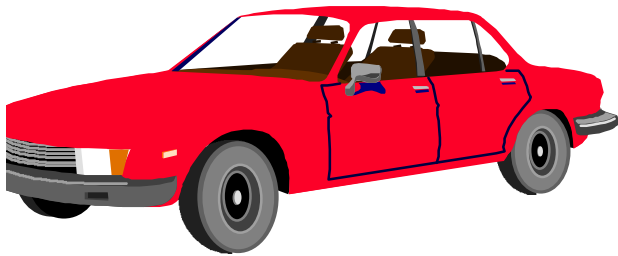

Wireless Data Networking



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These slides are available at

<http://www.cis.ohio-state.edu/~jain/cis777-00/>

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Spread Spectrum

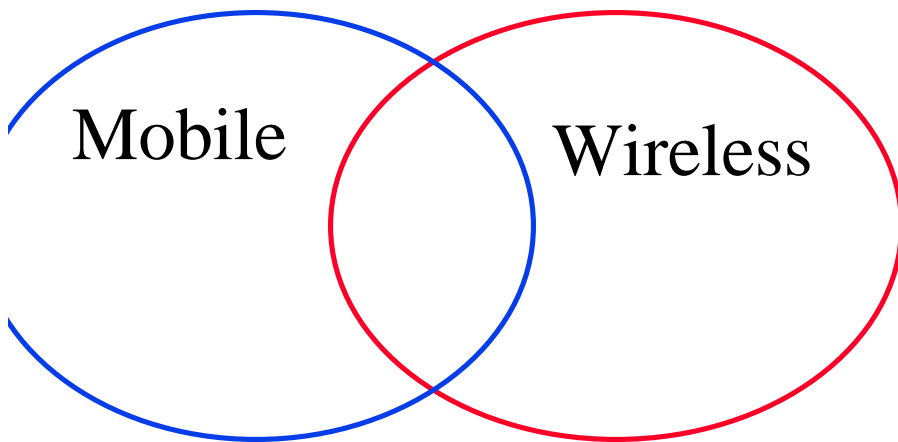
Wireless wide area networks: CDPD and Metricom

Wireless local area networks

Wireless LAN standard: IEEE 802.11, Hiperlan

te: wireless **phone** services and standards not covered

Mobile vs Wireless

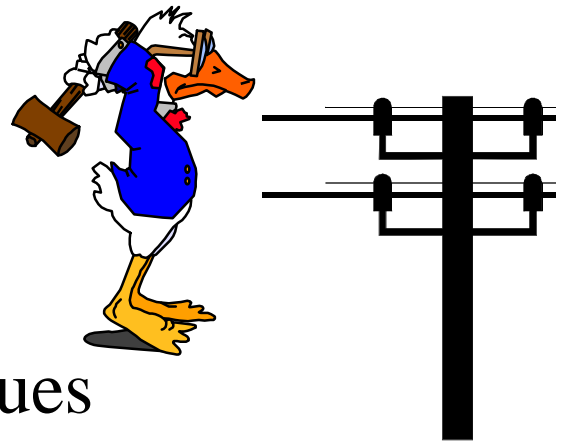


Mobile vs Stationary

Wireless vs Wired

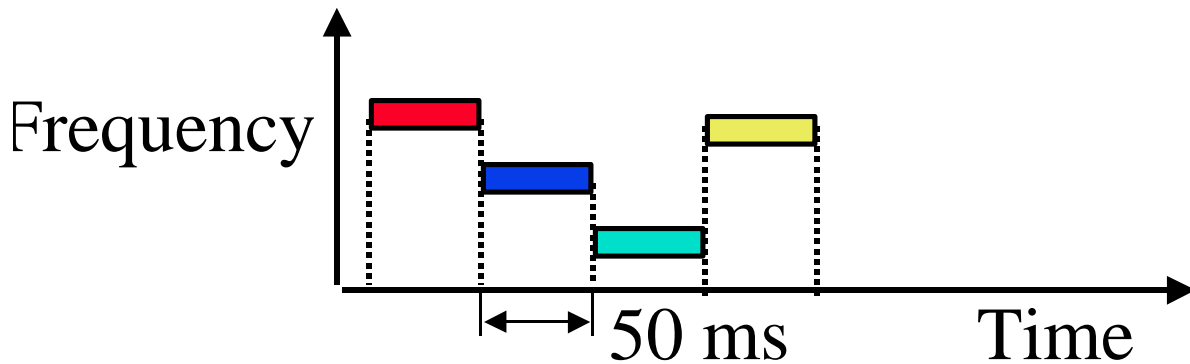
Wireless \Rightarrow media sharing issues

