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
Wireless ATM
Mobile IP
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
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

\[
\text{Frequency} \quad \begin{array}{c}
\text{Time} \\
\hline
\end{array}
\]

50 ms
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

(a) Data

(b) Code

Frequency Domain
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

![Diagram showing voice call, idle channel, and data packets]

Voice Call

Idle Channel

Data packets
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.
Metricom

- Spread-Spectrum in 902-928 MHz band
- In-building, campus, and metropolitan area networking
- Nearby units can communicate directly.
- If the intended destination is not directly reachable, go via a “node” through the network. Up to 56 kbps.
- Nodes are cheap (less than $1,000)
- Flat monthly rate based on speed only

Ref: http://www.metricom.com/ricohom.html
Wireless LANs

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

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<th>µwave</th>
<th>Infrared</th>
<th>Visible</th>
<th>Ultraviolet</th>
<th>x-rays</th>
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Wireless LANs

- Infrared
  - Line of Sight
  - Diffuse
    - InfraLAN
    - Photonics

- Radio
  - Spread Spectrum
    - 902 GHz
    - 2.4 GHz
    - 5.7 GHz

- Narrowband
  - Motorola
  - ALTAIR

- Collaborative
  - Proxim
  - RangeLAN
  - NCR WaveLAN

- Windata
  - Freeport

- FHDS DS FH
  - Proxim
  - RangeLAN2
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
C cannot hear A.
   It 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

Access Point

Ready to send

Clear to send

Data

Ack

Mobile Node
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 ⇒ Each packet is acked.
- MAC level retransmission if not acked.
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

- Server
- Access Point
- Station
- Basic Service Set
- 2nd BSS
- Station
- Ad-hoc Station
- Ad-hoc Station
- Ad-hoc network
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)
Contention-Free Period

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.
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 chts off.
Wireless ATM

- Group officially began August 96
- Wireless Access Layer (WAL) includes PHY, MAC, and LLC layers.
- M = Mobility enhanced = Handoff, Location, QoS
- PNNI’, UNI’, BICI’ support transport of mobility info

<table>
<thead>
<tr>
<th>AAL</th>
<th>ATM</th>
<th>WAL</th>
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**User Plane**

<table>
<thead>
<tr>
<th>PNNI + M, UNI + M, B-ICI + M</th>
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<th>WAL</th>
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<tbody>
<tr>
<td>Signaling AAL</td>
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**Control Planes**

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The Ohio State University

Raj Jain
Reference Configurations

- Fixed Wireless
- End user mobility
- Network mobility
- Ad-hoc
Mobile IP: Features

- You can take you notebook to any location
- Finds nearby IP routers and connects *automatically*. You don't even have to find a phone jack.
- Only "Mobility Aware" routers and mobile units need new s/w. Other routers and hosts can use current IP
- No new IP addresses or address formats
- Secure: Allows authentication
- Also supports mobile networks (whole airplane/car load of mobile units)
Mechanism (Cont)

- Mobile node finds foreign agents via solicitation or advertising
- Mobile registers with the foreign agents and informs the home agent
- Home agent intercepts mobile node's datagrams and forwards them to the care-of-address
- Care-of-address (COA): Address of the end-of-tunnel towards the mobile node. May or may not be foreign agent
- At COA, datagram is extracted and sent to mobile
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 ATM work is just beginning
- Mobile IP allows a node to move with same address
Wireless: Key References

- For a detailed list of references see: http://www.cis.ohio-state.edu/~jain/refs/wir.refs.htm
References (Cont)

Credits

This MBone transmission was made possible by:

- Mark Fullmer, OSU/UTS
- Mike Iverson, OSU/UTS
- Mike Douglas, OSU/UTS
- Jayaraman Iyer, OSU/CIS
- Sohail Munir, OSU/CIS