

CS 294-7: Wireless Local Area Networks

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Desirable Features

- **Ability to operate worldwide**
- **Minimize power drain**
- **License free operation**
- **Robust transmissions with security**
- **Collocated operation**
- **Easy operation and management**
- **Protection of investment**



Historical Perspectives

- **Early 1970s**
 - IBM: Diffused IR technology (100 kbps)
 - HP: Direct Sequence Spread Spectrum (required allocation of a commercial band)
 - Motorola RF network @ 1.7 GHz
- **1981**
 - HP Labs petitions the FCC for a data band
 - 1985: FCC supports commercial spread spectrum in the ISM bands
 - Motorola license @ 18-19 GHz
- **1990s**
 - WLAN products come to market
 - 802.11 Committee formed
 - 1992: WINFORUM formed yielding etiquette rules in 1995



Evolution of Wireless LANs

- **First Generation**

- For workstations, 20 W transmitters, LAN extensions
- Extend LANs to areas inside buildings that are hard to reach
- Building-to-building connectivity

- **Second Generation**

- Laptop/palmtop computers + PCMCIA card network interfaces
- Ad-hoc networking (e.g., conference room)
- “Ubiquitous” computing



Physical Layer

- **Infrared versus Radio Frequency**

- IR advantages:

- » Inexpensive due to simple amplitude detection schemes and technology: LEDs & photosensitive diodes
 - » No regulation necessary
 - » Advantageous containment yielding high re-use of spectrum

- IR disadvantages:

- » Interference from sun, incandescent light: cannot be used outside
 - » Shadows from moving objects near receivers/transmitters

- RF advantages:

- » Riding the cellular/cordless telephone learning curves towards lower costs
 - » Wide-area coverage

- RF disadvantages:

- » Licensed operation (except for unlicensed bands)
 - » Complexity of propagation and interference



