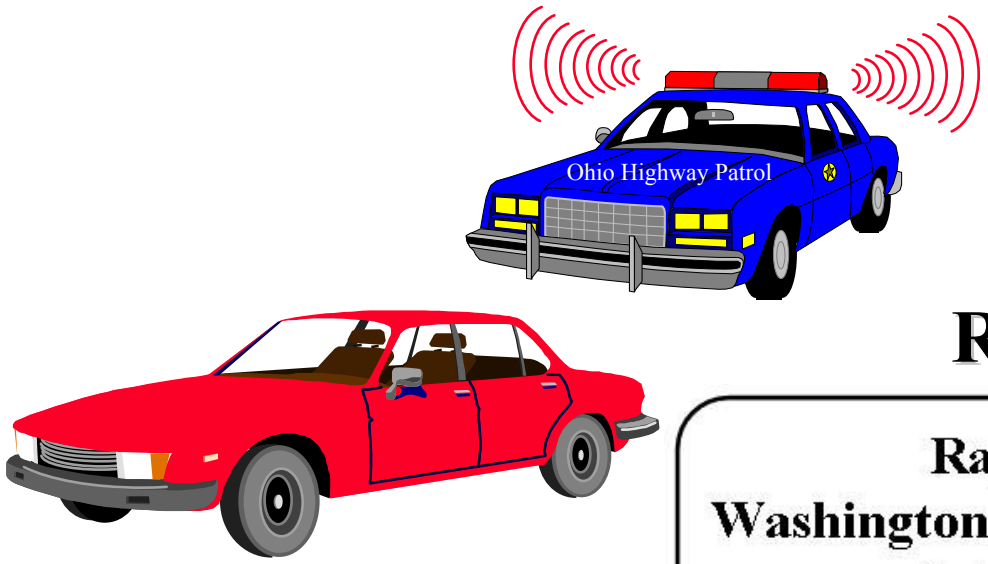
Wireless Data Networking



Raj Jain

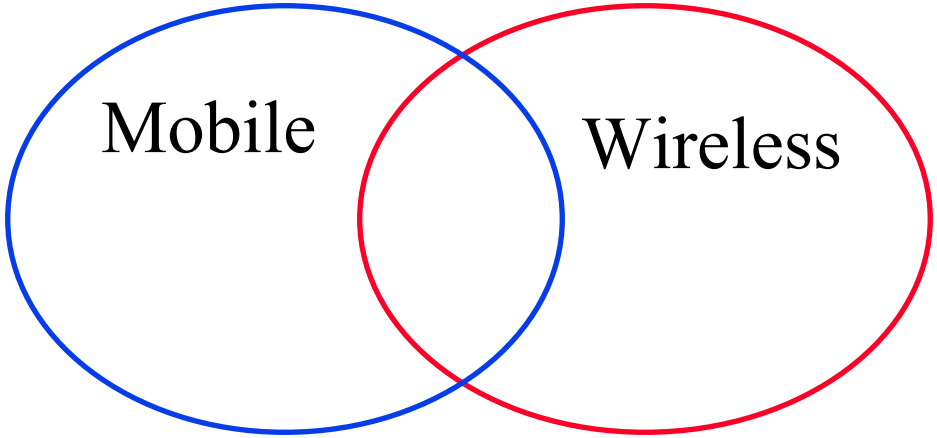
Raj Jain is now at
Washington University in Saint Louis
Jain@cse.wustl.edu
http://www.cse.wustl.edu/~jain/

Overview

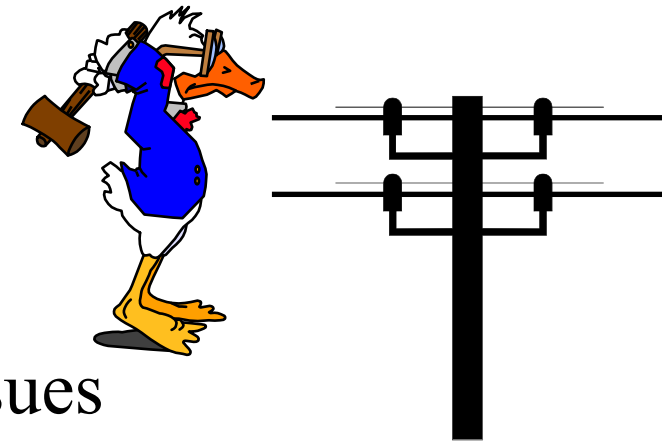
- Spread Spectrum
- Wireless wide area networks: CDPD and Metricom
- Wireless local area networks
- Wireless LAN standard: IEEE 802.11, Hiperlan

Note: wireless phone services and standards not covered.

Mobile vs Wireless



- Mobile vs Stationary
- Wireless vs Wired
- Wireless ⇒ media sharing issues
- Mobile ⇒ routing, addressing issues