Mobile \Rightarrow routing, addressing issues





Frequency Hopping Spread Spectrum



↳ pseudo-random frequency hopping

↳ spreads the power over a wide spectrum

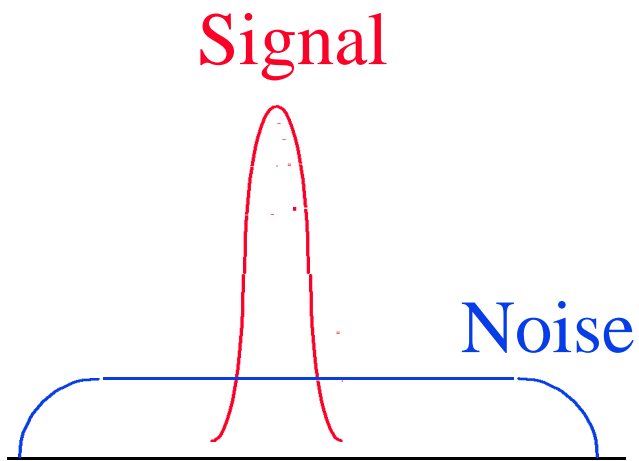
⇒ Spread Spectrum

Developed initially for military

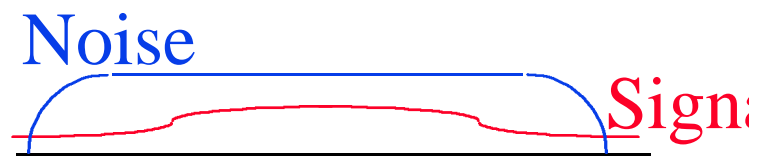
Patented by actress Hedy Lamarr

Narrowband interference can't jam

Spectrum

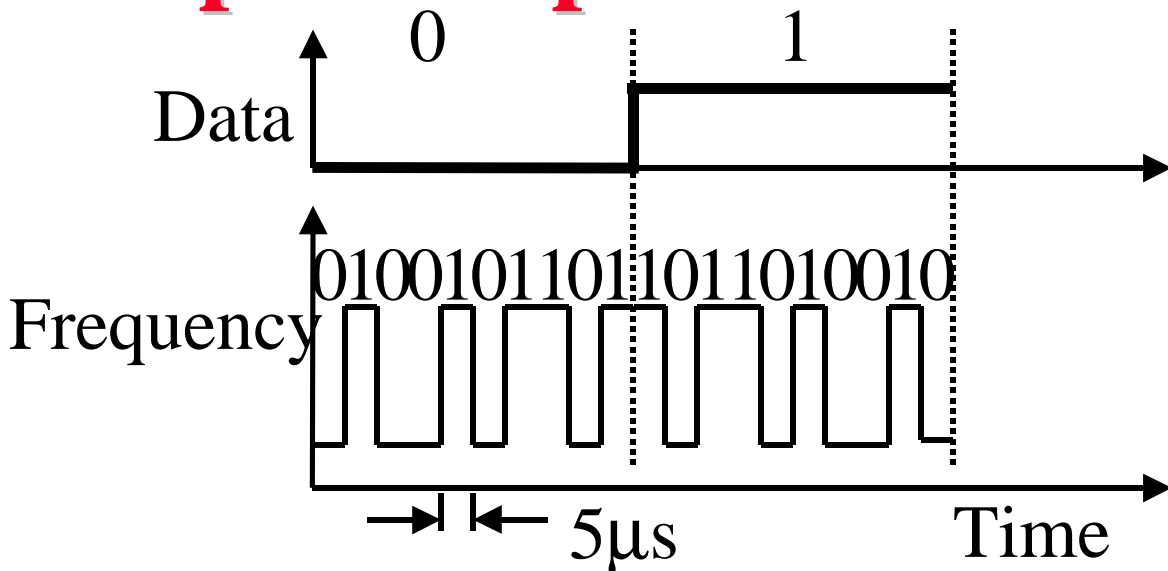


(a) Normal



(b) Frequency Hopping

Direct-Sequence Spread Spectrum



Spreading factor = Code bits/data bit, 10-100
Commercial (Min 10 by FCC), 10,000 for military
Signal bandwidth $>10 \times$ data bandwidth

Code sequence synchronization

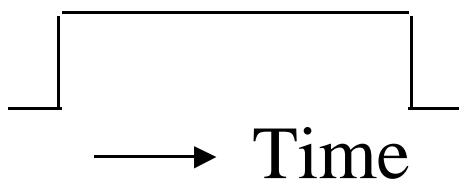
Correlation between codes \Rightarrow Interference \Rightarrow Orthogonal

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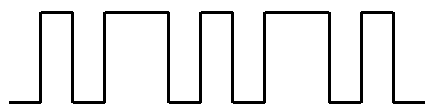
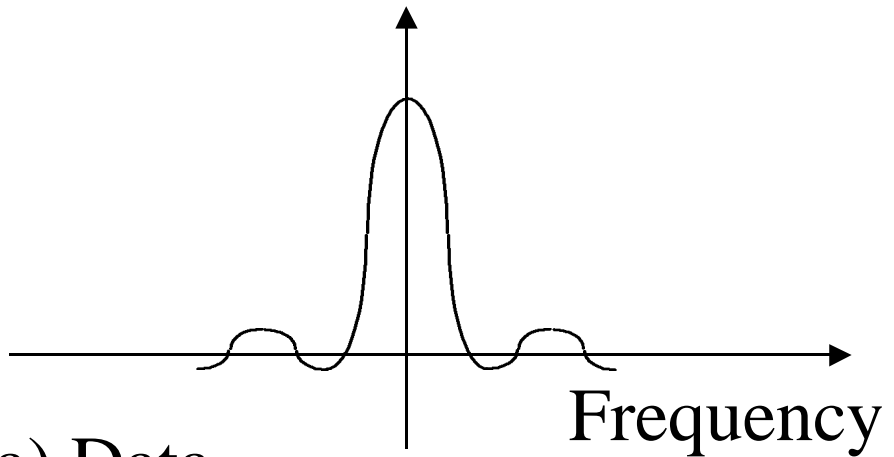
DS Spectrum

