Wireless LAN Networks

Updated: 5/10/2011
Introduction

☐ Refer to notes
802 Protocols

- The services and protocols specified in IEEE 802 map to the lower two layers
  - Data Link and Physical
  - IEEE 802 splits the OSI Data Link Layer into two sub-layers named
    - Logical Link Control (LLC)
    - Media Access Control (MAC)

## 802 Protocols

<table>
<thead>
<tr>
<th>name</th>
<th>description</th>
<th>note</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE 802.1</td>
<td>Bridging (networking) and Network Management</td>
<td>inactive</td>
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<tr>
<td>IEEE 802.2</td>
<td>Logical link control</td>
<td>inactive</td>
</tr>
<tr>
<td>IEEE 802.3</td>
<td>Ethernet</td>
<td></td>
</tr>
<tr>
<td>IEEE 802.4</td>
<td>Token bus</td>
<td>disbanded</td>
</tr>
<tr>
<td>IEEE 802.5</td>
<td>Defines the MAC layer for a Token Ring</td>
<td>inactive</td>
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<tr>
<td>IEEE 802.6</td>
<td>Metropolitan Area Networks</td>
<td>disbanded</td>
</tr>
<tr>
<td>IEEE 802.7</td>
<td>Broadband LAN using Coaxial Cable</td>
<td>disbanded</td>
</tr>
<tr>
<td>IEEE 802.8</td>
<td>Fiber Optic TAG</td>
<td>disbanded</td>
</tr>
<tr>
<td>IEEE 802.9</td>
<td>Integrated Services LAN</td>
<td>disbanded</td>
</tr>
<tr>
<td>IEEE 802.10</td>
<td>Interoperable LAN Security</td>
<td>disbanded</td>
</tr>
<tr>
<td>IEEE 802.11 a/b/g/n</td>
<td>Wireless LAN (WLAN) &amp; Mesh (Wi-Fi certification)</td>
<td>disbanded</td>
</tr>
<tr>
<td>IEEE 802.12</td>
<td>demand priority</td>
<td></td>
</tr>
<tr>
<td>IEEE 802.13</td>
<td>Not used (officially)</td>
<td></td>
</tr>
<tr>
<td>IEEE 802.14</td>
<td>Cable modems</td>
<td>disbanded</td>
</tr>
<tr>
<td>IEEE 802.15</td>
<td>Wireless PAN</td>
<td>disbanded</td>
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<tr>
<td>IEEE 802.15.1</td>
<td>Bluetooth certification</td>
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<tr>
<td>IEEE 802.15.2</td>
<td>IEEE 802.15 and IEEE 802.11 coexistence</td>
<td></td>
</tr>
<tr>
<td>IEEE 802.15.3</td>
<td>High-Rate WPAN certification</td>
<td></td>
</tr>
<tr>
<td>IEEE 802.15.4</td>
<td>Low-rate WPAN certification</td>
<td></td>
</tr>
<tr>
<td>IEEE 802.15.5</td>
<td>Mesh networking for WPAN</td>
<td></td>
</tr>
<tr>
<td>IEEE 802.16</td>
<td>Broadband Wireless Access (WiMAX certification)</td>
<td></td>
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<tr>
<td>IEEE 802.16e</td>
<td>(Mobile) Broadband Wireless Access</td>
<td></td>
</tr>
<tr>
<td>IEEE 802.16.1</td>
<td>Local Multipoint Distribution Service</td>
<td></td>
</tr>
<tr>
<td>IEEE 802.17</td>
<td>Resilient packet ring</td>
<td></td>
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<td>IEEE 802.18</td>
<td>Radio Regulatory TAG</td>
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<td>IEEE 802.19</td>
<td>Coexistence TAG</td>
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<td>IEEE 802.20</td>
<td>Mobile Broadband Wireless Access</td>
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<td>IEEE 802.21</td>
<td>Media Independent Handoff</td>
<td></td>
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<td>IEEE 802.22</td>
<td>Wireless Regional Area Network</td>
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<td>IEEE 802.23</td>
<td>Emergency Services Working Group</td>
<td></td>
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</tbody>
</table>
Wireless LAN Classifications & Implementations

