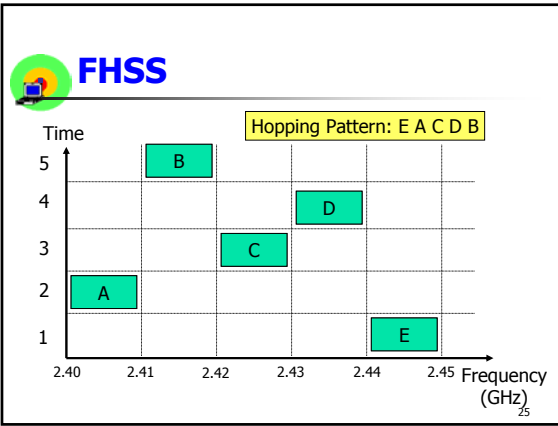
- Frequency Hopping Spread Spectrum (FHSS)
- Direct Sequence Spread Spectrum (DSSS)

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## FHSS

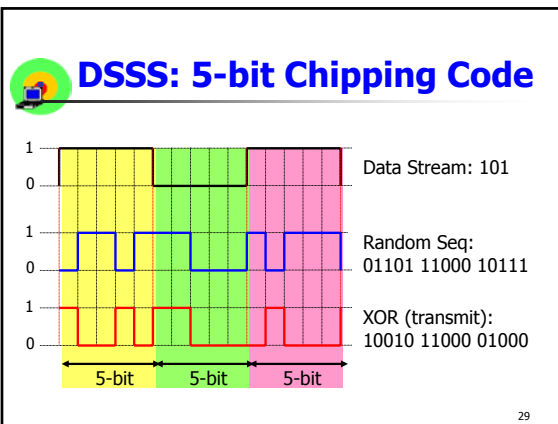
- A carrier signal
  - hops from frequency to frequency as a function of time
- Hopping code:
  - frequency use and order to transmit
- FCC
  - >75 frequencies / transmission
  - Max dwell time is 400 msec

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- ### FHSS
- Achieve up to 2 Mbps
    - Faster data rate → high errors
  - Reduce the interference effect
  - Can operate radios with different hopping pattern in the same frequency band
    - Hopping code used is called **Orthogonal**
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- ### DSSS
- Combines a data signal with higher data rate bit sequence
    - Each bit → multiple bits
    - Actually sends XOR of a sending bit and n-random bits
    - n-random bit → n-bit **Chipping Code**
    - **Processing Gain**
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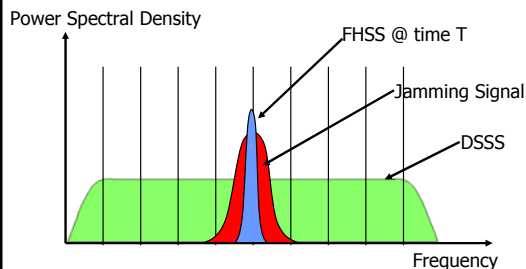
- ### DSSS
- Spread the signal (n-time) across the frequency band
    - Reduce power concentration over a frequency
  - Spreading ratio (Chipping code):
    - # of chip bits / data bit
- 30

## DSSS

- Higher spreading ratio
  - Better interference resistance
  - Lower data throughput
- Lower spreading ratio
  - Lower interference resistance
  - Better data throughput
- Federal Communications Corporation (FCC) regulations:
  - Spreading ratio  $\geq 10$
  - IEEE 802.11  $\rightarrow 11$

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## FHSS & DSSS



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## FHSS & DSSS

- DSSS can achieve much higher than 2 Mbps
- DSSS is harder to implement
  - More expensive than FHSS
- FHSS is higher interference resistance
- DSSS transmits farther than FHSS ?

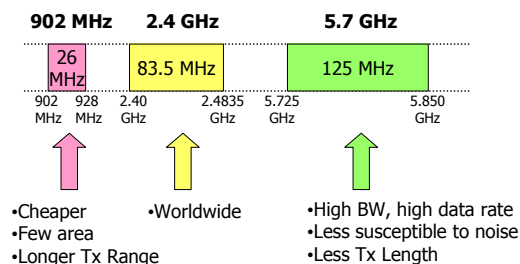
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## ISM Bands

- **I**ndustrial, **S**cientific, and **M**edical frequency band
- Can operate without FCC licenses
- Tx output power  $\leq 1$  watt
- Eliminate cost and time consuming for licenses

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## ISM Bands Radio Spectrum



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## WLAN Operation

- Medium Access Control (MAC)
- Modulation Techniques
- **Wireless LAN Topologies**

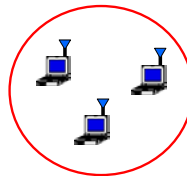
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## Wireless LAN Topologies