Time Domain

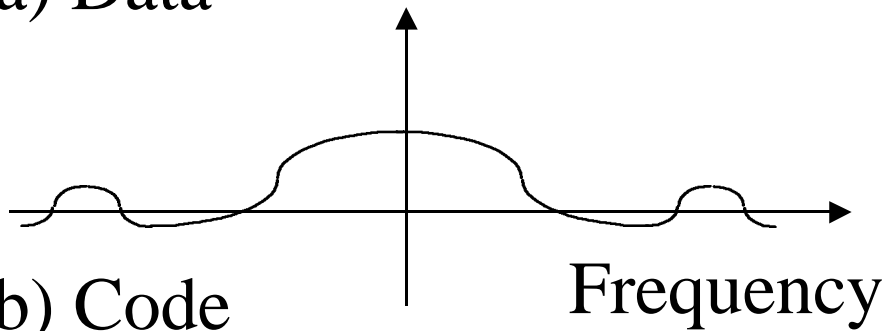
Frequency Domain



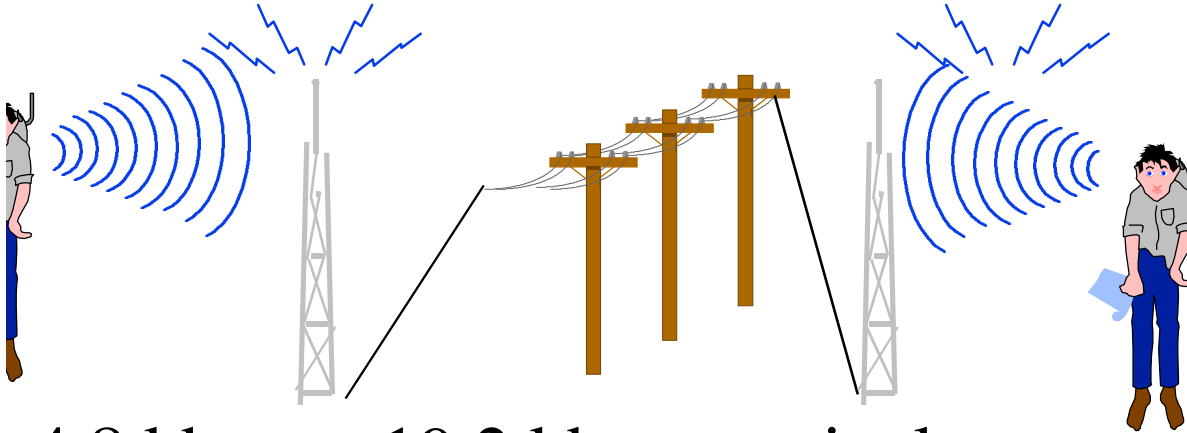
(a) Data



(b) Code



Wireless WAN Services



4.8 kbps to 19.2 kbps nominal

Throughput 2 to 8 kbps

Wired backbone using leased lines

Packetized short transmission

Email, stock quotes, weather

Options: Ardis, RAM Mobile Data, Cellular, Cellular Digital Packet Data (CDPD), and Metrico

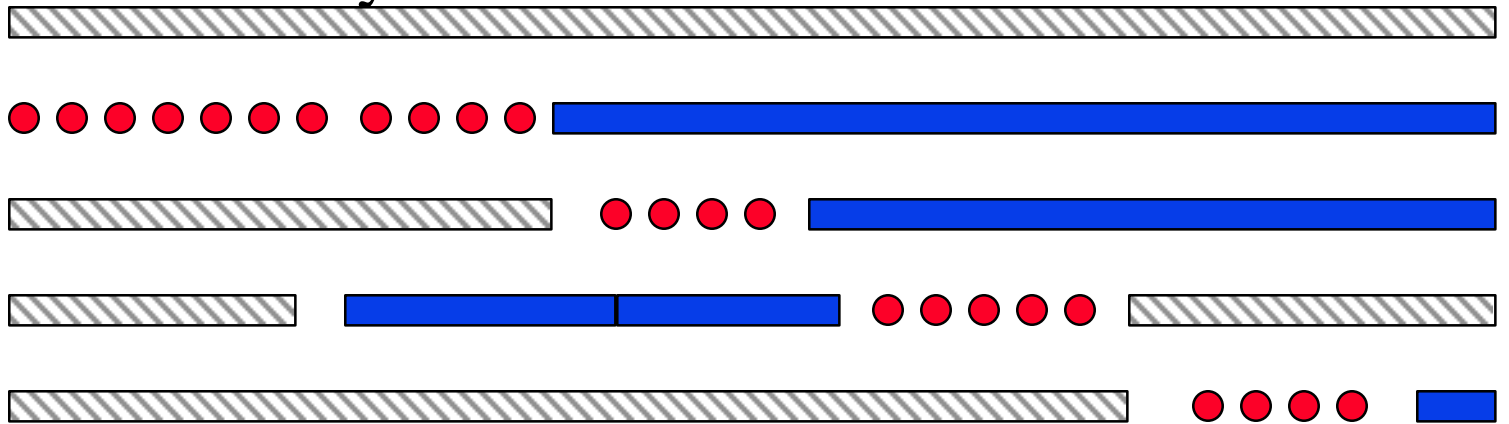
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Cellular Digital Packet Data (CDPD)