- Remember what LAN is!
- LAN Classification according to transmission technology
  - Infrared (LAN)
  - Spread Spectrum
  - Narrowband Microwave
- Wireless implementation approaches
  - LAN Extension
  - Cross-building interconnect
  - Nomadic Access
  - Ad hoc networking
LAN Extension

- Wireless LAN linked into a wired LAN on same premises
  - Wired LAN
    - Backbone
    - Support servers and stationary workstations
  - Wireless LAN
    - Stations in large open areas
      - UM: User Modules (connected to CM)
      - CM: Control modules
    - Manufacturing plants, stock exchange trading floors, and warehouses
Multiple-cell Wireless LAN

Different Center Freq. Within the same band

Each cell topology can be p2p or hub-based

CM (control module) is connected to the backbone

Note this is a case with infrastructure (hub-based)

Figure 13.2 Example Multiple-Cell Wireless LAN Configuration
Different Center Freq. Within the same band

In this figure we Have MULTI-CELL Wireless LAN
One CM per CELL

CM provides Control Access to end users:
Who should talk!

Note this is a case with infrastructure (hub-based)

CM (control module) is connected to the backbone

Each cell topology can be p2p or hub-based

Figure 13.2 Example Multiple-Cell Wireless LAN Configuration
Cross-Building Interconnect

- Another wireless implementation approaches
- Connecting LANs in nearby buildings
  - Wired or wireless LANs
- Point-to-point wireless link is used
  - Devices connected are typically bridges or routers
Nomadic Access

- Wireless link between LAN hub and mobile data terminal equipped with antenna
  - Laptop computer or notepad computer
- In this case nomadic stations can move from one cell to another
  - The network has an infrastructure
- Uses:
  - Transfer data from portable computer to office server
  - Extended environment such as campus
Ad Hoc Networking

- Temporary peer-to-peer network set up to meet immediate need
  - No infrastructure
  - A peer collection of nodes dynamically configure themselves
  - There are no cells or control modules!

- Example:
  - Group of employees with laptops convene for a meeting; employees link computers in a temporary network for duration of meeting
Wireless LAN Requirements

- Throughput
- Number of nodes
- Connection to backbone LAN
- Service area
- Battery power consumption
- Transmission robustness and security
- Collocated network operation (interface between LANs)
- License-free operation
- Handoff/roaming (Operated by the MAC)
- Dynamic configuration (automatic deletion, and addition)

In many cases these are conflicting requirements!
Kiviat Graph

(a) Wired LANs

(b) Wireless LANs

(c) Mobile data networks
Wireless LAN Categories

- Infrared (IR) LANs
- Spread spectrum LANs
- Narrowband microwave
## Technology Comparison

<table>
<thead>
<tr>
<th></th>
<th>Diffused Infrared</th>
<th>Directed Beam Infrared</th>
<th>Frequency Hopping</th>
<th>Direct Sequence</th>
<th>Narrowband Microwave</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data Rate (Mbps)</strong></td>
<td>1 to 4</td>
<td>1 to 10</td>
<td>1 to 3</td>
<td>2 to 20</td>
<td>10 to 20</td>
</tr>
<tr>
<td><strong>Mobility</strong></td>
<td>Stationary/mobile</td>
<td>Stationary with LOS</td>
<td>Mobile</td>
<td>Stationary/mobile</td>
<td></td>
</tr>
<tr>
<td><strong>Range (m)</strong></td>
<td>15 to 60</td>
<td>25</td>
<td>30 to 100</td>
<td>30 to 250</td>
<td>10 to 40</td>
</tr>
<tr>
<td><strong>Detectability</strong></td>
<td>Negligible</td>
<td></td>
<td>Little</td>
<td></td>
<td>Some</td>
</tr>
<tr>
<td><strong>Wavelength/ frequency</strong></td>
<td>$\lambda: 800$ to $900 \text{ nm}$</td>
<td>$2.4$ to $2.4835 \text{ GHz}$</td>
<td>$902$ to $928 \text{ MHz}$</td>
<td>$5.2$ to $5.775 \text{ GHz}$</td>
<td>$902$ to $928 \text{ MHz}$</td>
</tr>
<tr>
<td><strong>Modulation technique</strong></td>
<td>ASK</td>
<td>FSK</td>
<td>QPSK</td>
<td>FS/QPSK</td>
<td></td>
</tr>
<tr>
<td><strong>Radiated power</strong></td>
<td>—</td>
<td>$&lt;1 \text{ W}$</td>
<td></td>
<td>$25 \text{ mW}$</td>
<td></td>
</tr>
<tr>
<td><strong>Access method</strong></td>
<td>CSMA</td>
<td>Token Ring, CSMA</td>
<td>CSMA</td>
<td></td>
<td>Reservation ALOHA, CSMA</td>
</tr>
<tr>
<td><strong>License required</strong></td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
<td>Yes unless ISM</td>
</tr>
</tbody>
</table>

