Presentation Outline

• Historical Overview
• Radio Fundamentals
• US Developments in PCS
• Mobile Data
• Satellite Systems
• Problems with existing schemes
• Wireless Overlay Networks
• US Government Research Initiatives
Wide Area Mobile Data Services

- ARDIS
- EMBARC
- MobileComm
- Nextel
- RadioMail
- RAM Mobile Data
- SkyTel
- CDPD
- Metricom Richocet
ARDIS

- IBM, Motorola
- Originally designed for service dispatch
- 400 Metro Areas, 90% business coverage
- High transmit power for building penetration
- Multiple transmitters per region
- 4.8 Kbps, upgrading to 19.2 Kbps
- Two-way capability
- Nationwide roaming recently introduced
EMBARC

- Motorola
- 931 MHz paging frequency
- Email broadcasting, one-way
- Used for news feeds
- Satellite transmission to groundstations for local/regional retransmission
- 300 bps
- Different priority levels: standby (as available), express (1 hour), priority (15 minutes)
MobileComm

- BellSouth Enterprises
- Text messaging, one-way paging
- Up to 500 characters in length
- Single large regional transmitter
- Nationwide coverage
- ASAP, standard, overnight priorities
- PCMCIA cards for popular PDAs
Nextel

- Special Mode Radio (SMR)
- Based on Motorola MIRS technology
- Integrated voice, dispatch, data services
- Store and forward messaging: hold and deliver when terminal is in range
- TDMA, 6 conversations per channel
- Many basestations per region/cellular system
- 800 MHz band
RadioMail

• RadioMail Corp., San Mateo, CA
• 2-way wireless electronic messaging
• EMail gateway services: performs integration and format conversion across heterogeneous networks
• Operates on top of ARDIS or RAM Mobile Data RF networks
RAM Mobile Data

- RAM Broadcasting Corp., New York
- 2-way data communications services
- 90% urban business area coverage
- Based on Ericsson Mobitex technology
- Packet-switched data, 8 kbps
- Hierarchical architecture of intelligent base stations and switches
- Supports roaming, store-and-forward messaging, TCP/IP interfaces
SkyTel

- SkyTel Corp., Washington, DC
- First satellite-based paging service
- Alphanumeric paging
- 4.8 Kbps, 240 character messages max
- 2-way paging systems being deployed
Cellular Digital Packet Data

- IBM, McCaw Cellular
- Data network overlay on analog cellular telephone system
- Uses same 30 KHz channels @ 800 MHz; potentially same coverage as cellular system
- Schedule data packets to unused voice channels
- (Up to) 19.2 kbps
- Provides IP packet service
Cellular Digital Packet Data

Intermediate System:
Routes to Corporate and Value-Added networks like the Internet

Mobile Data Intermediate System:
Mobility management

Mobile Data Base Station:
Collocated with cellular MTSO
Manages cells/air interfaces

Mobile End Station:
terminal, laptop
Metricom

- Microcellular “packet relay” network
- 1-5 mile cell diameter
- Poletap radios: 100 kbps, geographic routing
- Wired access points: every 2-3 hops to keep latencies low (approx. 100 ms)
- User modems: 20-30 kbps effective data rate
- Uses 902-928 MHz ISM band and 1W transmitters
- Available in SF Bay Area and Redmond, WA
## Wide Area Mobile Data Summary

<table>
<thead>
<tr>
<th>Metric</th>
<th>ARDIS</th>
<th>Mobitex</th>
<th>CDPD</th>
<th>IS-95</th>
<th>TETRA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Band</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Base TX (Mhz):</td>
<td>(800 Band, 45 kHz sep.)</td>
<td>935-940</td>
<td>869-894</td>
<td>869-894</td>
<td>(400 and 900 Bands)</td>
</tr>
<tr>
<td>Mobile TX (Mhz):</td>
<td>25 kHz (U.S.)</td>
<td>896-901</td>
<td>824-849</td>
<td>824-849</td>
<td>25 kHz</td>
</tr>
<tr>
<td>RF Ch. Spacing</td>
<td>FDMA/DSMA</td>
<td>FDMA/DSMA</td>
<td>FDMA/DSMA</td>
<td>FDMA/CDMA-SS</td>
<td>FDMA/DSMA&amp;SAPR</td>
</tr>
<tr>
<td>Channel Access</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Multiuser Access</td>
<td></td>
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<tr>
<td>Modulation Method</td>
<td></td>
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</tr>
<tr>
<td>Channel Rate (kb/s)</td>
<td>FSK, 4-FSK 19.2</td>
<td>GMSK 8.0</td>
<td>GMSK 19.2</td>
<td>4-PSK/DSSS 9.6</td>
<td>PI/4-QDPSK 36</td>
</tr>
<tr>
<td>Packet Length</td>
<td>up to 256 bytes (HDLC)</td>
<td>up to 512 bytes</td>
<td>24 to 928 bits</td>
<td>(packet service TBD)</td>
<td>192 bits (short)</td>
</tr>
<tr>
<td>Open Architecture</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Private or Public Carrier</td>
<td>Private</td>
<td>Public</td>
<td>Public</td>
<td>Public</td>
<td>Public</td>
</tr>
<tr>
<td>Service Coverage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major Metro. Areas in US</td>
<td></td>
<td></td>
<td>All AMPS areas</td>
<td>All CDMA cellular areas</td>
<td>European Trunked Radio</td>
</tr>
<tr>
<td>Type of Coverage</td>
<td>In-building and Mobile</td>
<td>In-building and Mobile</td>
<td>Mobile</td>
<td>Mobile</td>
<td>Mobile</td>
</tr>
</tbody>
</table>
## Local Area Mobile Data