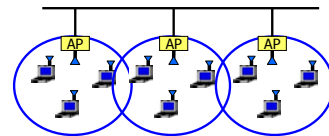
- Physical:
  - Single Cell & Multiple Cells
- Logical:
  - Ad-hoc & Infrastructure
- Connectivity:
  - Standalone & Wired Network Interface
- MAC:
  - Distributed & Centralized

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## Single Cell VS. Multiple Cells



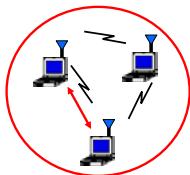
Single Cell



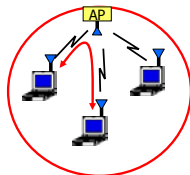
Multiple Cells

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## Ad-hoc VS. Infrastructure



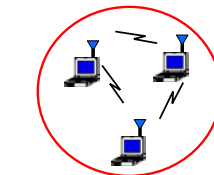
Ad-hoc



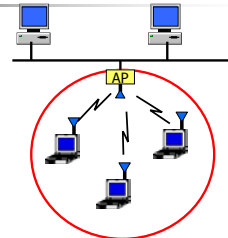
Infrastructure

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## Standalone VS. Wired Network Interface



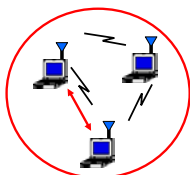
Standalone



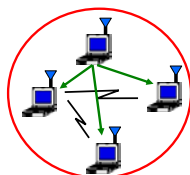
Wired Network Interface

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## Distributed VS. Centralized



Distributed



Centralized

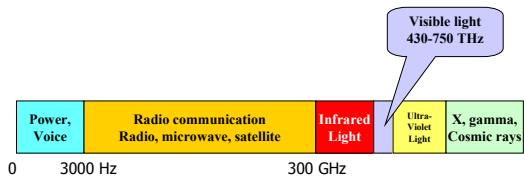
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## Electromagnetic Spectrum



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## Infrared Light Based WLAN

- Invisible to the naked eye
- Infrared Light LAN operate @ 820 nm.
  - Least attenuation by air
- Advantages over Radio Waves:
  - More Secure
  - Less susceptible to common noises (e.g.oven)
  - Better performance → High data rate
- Disadvantage:
  - Limited Coverage

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## Components

- Adapter Card (NIC)
  - Protocol for accessing shared medium
- Transducer
  - Similar to radio antenna
  - Transmits & receive infrared light signal

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## Infrared Light LAN Categories

- Diffused
- Point-to-point

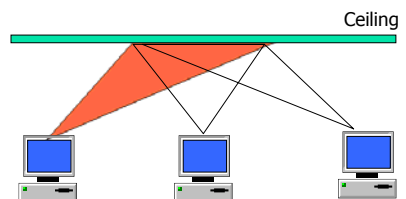
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## Diffused Infrared LAN

- Same as remote control for TV
  - Higher power
  - Use protocol to transmit
- Ceiling is the reflection point
- Operate @ 1 – 4 Mbps

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## Diffused Infrared LAN



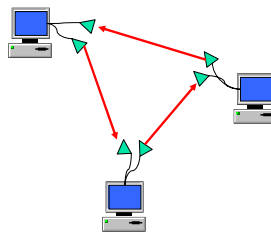
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## Point-to-point Infrared LAN

- A pair of transducers (Tx & Rx)
- Replace cable (Token Ring)
- Advantages:
  - Security
  - Performance
- Disadvantages:
  - Line of sight
  - (non-blocking path)

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## Point-to-point Infrared LAN



Token-Ring

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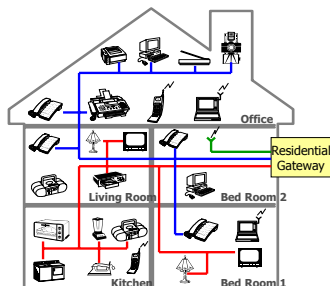
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## Carrier Current LANs

- Powerline network
- Phoneline network
- “No new wire” LAN
  - Home networks

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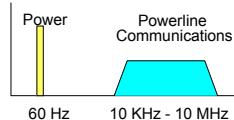
## Home Network



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## Powerline Network

- Carrier-current network
- Wiring from the distribution transformer
  - many house → share the same media
- Start with the low speed for control application

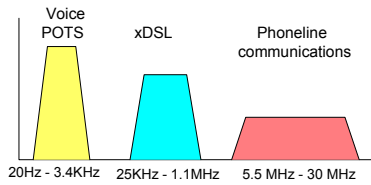


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## Phoneline Network

- Existing phone wiring
- Similar to powerline communication
- Implement frequency division multiplex



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## Common Characteristics

- Shared broadcast media
- Harsh channel condition
  - attenuation, noise, and interference
- Changing channel condition
- Dynamic network topology

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