Convergence...

- Operational Portability
- Installation Flexibility
- Anytime/Anywhere Computing and Communications

- Computing
  - Mainframes
  - Minicomputers
  - PCs/Workstations
  - Mobile Computers

- Communications
  - Leased Low-Speed Lines
  - Modems
  - LANs
  - Wireless Communications
Wireless LANs - Introduction

- The goal: make the air look like a LAN
- Primary applications
  - Reduce costs - moves/add/changes, etc.
  - Simplify installation
    - Time or physical constraints
  - In-building and campus mobility
- Modern systems are little more complicated than wired LANs
  - Only minimal knowledge of radio issues is required

Wireless LANs - Advantages and Disadvantages

- Advantages
  - Fast, easy installation (well, mostly!)
  - Recoverable investment
  - Goes where wire can't
  - Enables dynamic mobility
- Disadvantages
  - Larger up-front investment (usually)
  - Lower measured performance (usually)
  - Radio/IR propagation issues - uncertainty
**Wireless Network Topologies**

- **Three (Wireless) Topologies:**
  - **Peer-to-Peer**
    - Every node must "see" every other node
    - Performance can suffer as network grows
    - Best for small, simple networks
    - Can be extended with access points
  - **Hub**
    - Central hub enforces radio protocol
    - Hub is logical place to connect to backbone
    - But: cost; single point of failure
    - Hubs are evolving into access points
  - **Microcellular**

---

**Peer vs. Hub Topologies**

- **Peer:** Each system must "see" every other
- **Hub:** Each system must "see" only a central hub
**Access Points and Roaming**

- An "access point" provides a bridge from wireless to wire
- A "repeater" extends the range of a signal
- "Microcellular" architectures - similar in concept to the cellular phone system, with handoffs between access points
- A "wire protocol" is used for communication between access points
- Power management is always an issue
- Most systems use RF - Spectrix uses IR

**Roaming - A Schematic**

![Diagram showing wireless access points and roaming within microcells](source: Farpoint Group)
**Interface Options**

- **Two System Interface Choices:**
  - **Network Replacement** - physical and data-link layers. Custom boards, adapters, drivers
  - **Wire Replacement** - physical layer only. "Looks like" wire; no software impacts
    - A wired network adapter (NIC) is required
    - Makes moving between wireless and wired easy

**Operational Modes**

- **Two Form Factors:**
  - **Stationary/Fixed**
    - Advantage: AC power
    - Disadvantage: AC power
    - Justification: cost savings; rapid deployment; wire-to-the-desktop replacement
  - **Portable/Mobile**
    - Light weight; usually low power
    - "Relocatable" or "operationally portable"
  - The most important trend is to mobility extended by access points
**Wireless LANs - Throughput**

- Take whatever the vendor tells you and derate it by 50-66%
  - Not really that different from wire!
- The environment is always a factor - and it can change from moment to moment
- Benchmarking is very difficult
- Perceived performance is more important than real performance

**Performance - Key Variables**

- The distance/data-rate inverse problem
- Antenna type and placement
- Physical topology and building construction (or terrain)
- Prevailing RF environment
- Allotted bandwidth
- Modulation (including spread-spectrum if used)
- Radio design
- Network OS and protocols
- A spectrum analyzer can be used for initial evaluation and troubleshooting
**Range (Distance)**

- Two arguments:
  - More is better (the traditional high-power approach)
  - Small is beautiful (microcells and roaming)
- In the US, the FCC allows up to 1W plus 6 db (4X power)
- A major objective should be to make the best possible use of a scarce resource - the radio spectrum
  - Regulatory concerns play a major role
  - Improvements in radio design - there are no regulatory limits, for example, on receiver gain...

