CS 294-7: Wide-Area Mobile Data Systems

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Wide Area Mobile Data Services

• Messaging Systems
  – EMBARC
  – MobileComm
  – SkyTel

• Data Overlays
  – Nextel
  – CDPD

• Wide-Area Data Systems & Services
  – ARDIS
  – RAM Mobile Data
  – RadioMail
  – Metricom Ricochet
Wide Area Mobile Data Services

- Messaging Systems
- Data Overlays
- Wide-Area Data Systems & Services
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
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
Wide Area Mobile Data Services

- Messaging Systems
- Data Overlays
- Wide-Area Data Systems & Services
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
CDPD

- McCaw, IBM
- Cellular Digital Packet Data overlay on existing analog cellular system
- Signaling rates at 19.2 kbps
- Widely available in metropolitan areas
- Full IP connectivity
Wide Area Mobile Data Services

- Messaging Systems
- Data Overlays
- Wide-Area Data Systems & Services
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 9.6 Kbps (12.5 KHz) and 19.2 Kbps (25 KHz channel)
• Two-way capability
• Nationwide roaming recently introduced
**ARDIS**

- **Access Protocol**
  - Slotted digital sense multiple access (DSMA)
  - BS sending an outbound message, MS must wait a random amount of time between 0-50 ms
  - BS not sending, MS must wait to gain frame sync
  - MS detects frame sync, must check for channel status symbol at end of outbound message: indicates whether the next inbound slot is IDLE or BUSY; if BUSY, must wait 0-700 ms before trying again

<table>
<thead>
<tr>
<th>Base TX</th>
<th>Data 1</th>
<th>Data 2</th>
<th>Data 3</th>
<th>Idle Signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Busy/Idle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base RX</td>
<td>Data Packet</td>
<td>Ack 3</td>
<td>Ack 2</td>
<td>Ack 1</td>
</tr>
</tbody>
</table>

Acks have priority
Come in reverse sequence
ARDIS

- **RD-LAP**
  - Radio Data Link Access Procedure
  - 4 Level FSK, 4.8 kbaud symbol rate
  - Block coding, interleaving, CRC, ARQ all used:
    - Header block: 10 bytes + 16 bit CRC
    - Intermediate blocks: 12 bytes + 32 bit CRC
    - CRC2: second level 32 bit CRC calculated over all of the data
    - FEC applied to each 12 byte block
    - 96 bit blocks become 66 symbols after coding (32 three bit symbols) + one all zeros three bit symbol
    - Resulting 33 symbol string transformed into 66 four-level symbols, which are then interleaved to a depth of 8 levels for transmission
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 (840 BS, 40 switches in mainland US and Hawaii)
- Supports roaming, store-and-forward messaging, TCP/IP interfaces
RAM Mobile Data Architecture

Note: ARDIS uses a flat network architecture

X.25, LU6.2, TCP/IP, SNA 64 kbps
RAM Mobile Data

• Supports transparent roaming
  – Reregisters as mobile moves among base stations
  – Mobile *initiated* handoff: measures RSS, BER and chooses to reregister with a new, closer BS
  – Store-and-forward capability in modems and switches aka “mailbox facility”: keeps messages queued for some maximum time (e.g., 24 hrs)

• Multiple channels per service area
  – 10-30 channels typical (12.5 Khz channel bandwidth)
  – Frequency reuse/cell splitting supported
RAM Mobile Data/Mobitex

• Modified form of CSMA, with busy/idle bit (aka Inhibit Sense Multiple Access)
  – BS generates “sweep” message periodically, to broadcast network id and other parameter info
  – BS also sends Free Signal (FRI) messages: certain number of following slots available for random access
  – MS generates random number, determines which slot it will compete for; lowest number goes first
  – BS generates ACK to inhibit other MS from attempting access
  – If MSs collide, no ACK generated, and a higher number MS will compete for a later slot

• Not Reservation Aloha!
  – Does not require BS to tell MS when it can send
  – Messages up to 512 octets can be sent
  – Special SILENCE messages to inhibit other senders during long msgs
  – Max message size, # of random access slots, size of random access slots can be varied with traffic patterns
RAM Mobile Data/Mobitex

• **Mobitex Radio Framing**

<table>
<thead>
<tr>
<th>Frame Head</th>
<th>Primary Block (240 bits)</th>
<th>Following Block (240 bits)</th>
<th>Following Block (240 bits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>56 bits</td>
<td>6 octet addr + cntl + 12 octets data + 16 bit CRC</td>
<td>18 octets data + 16 bit CRC</td>
<td>18 octets data + 16 bit CRC</td>
</tr>
</tbody>
</table>

