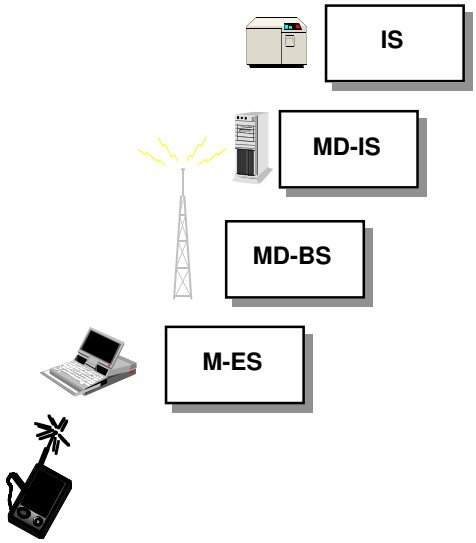
CS 294-7: Cellular Digital Packet Data (CDPD)

Prof. Randy H. Katz
CS Division
University of California, Berkeley
Berkeley, CA 94720-1776
© 1996

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

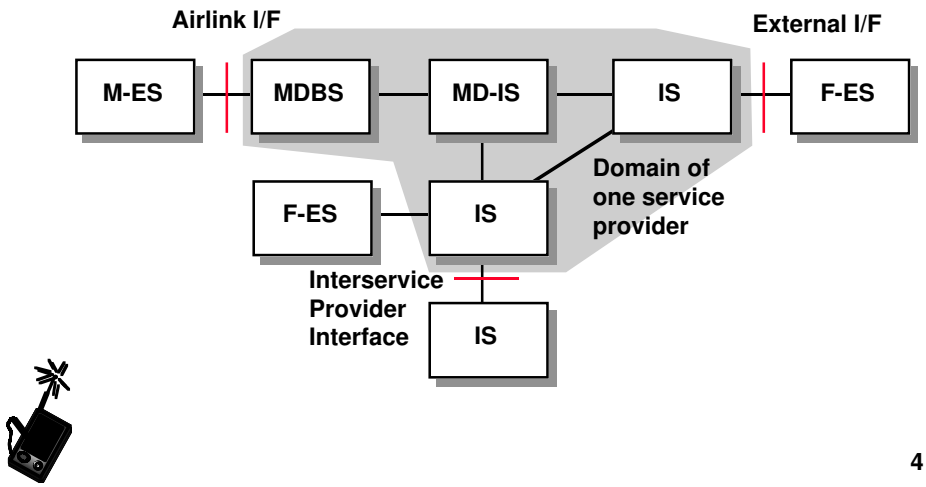
Mobile Data Intermediate System:
Mobility management

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

Mobile End Station:
terminal, laptop

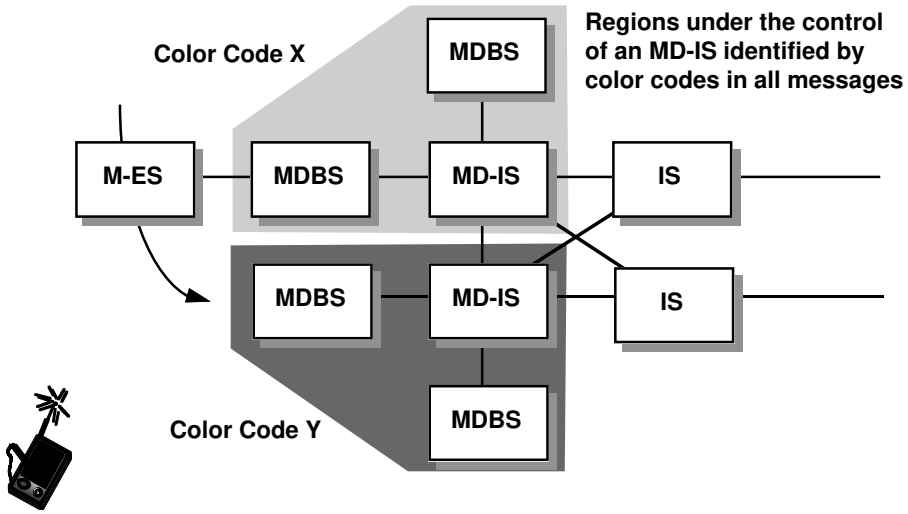
3

CDPD Network Architecture



4

CDPD Network Architecture



5

CDPD Entities

- **M-ES**
  - CDPD network trackes location of ES' and routes them network datagrams
  - ES' address does NOT imply location; current subnetwork "point of attachment" determines this
  - ES' are associated with the CDPD network's routing domain, *not* the user's corporate home network
  - Mobility support functions:
    - » Mobility management: tracking MDES and routing
    - » Radio resource management: connectivity to subnetwork "point of attachment"

6

CDPD Entities

- **Fixed End Systems (F-ES)**
  - Fixed location, traditional routing can be used
  - Internal F-ES: provided by service provider, considered to be inside the security firewall
    - » For authentication, authorization, network mgmt, accounting
    - » For domain name services, location services, etc.
  - External F-ES: external to CDPD, must operate over the external network interface