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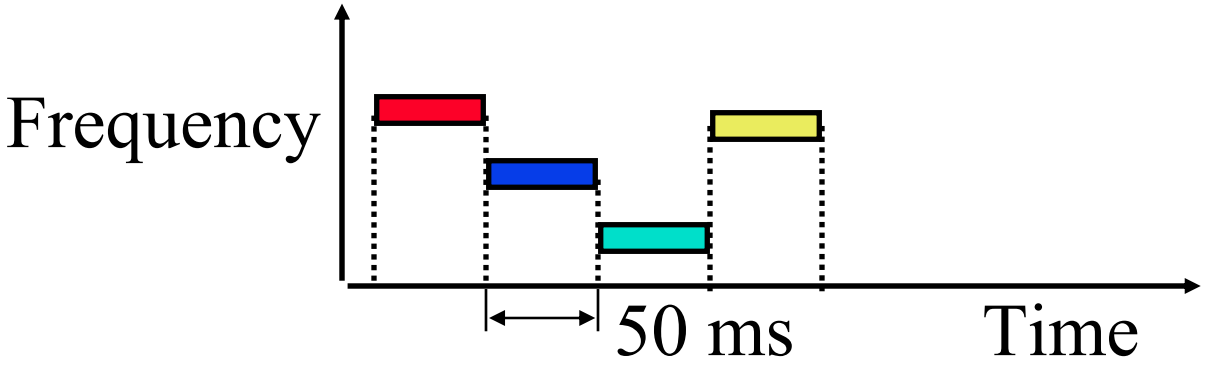
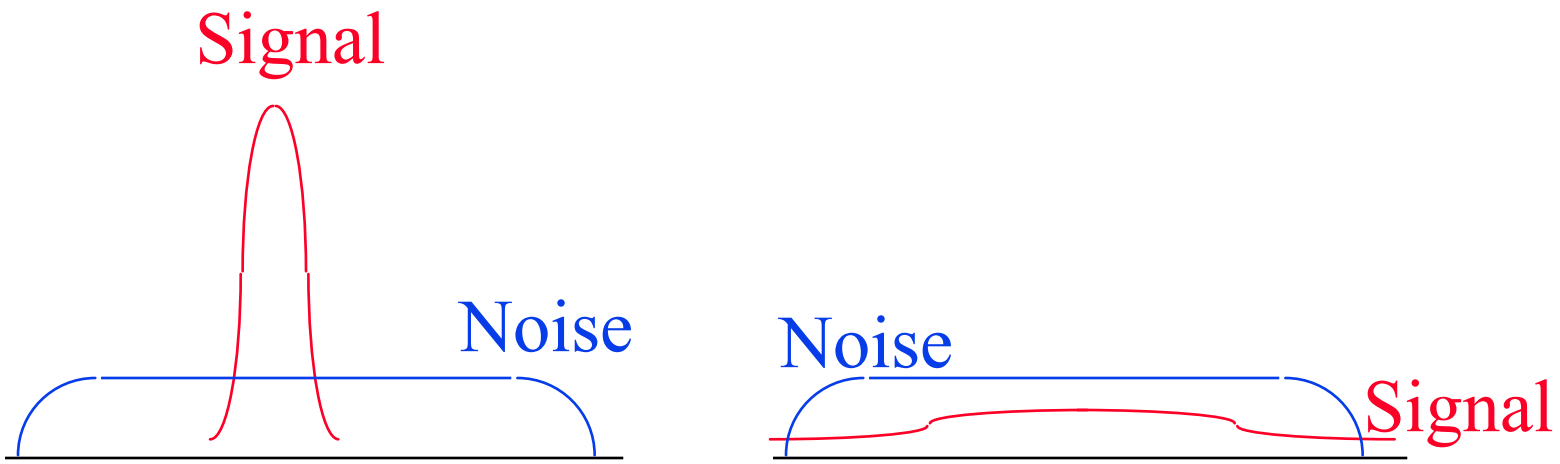
Frequency Hopping Spread Spectrum



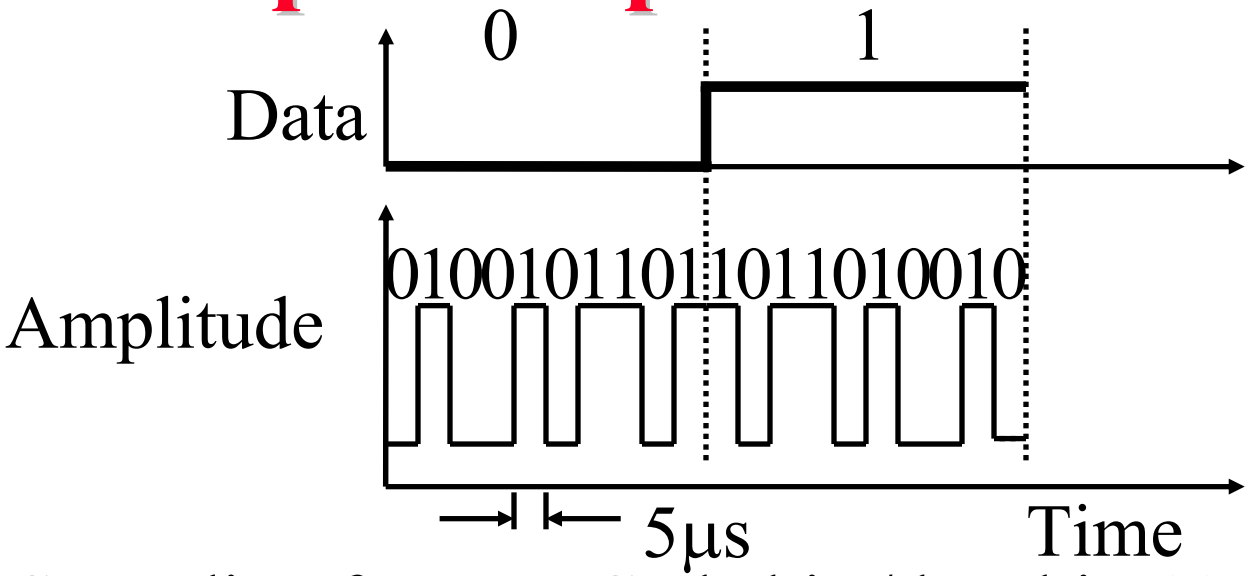
- Pseudo-random frequency hopping
- Spreads the power over a wide spectrum
  $\Rightarrow$ Spread Spectrum
- Developed initially for military
- Patented by actress Hedy Lamarr
- Narrowband interference can't jam