Originally named “Celluplan” by IBM

Allows data to use idle cellular channels

Data hops from one channel to next as the channels become busy or idle



 Voice Call
 Idle Channel

 Data packets

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CDPD

Backed by 9 major service providers

Nationwide cellular packet data service

Connectionless and connection-oriented service

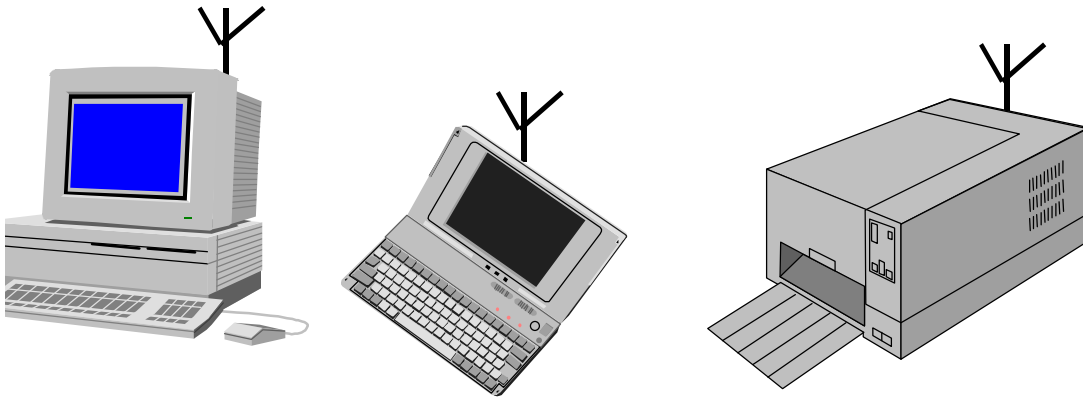
Connectionless \Rightarrow No ack, no guarantees

Connection-oriented \Rightarrow reliable delivery,
sequencing, flow control

Point-to-point and multipoint connections

Quickly hops-off a channel grabbed by cellular
system. Currently, dedicated channels.