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Link Rate</th>
<th>User Rate</th>
<th>Protocol</th>
<th>Access</th>
<th># of chan/spread factor</th>
<th>Mod/Coding</th>
<th>Power</th>
<th>Network Topology</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-19 GHz</td>
<td>15 Mbps</td>
<td>5.7 Mbps</td>
<td>Ethernet</td>
<td></td>
<td></td>
<td>4-level FSK</td>
<td>25 mW peak</td>
<td>8 devices per radio</td>
</tr>
<tr>
<td>902-928 MHz</td>
<td>2 Mbps</td>
<td>1.6 Mbps</td>
<td>Ethernet-like</td>
<td>DS SS</td>
<td></td>
<td>DQPSK</td>
<td>250 mW</td>
<td>peer-to-peer</td>
</tr>
<tr>
<td>902-928 MHz</td>
<td>2 Mbps</td>
<td>2 Mbps</td>
<td>Ethernet</td>
<td>DS SS</td>
<td></td>
<td>DQPSK</td>
<td>250 mW</td>
<td>radio to hub</td>
</tr>
<tr>
<td>902-928 MHz</td>
<td>16 Mbps</td>
<td>5.7 Mbps</td>
<td>Ethernet</td>
<td>DS SS</td>
<td>32 chips/bit</td>
<td>16 PSK trellis coding DQPSK</td>
<td>650 mW</td>
<td>Hub</td>
</tr>
<tr>
<td>902-928 MHz</td>
<td>2 Mbps</td>
<td>2 Mbps</td>
<td>Ethernet, Token Ring</td>
<td>DS SS</td>
<td></td>
<td>DQPSK</td>
<td>250 mW</td>
<td>Hub</td>
</tr>
<tr>
<td>902-928 MHz</td>
<td>38.4 kbps</td>
<td>X.25</td>
<td>SS</td>
<td>20 users/ch; 4 chan</td>
<td></td>
<td>Unconventional</td>
<td>20 mW</td>
<td>peer-to-peer</td>
</tr>
<tr>
<td>902-928 MHz</td>
<td>20 Mbps</td>
<td>1.5 Mbps/ch</td>
<td>Ethernet, Token ring</td>
<td>CDMA/TDMA</td>
<td>3 ch 10-15 links</td>
<td>Unconventional</td>
<td>30 mW</td>
<td>peer-to-peer</td>
</tr>
<tr>
<td>902-928 MHz</td>
<td>242 kbps</td>
<td>242 kbps</td>
<td>Ethernet</td>
<td>SS</td>
<td>3/3 channels</td>
<td>Unconventional</td>
<td>100 mW</td>
<td>peer-to-peer</td>
</tr>
</tbody>
</table>

**Manufacturers:**
- Altair-II
- Moto
- WaveLAN
- AT&T
- AirLAN
- Solectek
- Freeport
- Windata
- Intersect
- Persoft
- LAWN
- O’Neil
- WiLAN
- WI-LAN
- RadioPort
- ALPS
## Local Area Mobile Data

<table>
<thead>
<tr>
<th>Freq (MHz)</th>
<th>Link Rate</th>
<th>User Rate</th>
<th>Protocol</th>
<th>Access</th>
<th># of chan/spread factor</th>
<th>Mod/Coding</th>
<th>Power</th>
<th>Network Topology</th>
</tr>
</thead>
<tbody>
<tr>
<td>902-928</td>
<td>1.35 Mbps</td>
<td>Ethernet</td>
<td>SS</td>
<td></td>
<td></td>
<td></td>
<td>1 W</td>
<td>Radio to hub</td>
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<tr>
<td>2.4 GHz</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>max</td>
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<tr>
<td>902-928</td>
<td>250 kbps</td>
<td>64 kbps</td>
<td></td>
<td>FH SS</td>
<td>250 ms/hop 500 Khz</td>
<td></td>
<td>100 mW</td>
<td>Hub</td>
</tr>
<tr>
<td>MHz</td>
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<td></td>
<td></td>
<td></td>
<td>spacing 3 Channels</td>
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</tr>
<tr>
<td>RangeLAN</td>
<td>242 kbps</td>
<td>Ethernet, Token ring</td>
<td>DS SS</td>
<td>100 mW</td>
<td>peer-to-peer, bridge</td>
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<td>Proxim</td>
<td>50 kbps max</td>
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<td>Hub</td>
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<tr>
<td>2.4 Ghz</td>
<td>1.6 Mbps</td>
<td>Ethernet, Token ring</td>
<td>FH SS</td>
<td>100 mW</td>
<td>Hub</td>
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<td></td>
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<td></td>
<td></td>
<td>10 chan@5 kbps/ch, 15 subch each</td>
<td>16 PSK Trellis coding</td>
<td>100 mW</td>
<td></td>
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<tr>
<td>RangeLAN2</td>
<td>82 1 Mhz ch.</td>
<td></td>
<td>Ethernet, Token Ring</td>
<td>FH SS</td>
<td>Hub</td>
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<tr>
<td>Proxim</td>
<td>5.7 Mbps</td>
<td>Ethernet</td>
<td>DS SS</td>
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<td>Hub</td>
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<tr>
<td>2.4 and 5.8 GHz</td>
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<td>Netwave</td>
<td>1 Mbps</td>
<td>Ethernet</td>
<td>DS SS</td>
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