Spectrum



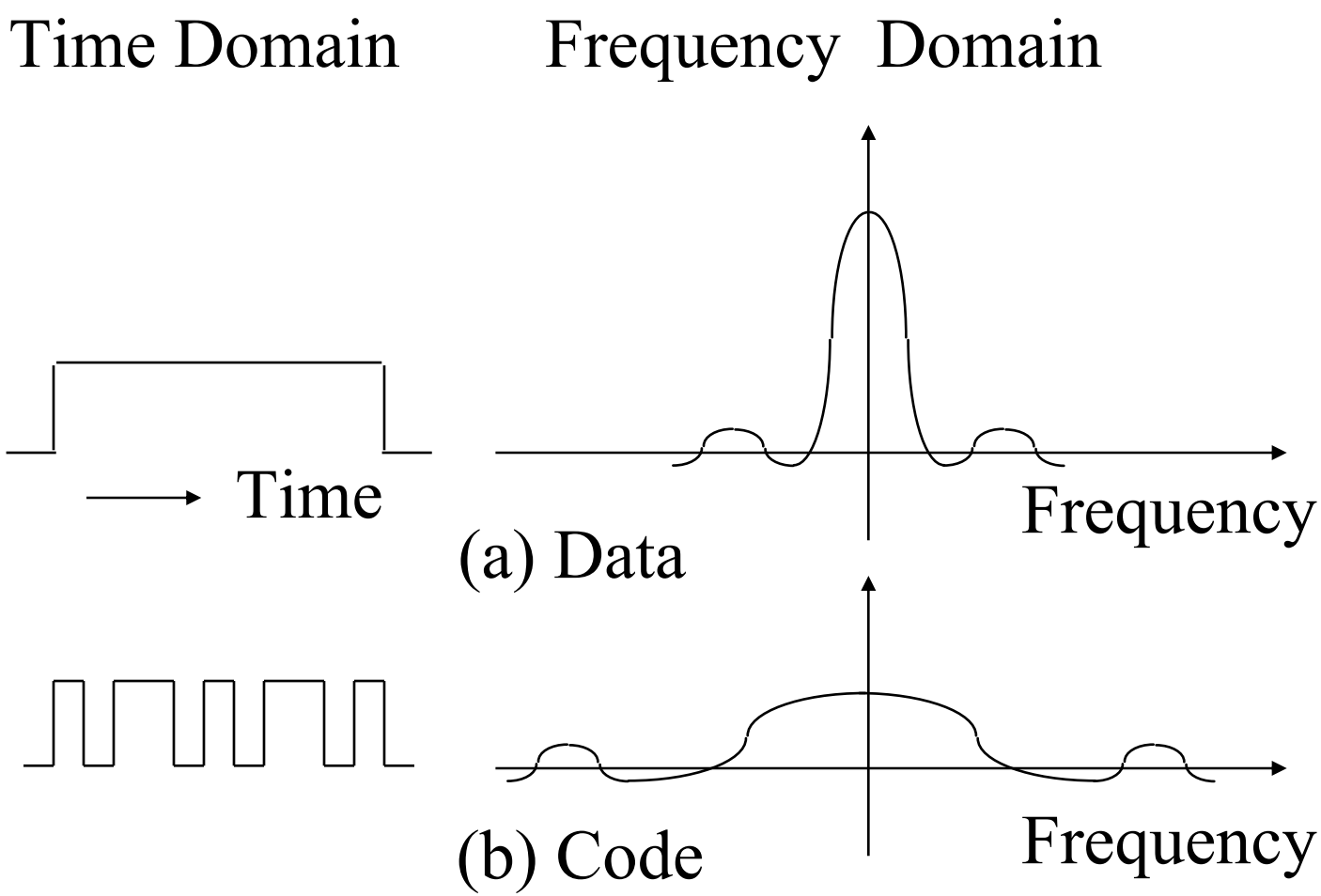
(a) Normal (b) Frequency Hopping

Direct-Sequence Spread Spectrum

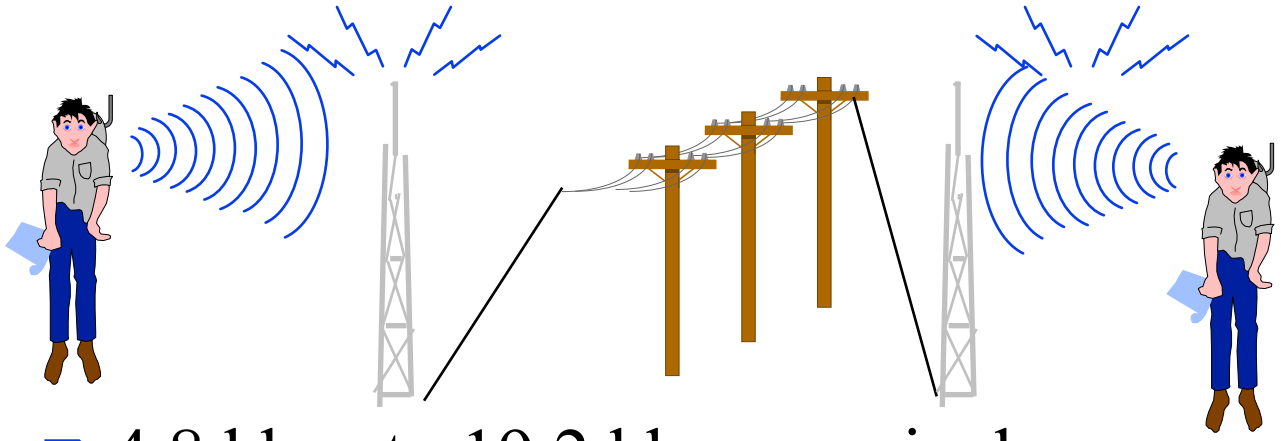


- Spreading factor = Code bits/data bit, 10-100 commercial (Min 10 by FCC), 10,000 for military
- Signal bandwidth >10 × data bandwidth
- Code sequence synchronization
- Correlation between codes ⇒Interference⇒ Orthogonal

