Wireless Data Networking

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- 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 $\Rightarrow$ 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 × data bandwidth
- Code sequence synchronization
- Correlation between codes ⇒ Interference ⇒ Orthogonal

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DS Spectrum

Time Domain

(a) Data

(b) Code

Frequency Domain

Frequency
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

Voice Call
Idle Channel

Data packets
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

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

<table>
<thead>
<tr>
<th>Wave</th>
<th>Frequency (GHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>μ wave</td>
<td>$10^9 - 10^{10}$</td>
</tr>
<tr>
<td>Infrared</td>
<td>$10^{11} - 10^{12}$</td>
</tr>
<tr>
<td>Visible</td>
<td>$10^{13} - 10^{14}$</td>
</tr>
<tr>
<td>Ultraviolet</td>
<td>$10^{15} - 10^{16}$</td>
</tr>
<tr>
<td>x-rays</td>
<td>$10^{17} - 10^{18}$</td>
</tr>
</tbody>
</table>

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Wireless LANs

- Infrared
  - Line of Sight
  - Diffuse

- Spread Spectrum
  - 902 MHz
  - 2.4 GHz
  - 5.7 GHz

- Radio
  - Narrowband
    - Motorola
    - ALTAIR
  - Collaborative
    - InfraLAN
    - Photonics
    - NCR WaveLAN
    - Telesystems
    - ArLAN

- Proxim
  - DS
    - FH
  - RangeLAN
  - Freeport

- Windata
  - FH
  - RangeLAN2

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

- Access Point
- Station
- Basic Service Set
- Access Point
- Station
- 2nd BSS
- Station
- Ad-hoc Station
- Ad-hoc Station
- Ad-hoc network

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IEEE 802.11 Priorities

- Initial interframe space (IFS)
- Highest priority frames, e.g., Acknowledgements, use short IFS (SIFS)
- Medium priority time-critical frames use “Point Coordination Function IFS” (PIFS)
- Asynchronous data frames use “Distributed coordination function IFS” (DIFS)
Timer 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.
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 cktts 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