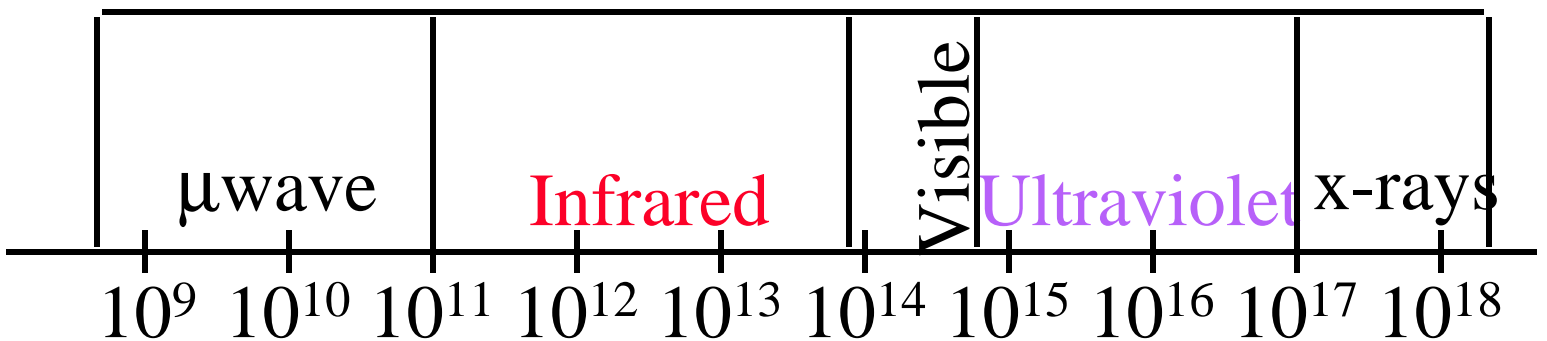
Wireless LANs



R \Rightarrow Line of sight, short range, indoors

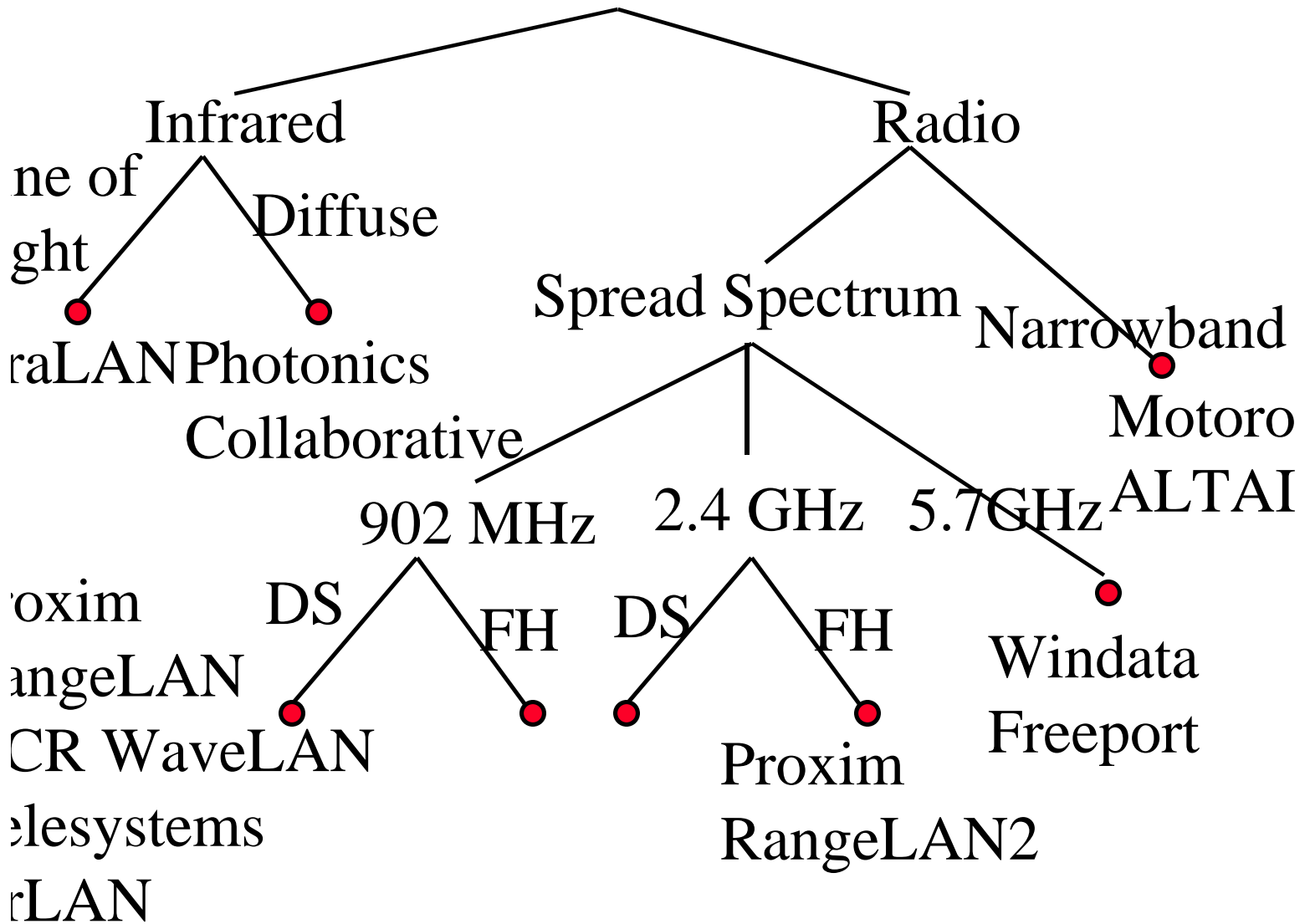
RF \Rightarrow Need license

Spread-Spectrum: Resistance to interference



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Wireless LANs



IEEE 802.11 Features

1 and 2 Mbps

↳ supports both Ad-hoc and base-stations

↳ spread Spectrum \Rightarrow No licensing required.

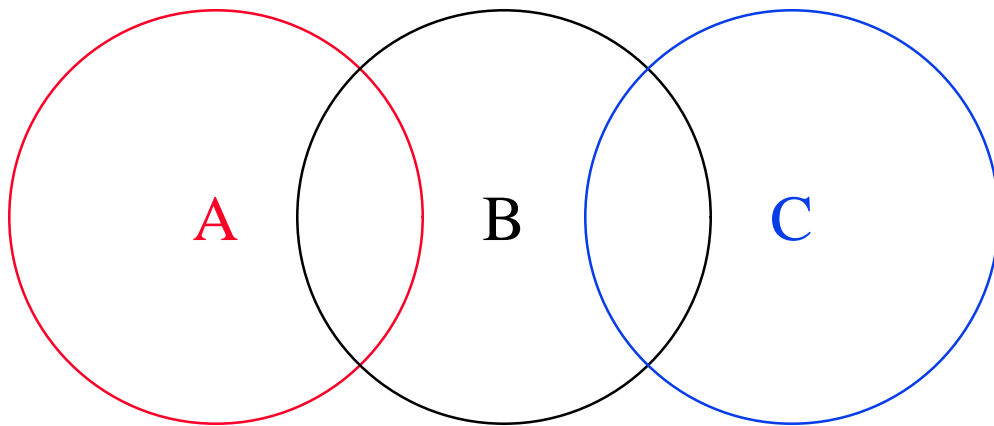
↳ three Phys: Direct Sequence, Frequency Hopping, 915-MHz, **2.4 GHz** (Worldwide ISM), 5.2 GHz, and Diffused Infrared (850-900 nm) bands.