DS Spectrum


Time Domain
Frequency Domain
Time
Frequency
(a) Data
Frequency
(b) Code

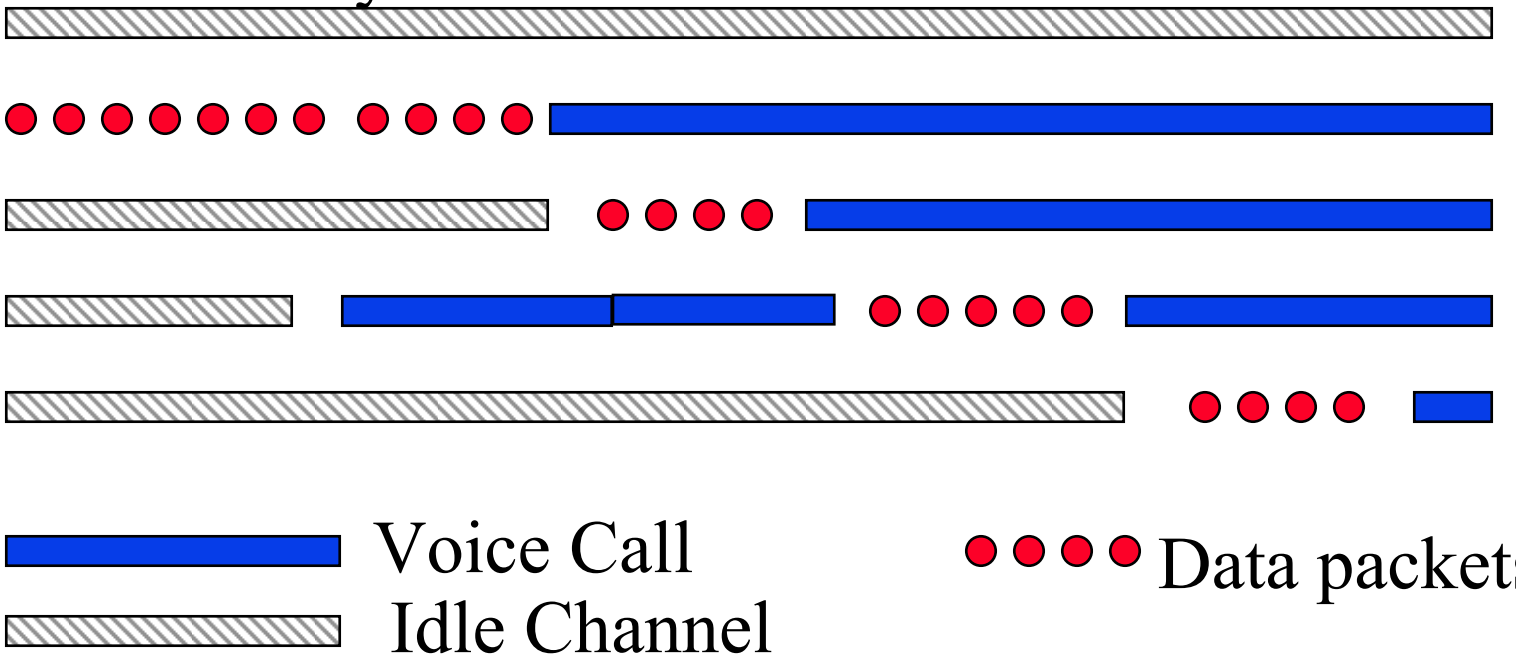
Wireless WAN Services



- 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 Metricom

Cellular Digital Packet Data (CDPD)

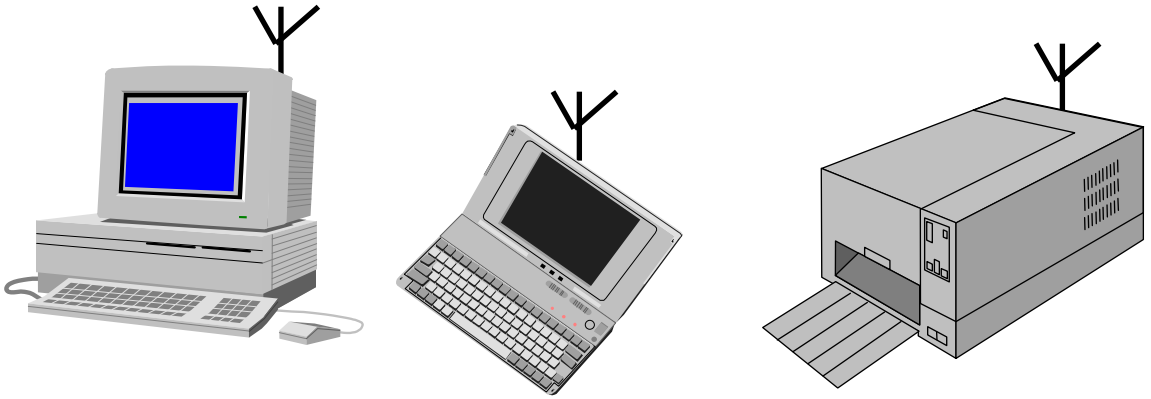
- Originally named "Celluplan" by IBM
- Allows data to use idle cellular channels
- Data hops from one channel to next as the channels become busy or idle