**Security**

- Spread-spectrum is "inherently" secure
- Many product offer security codes and data scrambling
- 100% security is an abstract, theoretical concept
- Encryption is always advisable - even on wire!
  - It is easier to tap a wired LAN than a wireless LAN!
- More networks will adopt security features over time
  - Limited security exists in the draft 802.11 standard
**Safety**

- This is the only wireless issue which cannot be adequately addressed today
  - Too many unknowns; very difficult to evaluate
  - Low-frequency radiation issues - MPR-II rules
  - The medical equipment/cellular phone issue
  - No documented health/safety effects for limited exposure
  - Be prudent, not paranoid

---

**Wireless Bridges**

- A fixed application
- Licensed - to T3 (45 Mbps)
- Infrared - to 155 Mbps; 900 feet
- Unlicensed - 2-10 Mbps; a few miles
- Line-of-sight is usually required
- Primarily used for internetworking (LAN bridging), and, increasingly, Internet access
  - Voice is sometimes optional in the form of a T1 subchannel
- New 10 Mbps unlicensed products with link costs below $10K
### Wireless LAN Product Classes

- Proprietary (the majority)
- 802.11 (single MAC, multiple PHY)
- Wireless LAN Interoperability Forum (WLIF) - Proxim RangeLAN2
- Medium-Speed (3-4 Mbps)
  - Wave Access - Jaguar
- High-Speed (>5 Mbps)
  - Windata, Clarion; 3Com; RadioLAN
- SUPERNet; HIPERLAN
- ???

### Wireless LANs - Products, cont'd.

<table>
<thead>
<tr>
<th>Company</th>
<th>Product</th>
<th>Technology</th>
<th>Topology</th>
<th>System Interface</th>
<th>Versions</th>
<th>Range (manufacturer specifications)</th>
<th>Performance (manufacturer specifications)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aironet Wireless Communications</td>
<td>ARLAN 1000/2000 Series</td>
<td>DSSS (902 and 2.4)</td>
<td>Micro-cellular</td>
<td>Network replacement</td>
<td>ISA, Micro-Channel, PC Card, parallel, access point, bridge</td>
<td>300-1000 feet</td>
<td>1.35 Mbps (902 MHz); 2 Mbps (2.4 GHz.)</td>
</tr>
<tr>
<td>Aironet Wireless Communications</td>
<td>ARLAN 3000 Series</td>
<td>FH (2.4)</td>
<td>Micro-cellular</td>
<td>Network replacement</td>
<td>PC Card, access point</td>
<td>500-1000 feet</td>
<td>1 Mbps</td>
</tr>
<tr>
<td>BreezeCom</td>
<td>BreezeNET</td>
<td>FHSS (2.4)</td>
<td>Micro-cellular</td>
<td>Wire replacement (Ethernet)</td>
<td>10baseT hub, PC Card, access point</td>
<td>200-600 feet (offices); 3000 feet (maximum)</td>
<td>3 Mbps</td>
</tr>
<tr>
<td>Clarion</td>
<td>MerLAN M19</td>
<td>DS (2.4)</td>
<td>Peer</td>
<td>Wire replacement (Ethernet)</td>
<td>External transceiver</td>
<td>3000 feet</td>
<td>10 Mbps</td>
</tr>
</tbody>
</table>