↳ supports multiple priorities

↳ supports time-critical and data traffic

↳ power management allows a node to doze off

Hidden Node Problem

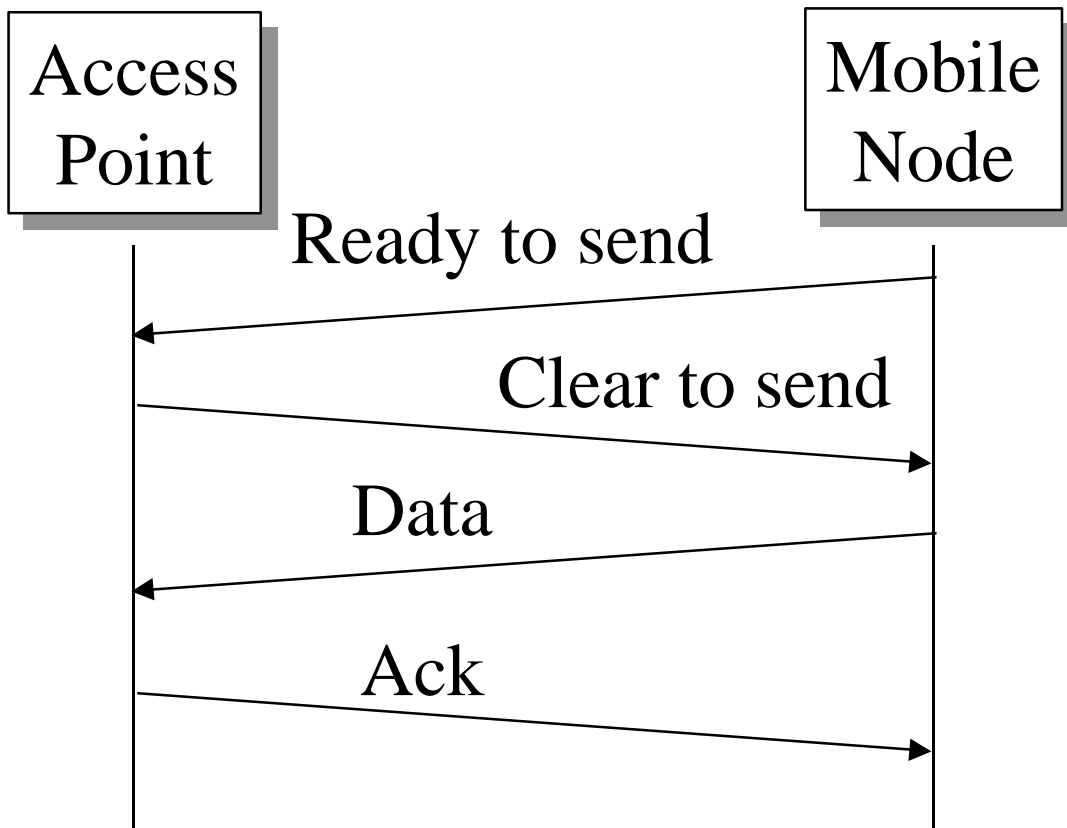


C cannot hear A.

C may start transmitting while A is also transmitting
⇒ A and C can't detect collision.

Only the receiver can help avoid collisions

4-Way Handshake



IEEE 802.11 MAC

Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)

Listen before you talk. If the medium is busy, the transmitter backs off for a random period.

Avoids collision by sending a short message:

Ready to send (RTS)

RTS contains dest. address and duration of message.

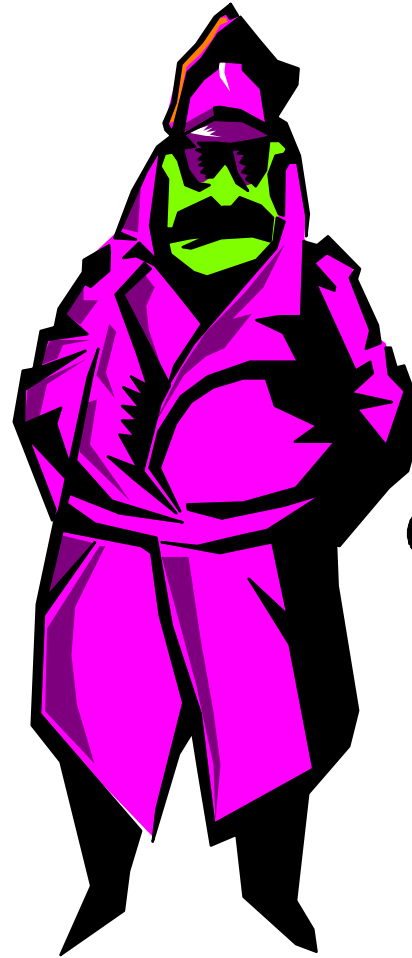
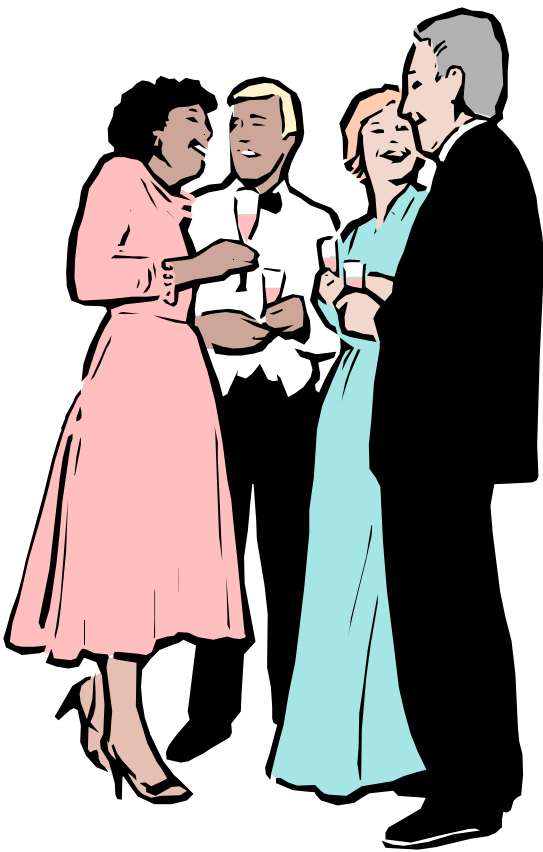
Tells everyone to backoff for the duration.

Destination sends: Clear to send (CTS)

Can not detect collision \Rightarrow Each packet is acked.

MAC level retransmission if not acked.

d-Hoc vs Infrastructure



Peer-to-Peer or Base Stations?