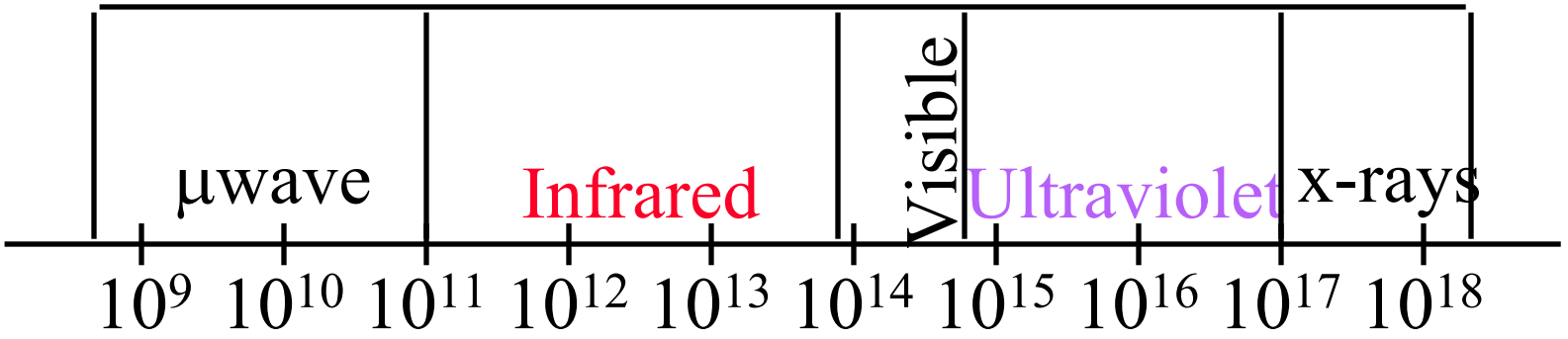
CDPD

- Backed by 9 major service providers
- Nationwide cellular packet data service
- Connectionless and connection-oriented service
  Connectionless ⇒ No ack, no guarantees
  Connection-oriented ⇒ reliable delivery, sequencing, flow control
- Point-to-point and multipoint connections
- Quickly hops-off a channel grabbed by cellular system. Currently, dedicated channels.