Source: Farpoint Group
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<tbody>
<tr>
<td>IBM</td>
<td>IBM Wireless LAN</td>
<td>FHSS (2.4)</td>
<td>Hub with roaming</td>
<td>Network replacement</td>
<td>ISA/MC and PC Card</td>
<td>1600 feet (maximum)</td>
<td>.5 - 1.2 Mbps (nominally 1 Mbps)</td>
</tr>
<tr>
<td>IBM</td>
<td>IBM Wireless LAN Entry</td>
<td>FHSS (2.4)</td>
<td>Micro-cellular</td>
<td>Network replacement</td>
<td>PC Card, access point</td>
<td>1200 feet (maximum)</td>
<td>350 Kbps</td>
</tr>
<tr>
<td>JVC</td>
<td>VIPSLAN-10</td>
<td>Directed IR</td>
<td>Peer</td>
<td>Wire replacement (Ethernet)</td>
<td>Satellite/Node PC Card/Mobile</td>
<td>33 feet (long range); 3 feet (short range)</td>
<td>10 Mbps</td>
</tr>
<tr>
<td>Lucent Technologies</td>
<td>WaveLAN</td>
<td>DSSS (902)</td>
<td>Micro-cellular</td>
<td>Network replacement</td>
<td>ISA, PC Card, access point</td>
<td>800 feet</td>
<td>2 Mbps</td>
</tr>
<tr>
<td>Netwave Technologies</td>
<td>Netwave</td>
<td>FHSS (2.4)</td>
<td>Micro-cellular</td>
<td>Network replacement</td>
<td>PC Card, parallel, access point</td>
<td>50-50 meters</td>
<td>1 Mbps</td>
</tr>
<tr>
<td>OTC Telecom</td>
<td>AirEZY</td>
<td>DSSS (902)</td>
<td>Peer</td>
<td>Wire replacement (Ethernet)</td>
<td>External transceiver</td>
<td>500 feet</td>
<td>1 Mbps</td>
</tr>
<tr>
<td>Proxim</td>
<td>RangeLAN2</td>
<td>FHSS (2.4)</td>
<td>Micro-cellular</td>
<td>Network replacement</td>
<td>ISA, PC Card, parallel, access point</td>
<td>800 feet</td>
<td>1.6 Mbps</td>
</tr>
<tr>
<td>Raytheon</td>
<td>Raylink</td>
<td>FH (2.4)</td>
<td>Micro-cellular</td>
<td>Network replacement</td>
<td>ISA, PC Card, access point</td>
<td>500-800 feet</td>
<td>2 Mbps</td>
</tr>
<tr>
<td>RDC Networks</td>
<td>PortLAN</td>
<td>FH (2.4)</td>
<td>Micro-cellular</td>
<td>Network replacement</td>
<td>ISA, PC Card, access point</td>
<td>150-450 feet</td>
<td>1 Mbps</td>
</tr>
<tr>
<td>Spectrix</td>
<td>SpectrixLite</td>
<td>Diffuse IR</td>
<td>Micro-cellular</td>
<td>Network replacement</td>
<td>Serial port, PC Card, access point</td>
<td>50 feet</td>
<td>4 Mbps</td>
</tr>
<tr>
<td>Symbol Technologies</td>
<td>Spectrum 24</td>
<td>FHSS (2.4)</td>
<td>Micro-cellular</td>
<td>Network replacement</td>
<td>ISA, PC Card, access point</td>
<td>180-250 feet (typical); 1000 feet (open office)</td>
<td>1 Mbps</td>
</tr>
</tbody>
</table>

Source: Farpoint Group
## Wireless LANs - Products

<table>
<thead>
<tr>
<th>Company</th>
<th>Product</th>
<th>Technology</th>
<th>Topology</th>
<th>System Interface</th>
<th>Versions</th>
<th>Range (manufacturer specifications)</th>
<th>Performance (manufacturer specifications)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wave Access</td>
<td>Jaguar</td>
<td>FH (2.4)</td>
<td>Microcellular</td>
<td>Network replacement</td>
<td>PC Card, access point</td>
<td>450 feet</td>
<td>3.2 Mbps</td>
</tr>
<tr>
<td>Windata</td>
<td>FreePort</td>
<td>DS (2.4 and 5.7)</td>
<td>Hub</td>
<td>Wire replacement (Ethernet)</td>
<td>External transceiver, hub</td>
<td>260 feet</td>
<td>5.7 Mbps</td>
</tr>
</tbody>
</table>

*Source: Farpoint Group*

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## Aironet - ARLAN 2000/3000 Series

- Part of Telxon; acquired Telesystems SLW - first roaming system
- Very broad and complete product line
- 902-928 and 2.4 GHz. models (really two separate product lines)
- Can be used with wired LAN adapter for simple bridge
- New 3000 series - 2.4 GHz., FH, one-piece