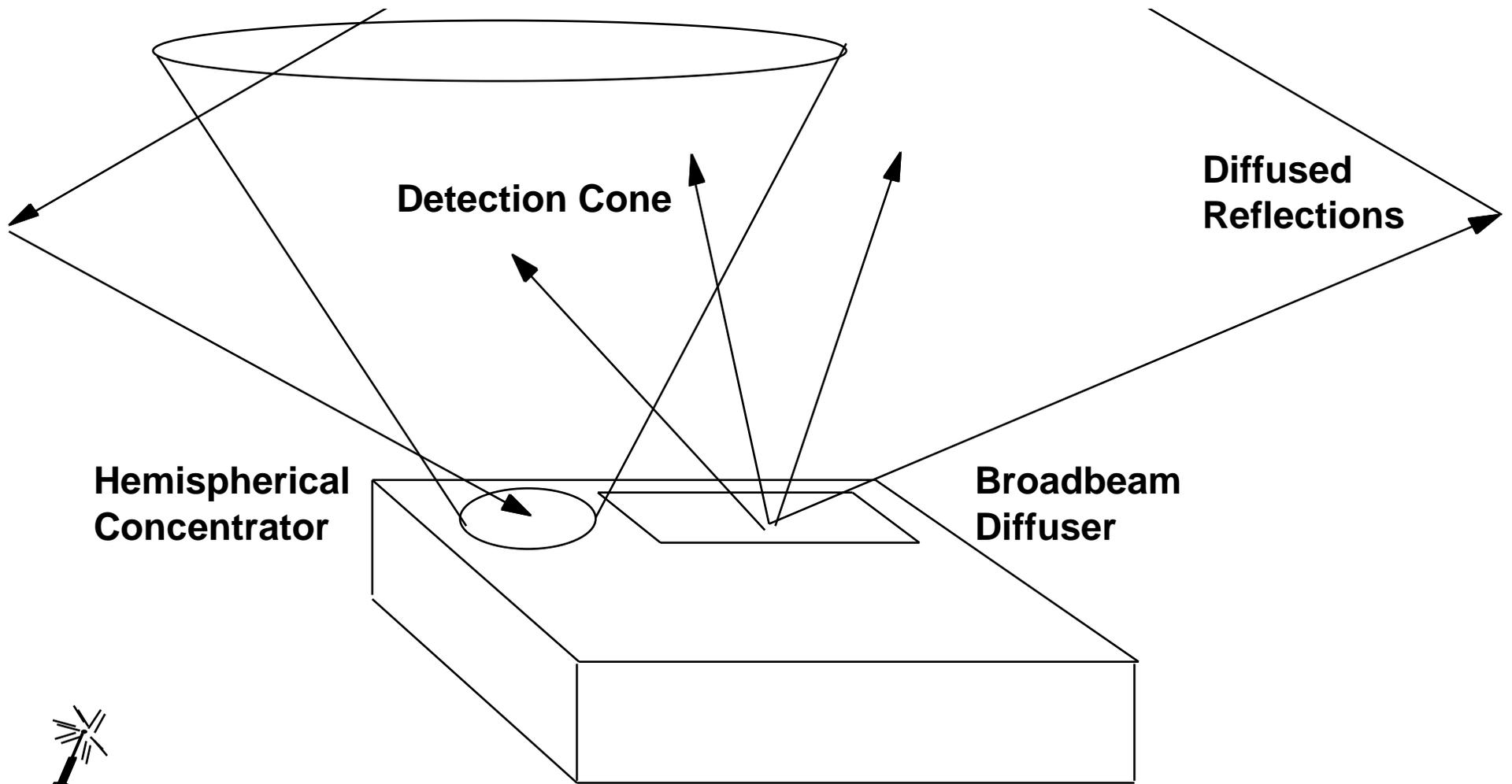
Physical Layer

- **Propagation Effects and Coverage**

- IR: Short wavelengths + room-sized distances + detectors large wrt to wavelength imply Rayleigh fading is not a problem
- RF: Big problem for radio waves
- IR: direct beam, ceiling bounce, diffused
 - » Direct beam: up to kilometer
 - » Diffused: 20 m
 - » Theoretical limit = 260 Mb-m/s (20 m room implies 13 Mbps)
- RF: 50-100 m typical, but depends on local geometric details, like corridors
- IR, RF: Intersymbol interference limits effective bandwidth