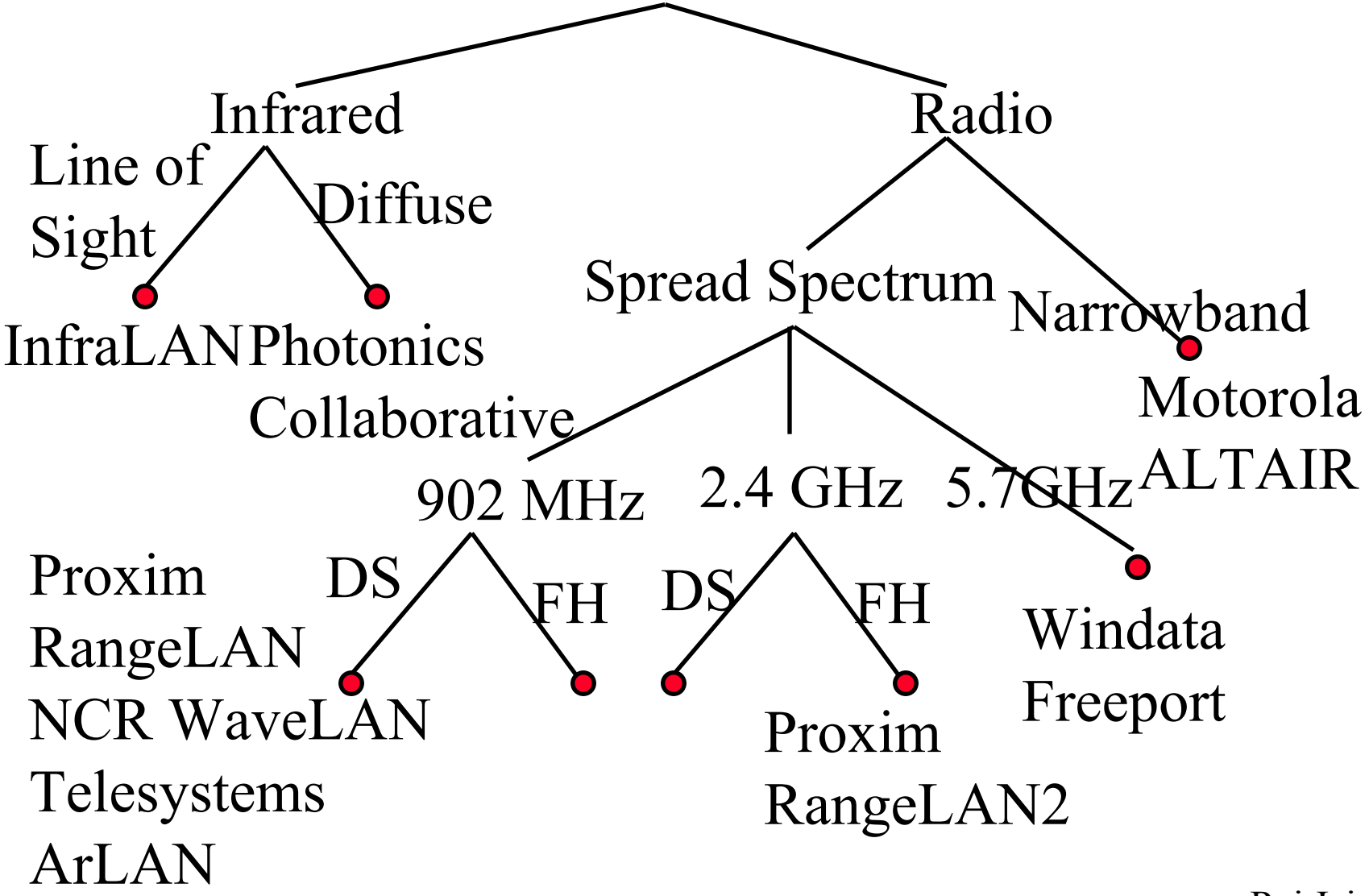
Wireless LANs



- IR ⇒ Line of sight, short range, indoors
- RF ⇒ Need license
- Spread-Spectrum: Resistance to interference



Wireless LANs



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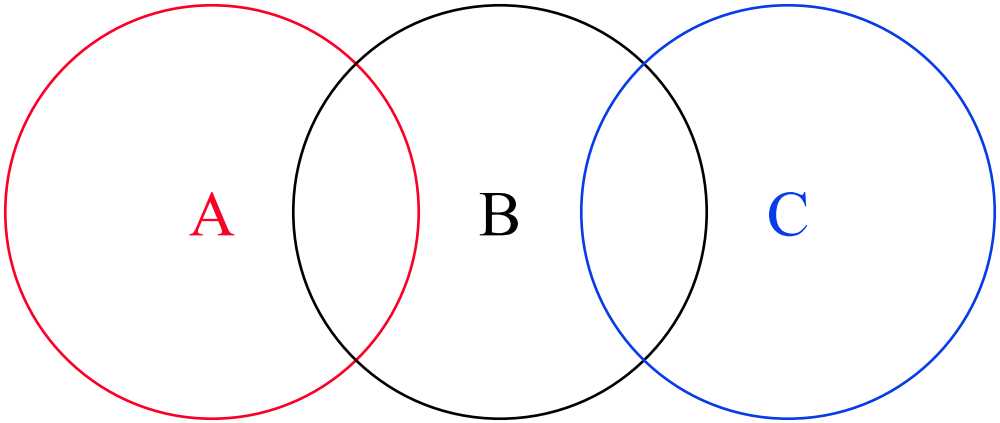
IEEE 802.11 Features

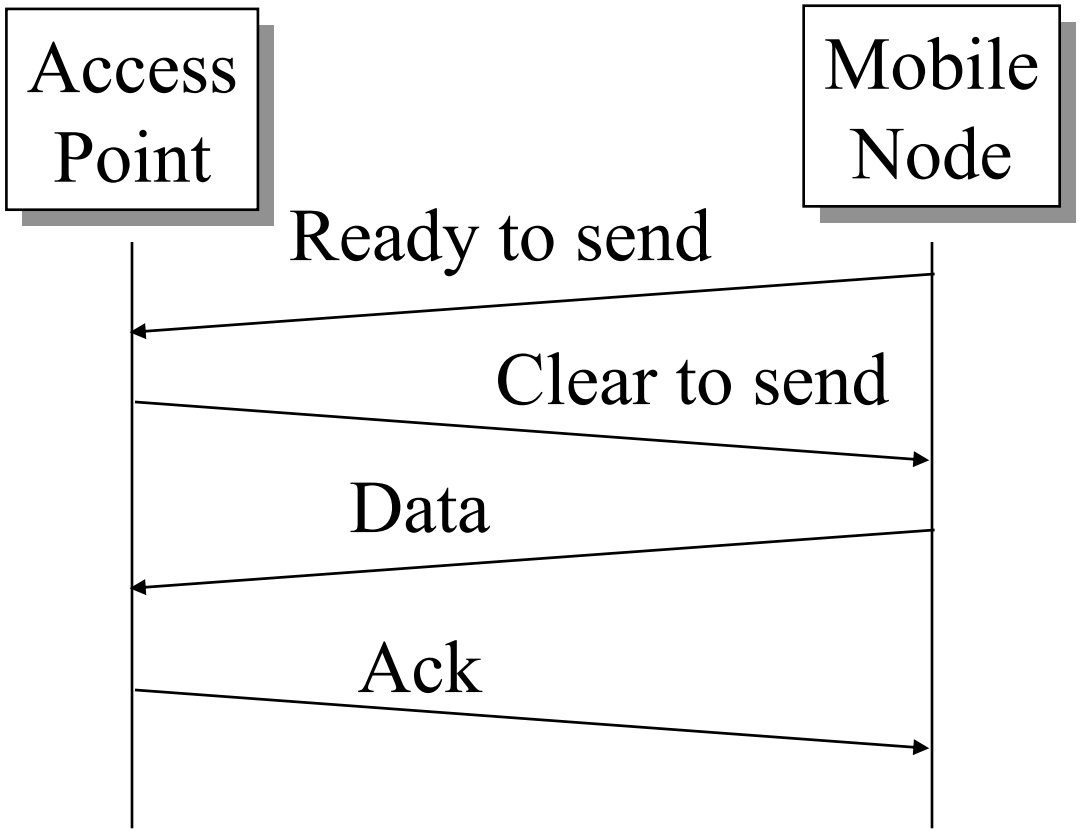
- 1 and 2 Mbps
- Supports both Ad-hoc and base-stations
- Spread Spectrum ⇒ No licensing required.
  Three Phys: Direct Sequence, Frequency Hopping, 915-MHz, **2.4 GHz** (Worldwide ISM), 5.2 GHz, and Diffused Infrared (850-900 nm) bands.
- Supports multiple priorities
- Supports time-critical and data traffic
- Power management allows a node to doze off