- 160 bits become 240 with (12,8) Hamming coding
- Single bit error correction, interleave depth 20 yields burst errors up to 20 bits long can be corrected
- Selective ARQ to retransmit block in error
# RAM Mobile Data/Mobitex

## Packet format (545 bytes)

<table>
<thead>
<tr>
<th>Sender (3 Bytes)</th>
<th>Addressee (3 Bytes)</th>
<th>Flag (1 Byte)</th>
<th>Packet Type (1 Byte)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optional Addressee List (22 Bytes)</td>
<td>Network Time Stamp (3 Bytes)</td>
<td>User Data (1 to 512 Bytes)</td>
<td></td>
</tr>
</tbody>
</table>

- Sender: Identifies sender (3 bytes)
- Addressee: Identifies receiver (3 bytes)
- Flag: Type of packet structure (1 byte)
- Packet Type: single address or address group
- Addressee List: identifies members of the address group
- Network Time Stamp: Date/timestamp
- User Data: 1 to 512 Bytes
RAM Mobile Data/Mobitex

<table>
<thead>
<tr>
<th>Customer App</th>
</tr>
</thead>
<tbody>
<tr>
<td>API</td>
</tr>
<tr>
<td>TCP/IP</td>
</tr>
<tr>
<td>Packet Driver</td>
</tr>
</tbody>
</table>

Mobile Host

RAM Mobile Data Services

Mobigate TCP/IP

TCP/IP API

Customer Host Computer
RAM Mobile Data/Mobitex

- **Effective data rate calculation:**
  - 512 data octets = 30 data blocks (MPAKs)
  - Minimum message takes 37 ms @ 8 kbps
  - Maximum message takes 907 ms
    » Total # of MPAKs = 30
    » # of Octets = 512
    » Time taken = 907 ms
    » Effective data rate = \( 512 \times \frac{8}{0.907} \) bps
      \( = 4.6 \) kbps
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
- Mid-1994: 1500 subscribers
RadioMail Hub Architecture

1. Translates addressing schemes and message formats
2. Routes messages to correct network address
3. Confirms delivery
RadioMail Software Components

• **Transport**
  – Links to transport layer of underlying network
  – Organizes messages into proper format
  – Uses compaction to conserve scarce bandwidth

• **Gateway**
  – Interconnects incompatible networks
  – Real-time format conversion
  – Automated billing, subscriber account management
  – Positive ACK to insure that messages are delivered

• **Interface & Applications**
  – Remote client message software
  – Composition, transmission, reading, disposal of messages
  – Filtering service
  – Mail-to-fax service
RadioMail API

- RadioMail API for Developers (RAPID)
  - “Mail enabled applications”: email, forms/database access, calendar scheduling, etc.
  - Message store & forward, guaranteed delivery, nationwide coverage, instant notification
  - Hides vagrancies of network connectivity from applications developers
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>(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>Base 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>Mobile TX (Mhz):</td>
<td>25 kHz</td>
<td>12.5 kHz</td>
<td>30 kHz</td>
<td>1.25 Mhz</td>
<td>FDMA/</td>
</tr>
<tr>
<td>RF Ch. Spacing</td>
<td>FDMA/</td>
<td>FDMA/</td>
<td>FDMA/</td>
<td>FDMA/</td>
<td>FDMA/</td>
</tr>
<tr>
<td>Channel Access</td>
<td>DSMA</td>
<td>Dynamic S-Aloha</td>
<td>DSMA</td>
<td>CDMA-SS</td>
<td>DSMA&amp;SAPR</td>
</tr>
<tr>
<td>Multiuser Access</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modulation Method</td>
<td>FSK, 4-FSK</td>
<td>GMSK</td>
<td>GMSK</td>
<td>4-PSK/DSSS</td>
<td>PI/4-QDPSK</td>
</tr>
<tr>
<td>Channel Rate (kbits/s)</td>
<td>19.2</td>
<td>8.0</td>
<td>19.2</td>
<td>9.6</td>
<td>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>
</tr>
<tr>
<td>Private or Public Carrier</td>
<td>Private</td>
<td>Private</td>
<td>Public</td>
<td>Public</td>
<td>Public</td>
</tr>
<tr>
<td>Service Coverage</td>
<td>Major Metro. Areas in US</td>
<td>Major Metro. Areas in US</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>
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</tbody>
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