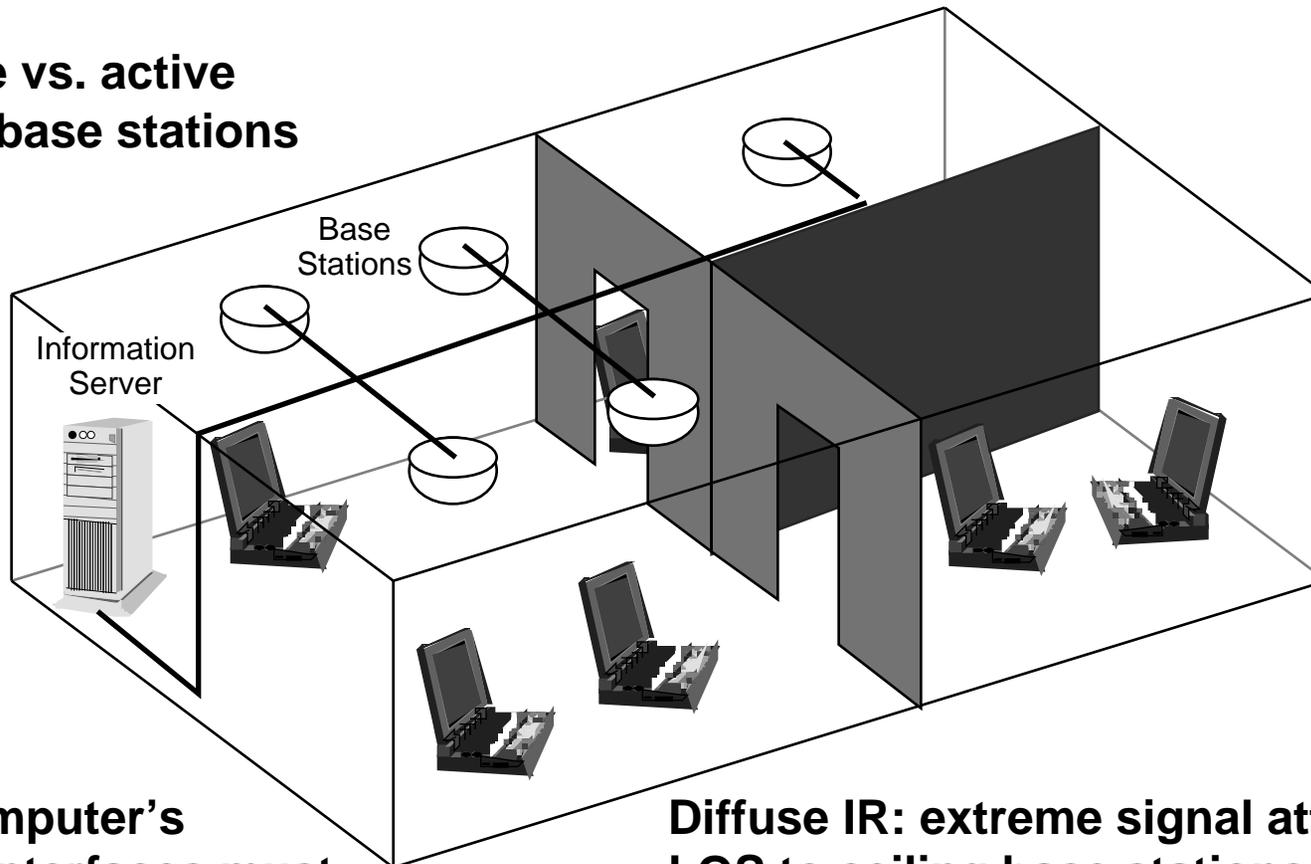


Diffused IR Transmitter/ Receiver



IR with Ceiling Base Stations

**Passive vs. active
ceiling base stations**



**Computer's
IR interfaces must
point towards ceiling**

**Diffuse IR: extreme signal attenuation
LOS to ceiling base stations can yield
higher bandwidth at lower power
(Rednet: 2 mbps at \$10 parts cost)**



RF WLANs

- **Technology Alternatives**

- **Spread spectrum technology**

- » **Frequency hopping spread spectrum**

- » **Direct sequence spread spectrum**

- **FCC Part 15.247**

- » **ISM bands made available for wide-band data communications systems (26MHz@915 MHz, 83.5MHz@2.4 GHz, 125MHz@5.8 GHz)**

- » **FHSS: all or most of the available channels must be used on average (FCC: 0.5-1.0 MHz min channel b/w; 50 of 52, 75 of 83, and 75 of 125 available channels must be used)**