Hidden Node Problem



- C cannot hear A.
  It may start transmitting while A is also transmitting
  $\Rightarrow$ A and C can't detect collision.
- Only the receiver can help avoid collisions

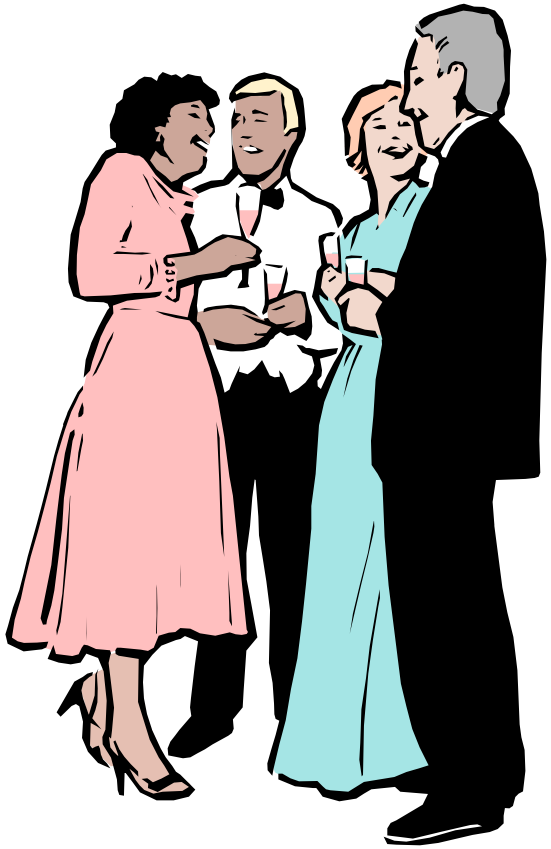
4-Way Handshake



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.