Ad-hoc (Autonomous) Group:

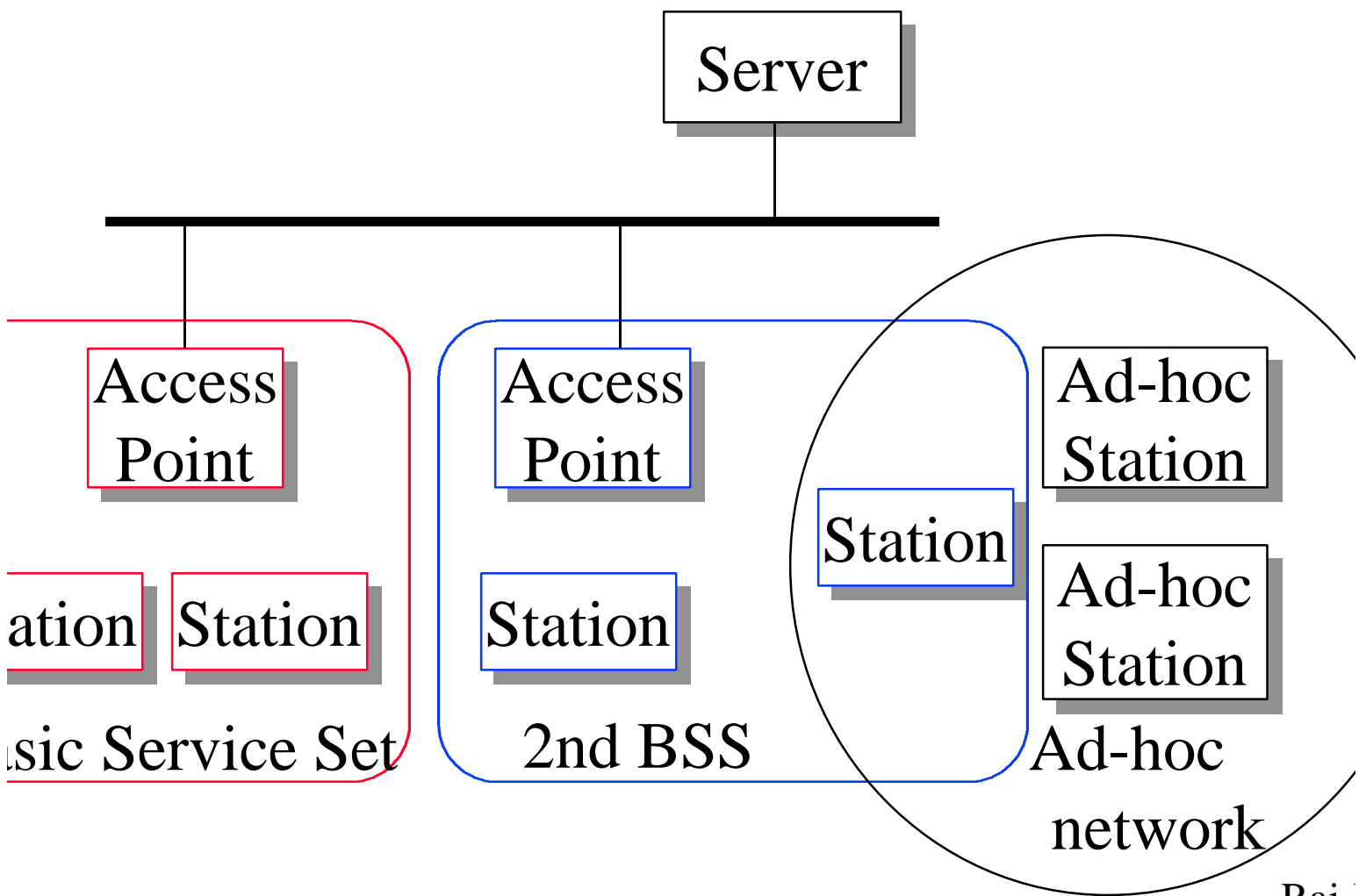
- Two stations can communicate
- All stations have the same logic
- No infrastructure, Suitable for small area

Infrastructure Based: Access points (base units)

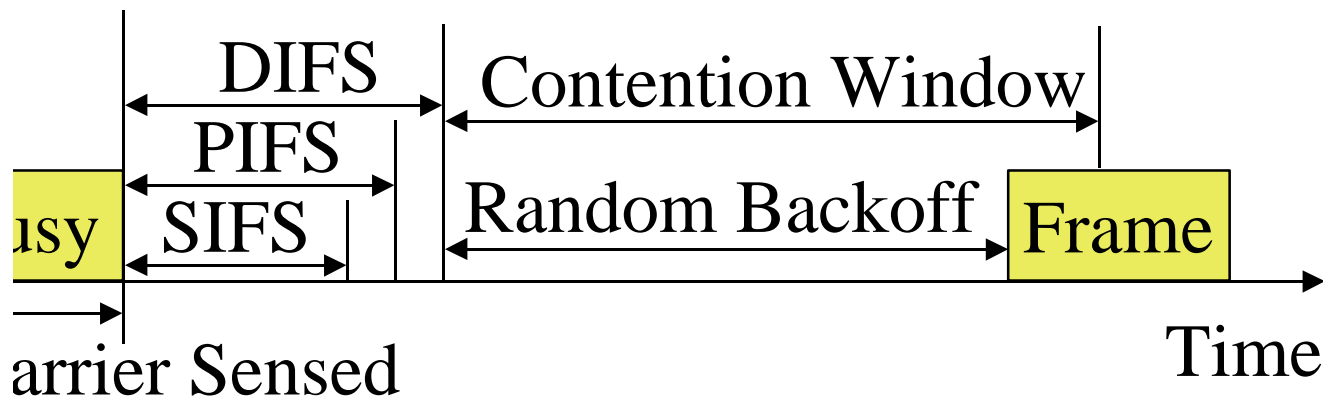
- Stations can be simpler than bases.
- Base provide connection for off-network traffic
- Base provides location tracking, directory, authentication \Rightarrow Scalable to large networks

IEEE 802.11 provides both.