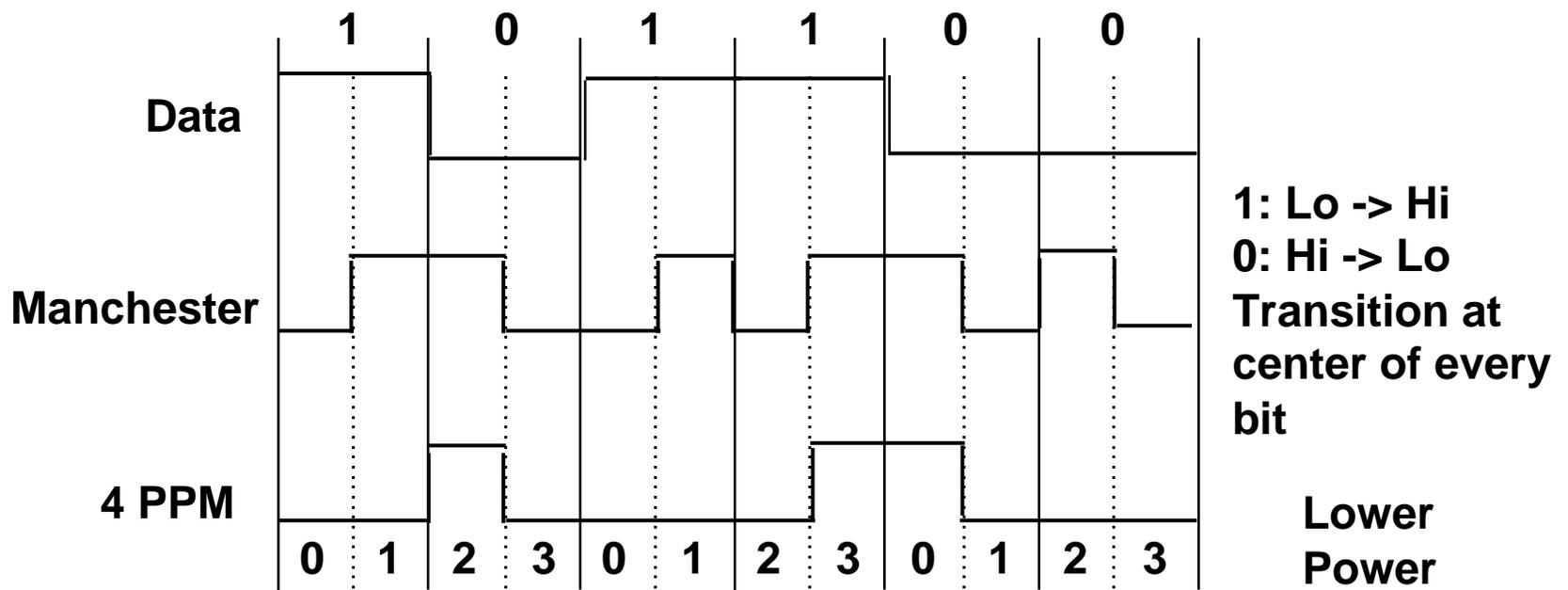
- » **DSSS: chipping rates of 10-100 commonly used (FCC: 10); Low spreading factors are not as interference tolerant**

- » **FHSS has some advantages wrt interference: easier to reject a high powered narrow band interferer than in DSSS systems**