**Carrier Sense Multiple Access (CSMA)**
Strengths of Infrared Over Microwave Radio

- Infrared spectrum **unregulated worldwide**
  - Spectrum for infrared virtually **unlimited**
  - Possibility of high data rates
- Equipment **inexpensive** and simple
- Reflected by **light-colored** objects
  - Ceiling reflection for entire room coverage
- Doesn’t **penetrate** walls
  - More easily secured against eavesdropping
  - Less interference between different rooms
Drawbacks of Infrared Medium

- Outdoor environments experience infrared background radiation
  - Sunlight and indoor lighting
  - Ambient radiation appears as noise in an infrared receiver
  - Transmitters of higher power required
    - Limited by concerns of eye safety and excessive power consumption
  - Range limitation
IR Data Transmission Techniques

- Directed Beam Infrared
- Ominidirectional
- Diffused
Directed Beam Infrared

- Used to create point-to-point links
- Range depends on emitted power and degree of focusing
- Focused IR data link can have range of kilometers
  - Cross-building interconnect between bridges or routers
Ominidirectional

- Single base station within line of sight of all other stations on LAN
- Station typically mounted on ceiling
- Base station acts as a multiport repeater
  - Ceiling transmitter broadcasts signal received by IR transceivers
  - IR transceivers transmit with directional beam aimed at ceiling base unit
Diffused

- All IR transmitters focused and aimed at a point on \textit{diffusely reflecting} ceiling
- IR radiation strikes ceiling
  - Reradiated omnidirectionally
  - Picked up by all receivers
Spread Spectrum LAN Configuration

- Multiple-cell arrangement
- Within a cell, either peer-to-peer or hub
- Peer-to-peer topology
  - No hub
  - Access controlled with MAC algorithm
    - CSMA
  - Appropriate for ad hoc LANs
Spread Spectrum LAN Configuration

- Hub topology
  - Connected to backbone
  - May control access
  - May act as multiport repeater
  - Automatic handoff of mobile stations

- Stations in cell either:
  - Transmit to / receive from hub only
  - Broadcast using omnidirectional antenna
Narrowband Microwave LANs

- Use of a microwave radio frequency band for signal transmission
- Relatively narrow bandwidth
- Licensed Narrowband
  - Controlled by FCC
- Interference free
  - Each geographic area has a radius of 28Km – 5 licenses / 10 frequencies
  - Motorola holds 600 licenses in 18-GHz band!
- Unlicensed
  - Low power / 2-5 GHz
Homework –

☐ Read Chapter 11: 329-348
☐ Read chapter 13
☐ Read the following papers and write one page summary for each (Note: the final-exam will include some of the issues discussed in these papers! Read them carefully)
  - **Wireless LAN design** alternatives Bantz, D.F. Bauchot, F.J. IBM Thomas J. Watson Res. Center, Yorktown Heights, NY;
  - **Wireless Infrared Communications**, JOSEPH M. KAHN, MEMBER, IEEE, AND JOHN R. BARRY
    http://www-ee.stanford.edu/~jmk/pubs/proc.ieee.2.97.pdf (relatively old but you the idea)