IEEE 802.11 Architecture



IEEE 802.11 Priorities



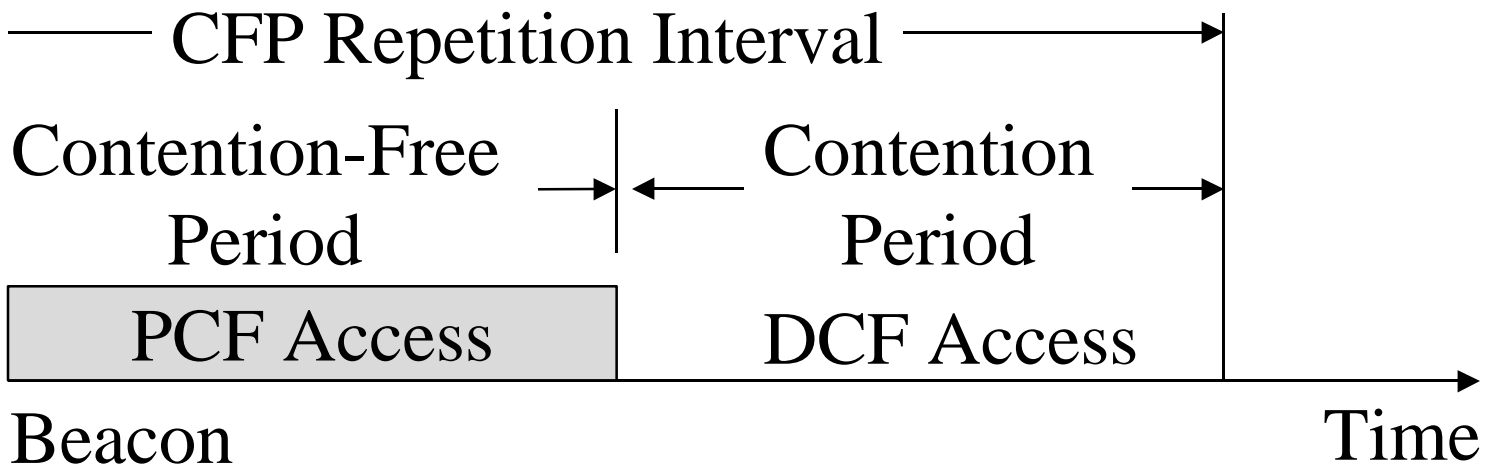
Initial interframe space (IFS)

Highest priority frames, e.g., Acks, use short IFS (SIFS)

Medium priority time-critical frames use “Priority Coordination Function IFS” (PIFS)

Asynchronous data frames use “Distributed Coordination Function IFS” (DIFS)

Time Critical Services



Timer critical services use Point Coordination Function
The point coordinator allows only one station to access the
Coordinator sends a beacon frame to all stations.
Then uses a polling frame to allow a particular station to
have contention-free access
Contention Free Period (CFP) varies with the load.

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Power Management

A station can be in one of three states:

- Transmitter on
- Receiver only on
- Dozing: Both transmitter and receivers off.

Access point (AP) buffers traffic for dozing stations

AP announces which stations have frames buffered.

Traffic indication map included in each beacon.

All multicasts/broadcasts are buffered.

Dozing stations wake up to listen to the beacon.

If there is data waiting for it, the station sends a poll frame to get the data.

Status and Future

802.11 including both MAC and PHY approved Jun 1997.

More bandwidth in future by:

1. Better encoding: Multilevel modulation \Rightarrow 8 Mb/s
2. Fewer channels with more bandwidth \Rightarrow 4 MHz channels. Or Entire ISM band for one channel.
3. Find another band. May get 150 MHz band in 5-GHz band. Fifteen 10-MHz channels with 15-20 Mb/s.

HIPERLAN

High Performance Radio LAN

European Telecom Standards Institute

(ETSI)'s subtechnical committee RES10.

5.12-5.30 GHz and 17.1-17.3 GHz bands

Phy: 23.5 Mbps on 23.5 MHz, non-spread spectrum
(GMSK)

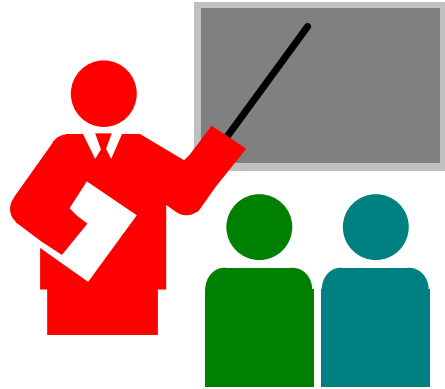
MAC: CSMA/CA but different from IEEE 802.11

Peer-to-peer only.

Power management: Nodes announce their wakeup
cycle. Other nodes send according to the cycle. A low
bit rate header allows nodes to keep most ckts off.

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Summary



Spread spectrum: Frequency hopping or direct sequence

WANs: Ardis, RAM, Cellular, CDPD, Metricom

Proprietary LANs: Photonics, RangeLan, ALTAIR

LAN Standards: IEEE 802.11, Hiperlan

Wireless: Key References

For a detailed list of references see:

http://www.cis.ohio-state.edu/~jain/refs/wir_refs.htm

‘Wireless Local Area Networks,’ Aug 97,

http://www.cis.ohio-state.edu/~jain/cis788-97/wireless_lans/index.htm

‘In-building wireless LANs,’ http://www.cis.ohio-state.edu/~jain/cis788-99/wireless_lans/index.html