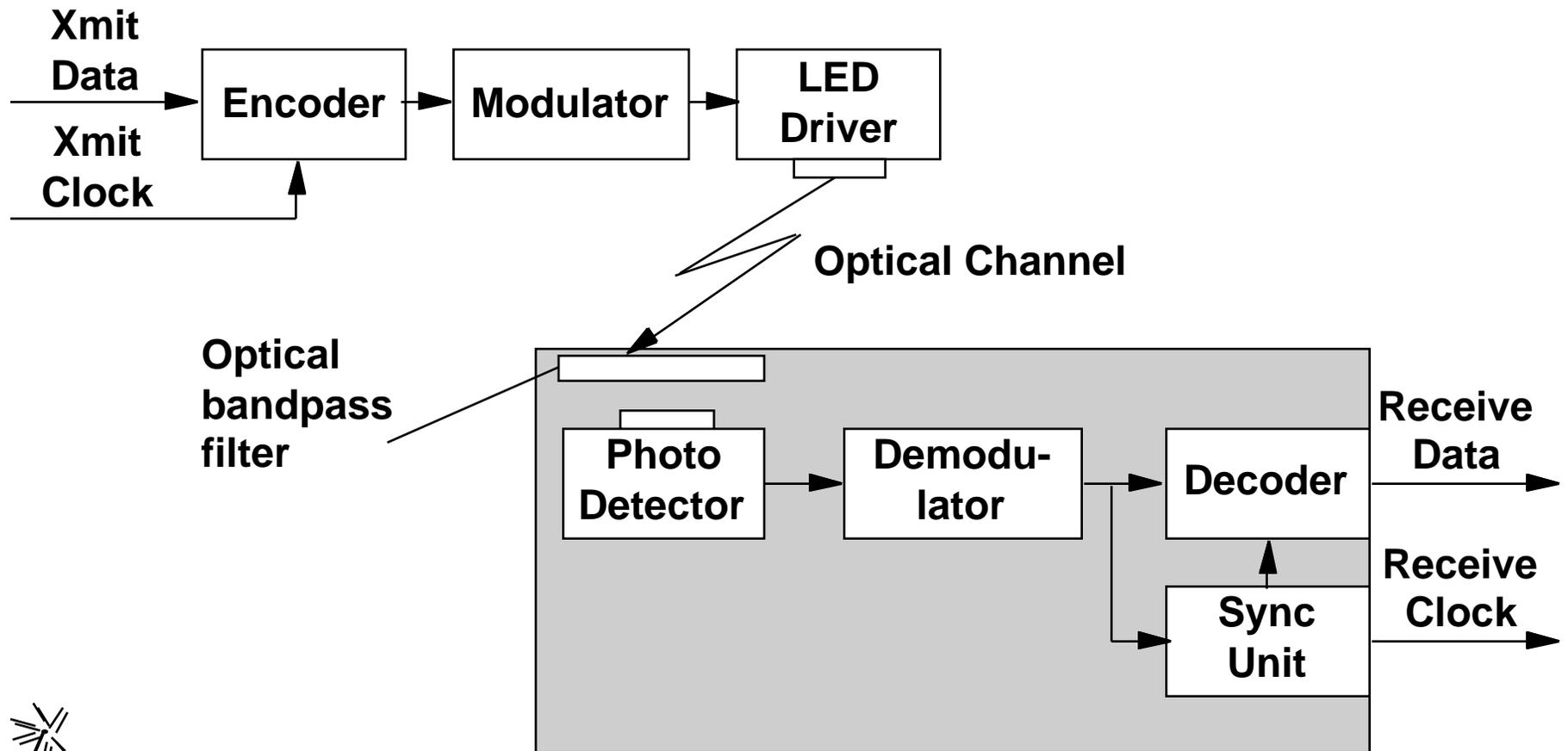
IR WLANs

- **Direct Modulation Schemes**
 - On-off keying (up to 2 mbps)
 - Pulse Position Modulation (up to 4 mbps)



- **Carrier Modulation Schemes (up to 10 mbps)**

IR WLANs



IR WLANs

- **ParcTab System**

- 19.2 kbps IR links for PDA-to-BS communications
- 850 nm wavelengths, wide-angle LEDs
- Pulse position modulation: simple on-off scheme
- Office-sized cells: hidden terminals not a problem
- CSMA scheme is used: easy for near-by receivers to detect transmitted signals
- 256 byte packets
- Checksum + retransmissions



IR WLANs

- **Rednet Project**

- ATM to the mobile device (PDA, terminal, keyboard)
- 2-5 mbps, 4 m link distance
- Ceiling mounted IR base stations
- On-Off Keying (OOK) modulation: edge detection to separate baseband signal from low frequency noise
- Link Protocol
 - » Slotted architecture corresponding to ATM cells
 - » Slot = Preamble + Contention + Data phases
- Media Access Scheme
 - » Contention Protocol/Binary Countdown
 - » Each node has unique contention address; during contention phase, these are sent bit serial, MSB first; base station echos these bits to eliminate hidden nodes; node receives echoed bit--if match transmitted bit, continue; otherwise drop out of contention
 - » Unfair: so add group priority bits to address--when node loses contention, it enters higher priority for next round



Network Topology and Media Access Method

- **CSMA/Peer-to-peer vs. TDMA/Base Station-to-remote station**
- **Base Stations**
 - Centralized access to media (e.g., time slots, priority allocation)
 - Access point to wireline environment
 - Well defined security control point
 - Power control
- **Most commercial products are spread spectrum without CDMA**
- **IBM's preferred WLAN: FH + TDMA @ 2.4 GHz**
 - TDMA slot times a submultiple of the hopping time



Standards Developments

- **Interoperable Rules**

- Different vendors products negotiate with each other
- IEEE 802.11: DSSS (1-2 Mbps), FHSS (1-2 Mbps), DFIR (1 mbps)
- ETSI Hiperlan: 5.2, 17.1 GHz bands (EC)
Target bandwidth: 20 mbps, 50 m range

- **Etiquette Rules**

- Minimum set of rules that allow multiple vendors to share available bandwidth fairly
- Winforum: Unlicensed PCS bands
 - » Listen before talk, transmission time limits, power limits