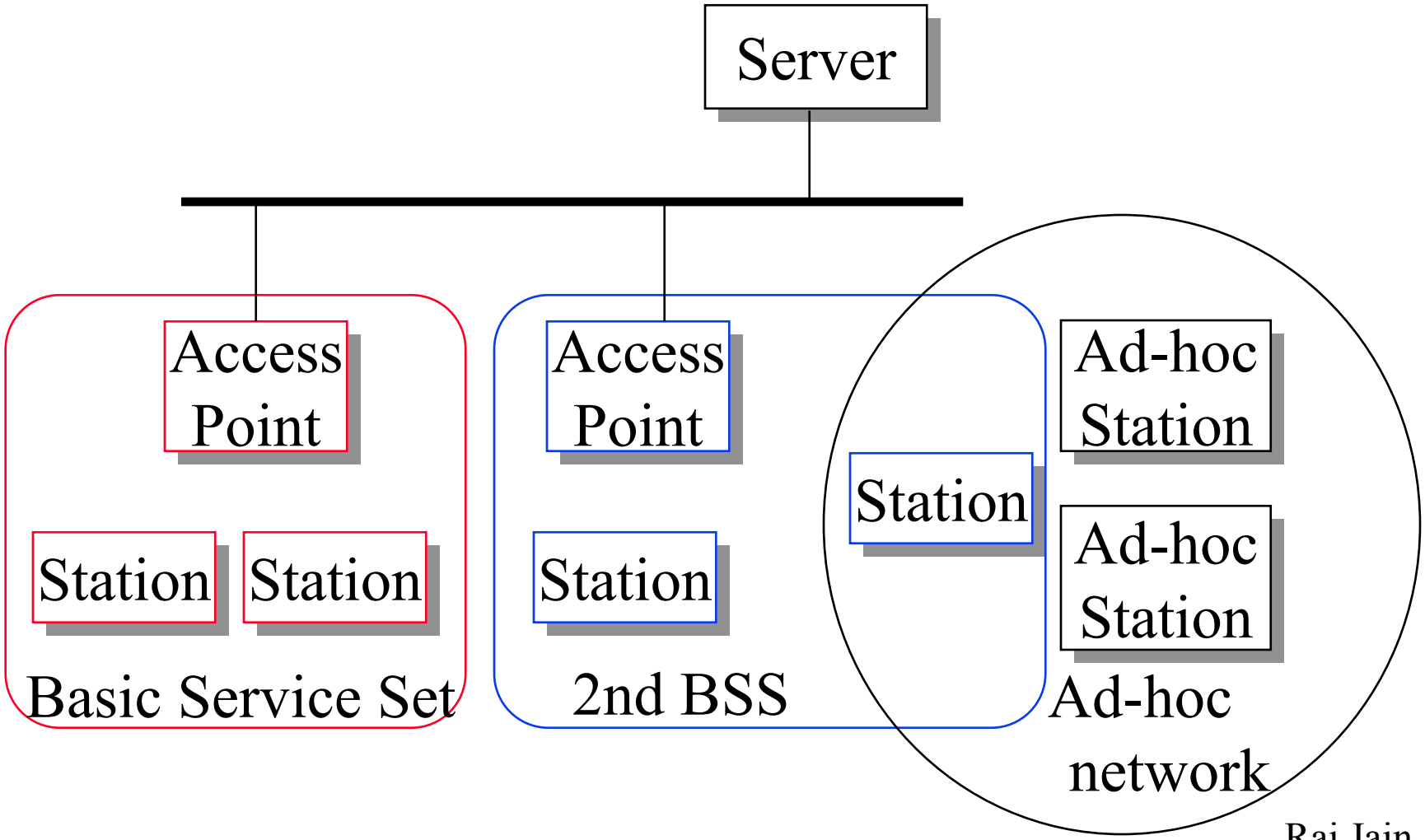
Ad-Hoc vs Infrastructure



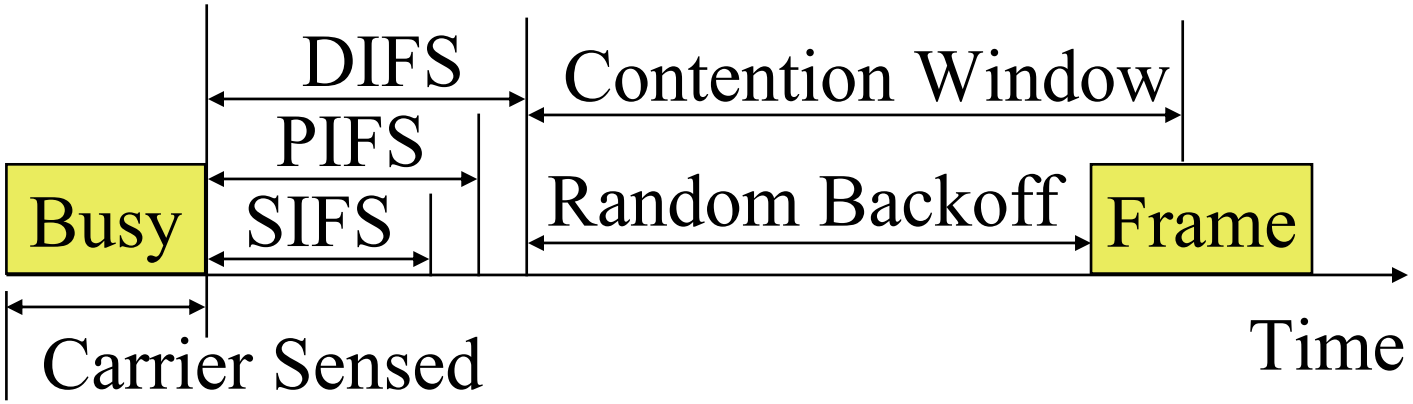
Peer-to-Peer or Base Stations?

- 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 ⇒ Scalable to large networks
- IEEE 802.11 provides both.

IEEE 802.11 Architecture

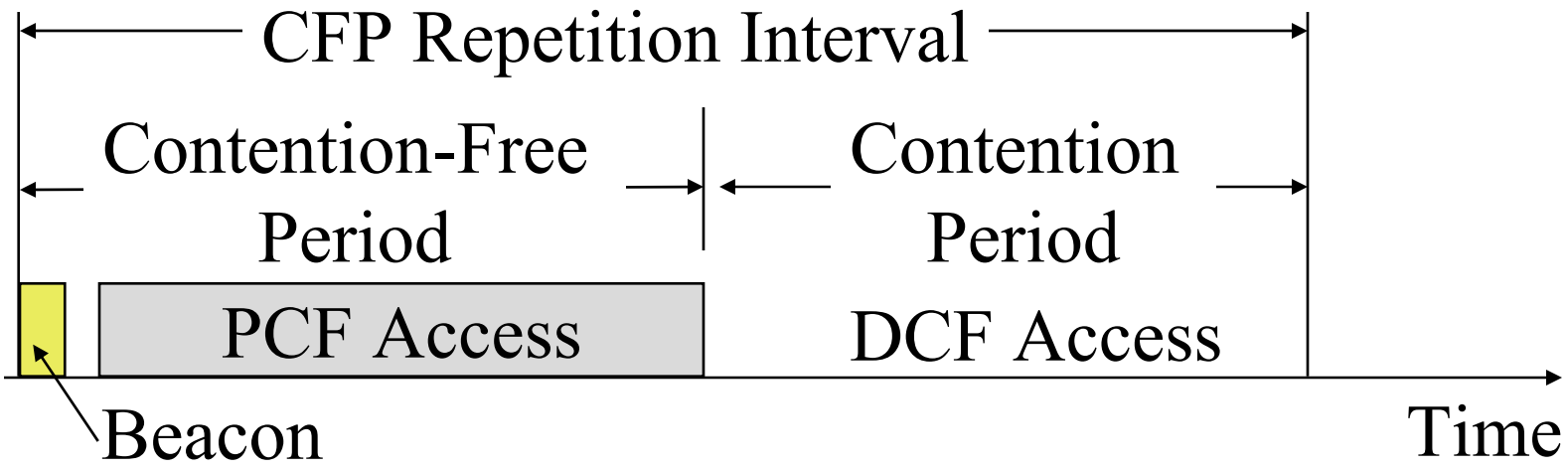


IEEE 802.11 Priorities



- Initial interframe space (IFS)
- Highest priority frames, e.g., Acks, use short IFS (SIFS)
- Medium priority time-critical frames use "Point 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
- 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.

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.

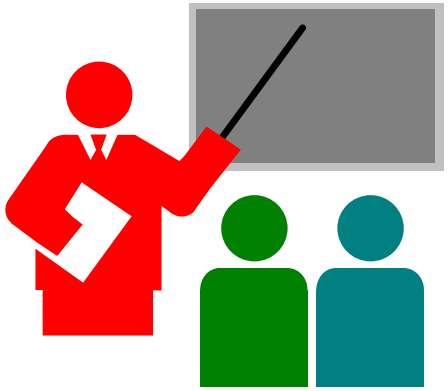
Status and Future

- 802.11 including both MAC and PHY approved June 1997.
- More bandwidth in future by:
  1. Better encoding: Multilevel modulation $\Rightarrow$ 8 Mbps
  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.

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