<table>
<thead>
<tr>
<th>Radio Technology</th>
<th>DSSS, 902-928 MHz. and 2.4 GHz.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configurations/Prices</td>
<td>ISA ($845/945), PCMCIA ($645/745), Access Point ($1,995/2,495), Bridge ($2,495/2,995)</td>
</tr>
<tr>
<td>Throughput</td>
<td>1.35 Mbps (902 MHz.); 2 Mbps (2.4 GHz.)</td>
</tr>
<tr>
<td>Range</td>
<td>1000 feet (open office), 300 feet (typical), 150 feet (closed office)</td>
</tr>
<tr>
<td>Features</td>
<td>More than 8 million system IDs for security; optional boot ROM</td>
</tr>
</tbody>
</table>
**BreezeCom - BreezeNET**

- Claimed high throughput; low price
- Wire-replacement
- 802.11 Draft D2 compliant
- DSP-based
- Fault-tolerant "WIX" architecture
- Sales through VARs, SIs, OEMs
- Second-generation product set announced with raytheon

<table>
<thead>
<tr>
<th>Radio Technology</th>
<th>FHSS, 2.4 GHz.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configurations/Prices</td>
<td>10baseT adapter ($695/1 port; $995/4 ports), PCMCIA ($395), Access Point ($1,295)</td>
</tr>
<tr>
<td>Throughput</td>
<td>3 Mbps (fallback to 2 and 1 Mbps)</td>
</tr>
<tr>
<td>Range</td>
<td>200-600 feet (office), 3000 feet (open space)</td>
</tr>
<tr>
<td>Features</td>
<td>SNMP; diversity antenna; downloadable firmware; roaming speeds to 25 MPH</td>
</tr>
</tbody>
</table>

**DEC - A Radio-Independent Infrastructure Provider**

- DEC's mission is the overall network, not wireless
- Supplies a "universal" access point - uses PCMCIA radio
  - Standalone and DEC hub versions
  - Also sold by Solectek
- Mobile IP roaming software

<table>
<thead>
<tr>
<th>Radio Technology</th>
<th>AT&amp;T WaveLAN; Proxim RangeLAN2; others possible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configurations/Prices</td>
<td>Access Point ($1,903), Bridge (N/A)</td>
</tr>
<tr>
<td>Throughput</td>
<td>Depends upon radio</td>
</tr>
<tr>
<td>Range</td>
<td>Depends upon radio</td>
</tr>
<tr>
<td>Features</td>
<td>PCMCIA slot; BNC and RJ-45 ports</td>
</tr>
</tbody>
</table>
**IBM - IBM Wireless LAN**

- Requires OS/2-based "base station" system; acts as controller and bridge to wire
- Uses TDMA over the air
- Three-year warranty
- Sold via "Options by IBM" PC add-on operation
- AS/400 wireless LAN is based on Aironet

<table>
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<tr>
<th>Radio Technology</th>
<th>FHSS, 2.4 GHz.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configurations/Prices</td>
<td>ISA/MCA ($795), PCMCIA ($795)</td>
</tr>
<tr>
<td>Throughput</td>
<td>.5 - 1.2 Mbps</td>
</tr>
<tr>
<td>Range</td>
<td>120-180 M (open office), 25-60 M (typical), 15-30 M (closed office)</td>
</tr>
<tr>
<td>Features</td>
<td>Antenna cable extension (170M, $495); SNMP; compression; encryption</td>
</tr>
</tbody>
</table>

**IBM - IBM Wireless LAN Entry**

- Not compatible with IBM Wireless LAN
- Separate, dedicated access point (model 8227)
- Unique hemispherical antenna
- One-piece PCMCIA design
- Also: IR system licensed from Photonics

