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

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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)

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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
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- 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

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Wide Area Mobile Data Services

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

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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

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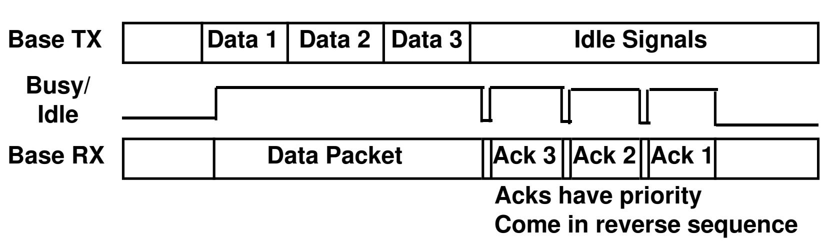
ARDIS

- 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



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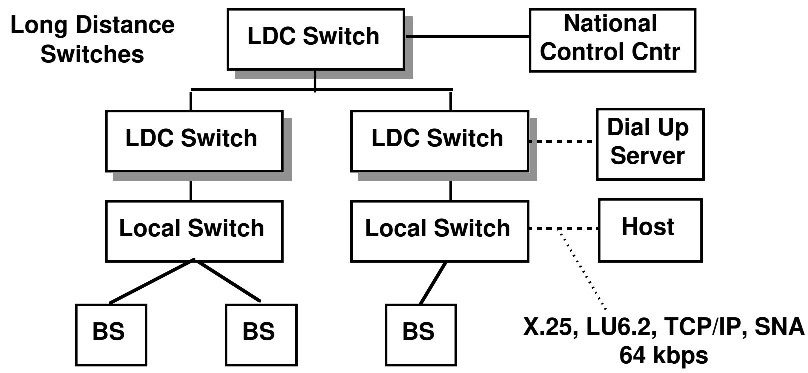
ARDIS

- **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

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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

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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

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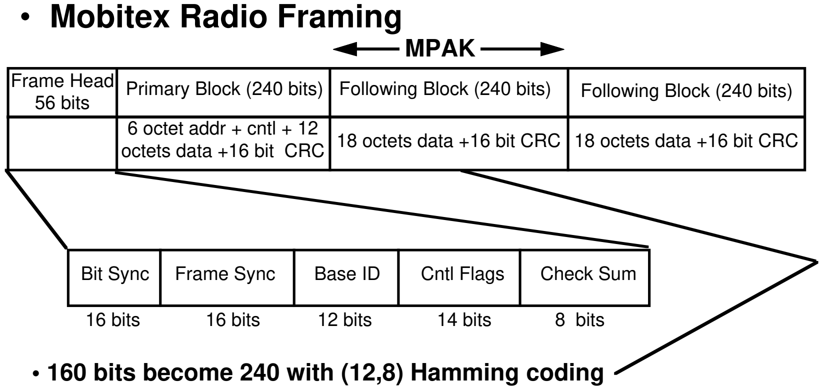
RAM Mobile Data/Mobitex

- **Mobitex Radio Framing**



- 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

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RAM Mobile Data/Mobitex

- **Packet format (545 bytes)**

<table>
<tr><td>Sender
(3 Bytes)</td><td>Addressee
(3 Bytes)</td><td>Flag
(1 Byte)</td><td>Packet Type
(1 Byte)</td></tr>
<tr><td colspan="2">Optional Addressee List
(22 Bytes)</td><td colspan="2">Network Time Stamp
(3 Bytes)</td></tr>
<tr><td colspan="4">User Data
(1 to 512 Bytes)</td></tr>
</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**

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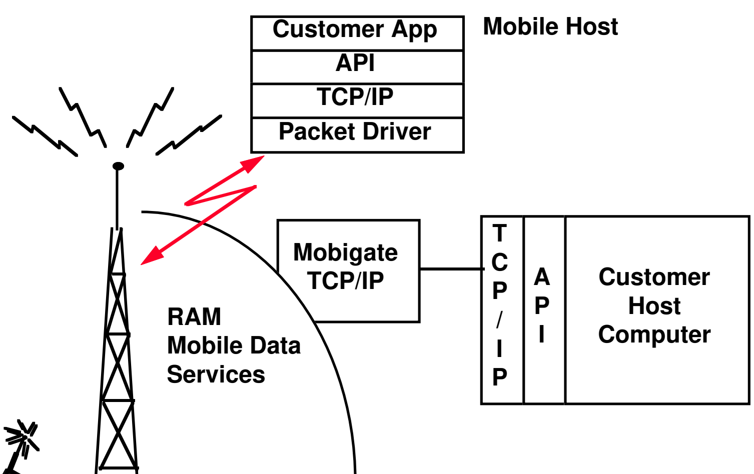
RAM Mobile Data/Mobitex



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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 x 8/0.907 bps
= 4.6 kbps

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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**

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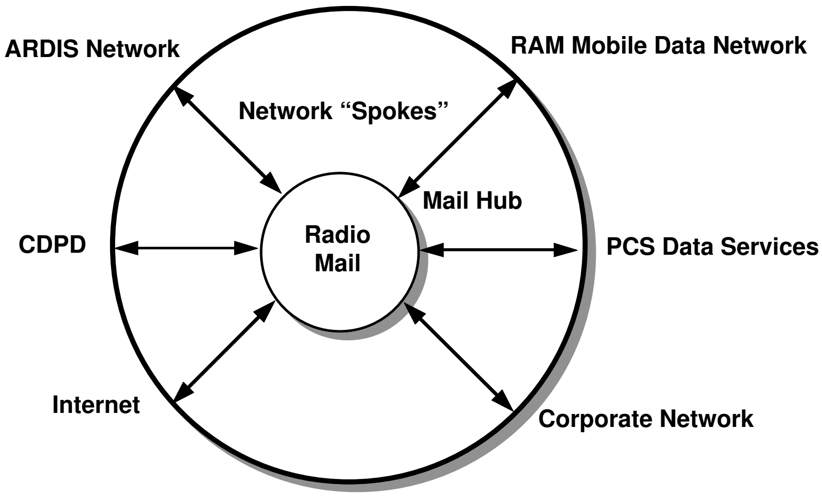
RadioMail Hub Architecture



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

Metric	ARDIS	Mobitex	CDPD	IS-95	TETRA
Frequency Band Base TX (Mhz): Mobile TX (Mhz):	(800 Band, 45 kHz sep.)	935-940 896-901	869-894 824-849	869-894 824-849	(400 and 900 Bands)
RF Ch. Spacing	25 kHz (U.S.)	12.5 kHz	30 kHz	1.25 Mhz	25 kHz
Channel Access Multiuser Access	FDMA/ DSMA	FDMA/ Dynamic S-Aloha	FDMA/ DSMA	FDMA/ CDMA-SS	FDMA/ DSMA&SAPR
Modulation Method	FSK, 4-FSK	GMSK	GMSK	4-PSK/DSSS	PI/4-QDPSK
Channel Rate (kbits/s)	19.2	8.0	19.2	9.6	36
Packet Length	up to 256 bytes (HDLC)	up to 512 bytes	24 [illegible] bits[illegible]	(pa[illegible] ser[illegible]TBD)	[illegible]s (short) [illegible]s (long)
Open Architecture	No	Yes	Yes	Yes	[illegible]
Private or Public Carrier	Private	Private	Public	Public	Public
Service Coverage	Major Metro. Areas in US	Major Metro. Areas in US	All AMPS areas	All CDMA cellular areas	European Trunked Radio
Type of Coverage	In-building and Mobile	In-building and Mobile	Mobile	Mobile	Mobile

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