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<th>FHSS, 2.4 GHz.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configurations/Prices</td>
<td>PCMCIA ($445), Access point ($1.350)</td>
</tr>
<tr>
<td>Throughput</td>
<td>350 Kbps</td>
</tr>
<tr>
<td>Range</td>
<td>1200 feet (maximum)</td>
</tr>
<tr>
<td>Features</td>
<td>SNMP; optimized for low power consumption; bridge software included with access point</td>
</tr>
</tbody>
</table>
**Lucent Technologies (and OEMs) - WaveLAN**

- One of the oldest wireless LAN products
- Originally developed by NCR for retail systems
- Strong OEM channels
- A volume leader
- Often wins published benchmarks
- Good large-account support
- New dual-PC Card access point

<table>
<thead>
<tr>
<th><strong>Radio Technology</strong></th>
<th>DSSS, 902-928 MHz. (2.4 GHz. in Europe)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Configurations/Prices</strong></td>
<td>ISA ($695), PCMCIA ($695), Access Point ($1,995)</td>
</tr>
<tr>
<td><strong>Throughput</strong></td>
<td>2 Mbps</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>120-180 M (open office), 25-60 M (typical), 15-30 M (closed office)</td>
</tr>
<tr>
<td><strong>Features</strong></td>
<td>Optional DES encryption, boot ROM, point-to-point diagnostics</td>
</tr>
</tbody>
</table>

"The WaveLAN Mafia"

- Digital Equipment Corp. - DEC WaveLAN (ISA, PCMCIA, Access Point)
- Digital Ocean - Grouper (Macintosh/Newton)
- Persoft - Intersect Concentrator and Remote Bridge
- Pure Data - PureLAN
- Solectek - AirLAN (ISA, Parallel, PCMCIA, Access Point, Bridge)
- New Media (PCMCIA and software)
  - Interoperability is not implied here
**Netwave Technologies - Netwave**

- The first one-piece RF PCMCIA adapter
- Originally developed and sold by Xircom
- Product line has been spun off to Netwave Technologies

<table>
<thead>
<tr>
<th></th>
<th>Radio Technology</th>
<th>Configurations/Prices</th>
<th>Throughput</th>
<th>Range</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FHSS, 2.4 GHz.</td>
<td>PCMCIA ($399), Access Point ($1,499)</td>
<td>1 Mbps</td>
<td>40 - 50 meters (typical)</td>
<td>Power management; encryption; compact access point (token ring version announced)</td>
</tr>
</tbody>
</table>

**Proxim - RangeLAN2**

- One of the oldest wireless companies (1984)
- Second-generation product (original RangeLAN was 902 MHz., DSSS, 242 Kbps)
- OEM orientation
- Building-to-building bridge (RangeLink) also available

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<tr>
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<th>Range</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FHSS, 2.4 GHz.</td>
<td>PCMCIA ($695), Access point ($1,895)</td>
<td>1.6 Mbps</td>
<td>500 feet (typical), 1000 feet (open office)</td>
<td>SNMP; site-survey tools; power management; 15 channels (hopping patterns)</td>
</tr>
</tbody>
</table>
Symbol Technologies - Spectrum/24

- Company is a leader in data collection systems
- Second-generation product (replaces 9.6 Kbps Spectrum/1)
- One-piece PCMCIA adapter
- Direct sales to end users
- Empasizing future 802.11 compatibility

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<tr>
<th>Radio Technology</th>
<th>FHSS, 2.4 GHz.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configurations/Prices</td>
<td>PCMCIA ($895), Access point ($1,895)</td>
</tr>
<tr>
<td>Throughput</td>
<td>1 Mbps</td>
</tr>
<tr>
<td>Range</td>
<td>180-250 feet (typical), 1000 feet (open office)</td>
</tr>
<tr>
<td>Features</td>
<td>SNMP; Flash ROM; Optional external antenna; Optional NetVISION configuration/management tool</td>
</tr>
</tbody>
</table>

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