7

CDPD Entities

- **Intermediate Systems (IS, MD-IS)**
  - IS provides routing (can be off-the-shelf
  - MD-IS provides MOBILE routing: MNLP (Mobile Network Location Protocol)
    - » Mobile Home Function: like home agent processing in Mobile IP or HLR function in cellular networks; uses encapsulation to forward packets to MD-IS in the visited region
    - » Mobile Serving Function: like foreign agent processing in Mobile IP or VLR function in cellular networks; Registration/authentication/authorization/accounting

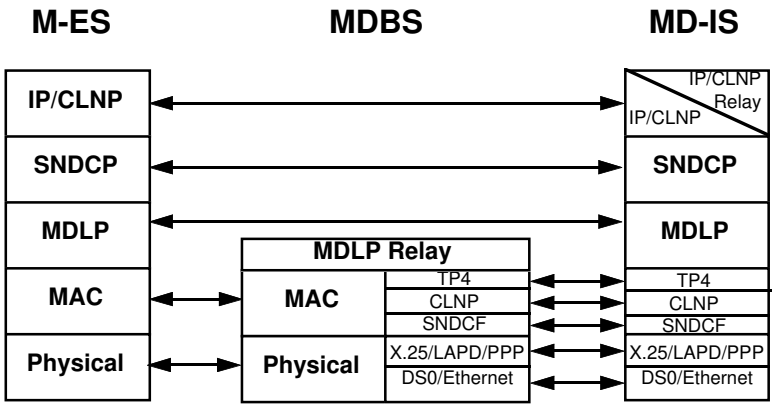
8

CDPD Entities

- **Mobile Data Base Station (MD-BS)**
  - **Controls radio interface, responsible for radio channel allocation, radio media access**
    - » **RF Channel Pair:**
      Forward link from BS to multiple ESs
      Reverse link from multiple ESs to BS
  - **Colocated with cellular voice equipment**
  - **CDPD channels must be able to hop to new frequencies as demanded by the voice services**

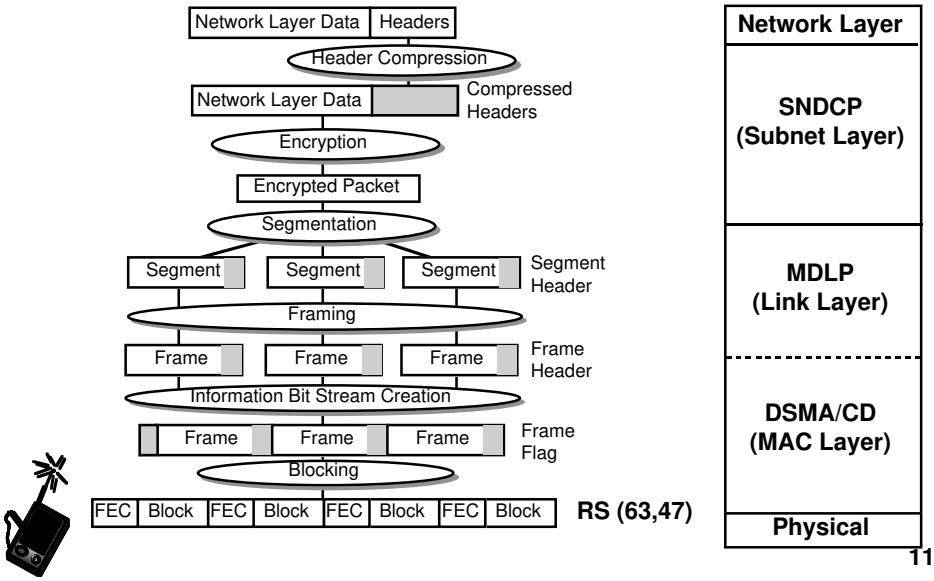
9

CDPD Protocols



10

CDPD Protocols

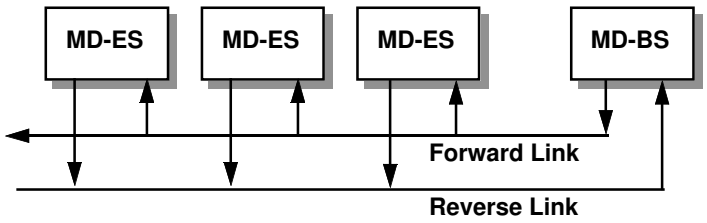


CDPD Protocols

- **Physical Layer**
  - **GMSK modulation, raw data rate = 19.2 Kbps; Actually data rate will be (much) less**
  - **Restricted to using pair of analog or digital TDMA cellular voice frequency pairs for each physical CDPD channel**
  - **Physical layer services:**
    - » **Tune to specified pair of RF channels**
    - » **Transmit/receive bits**
    - » **Set power levels**
    - » **Measure signal strengths**
    - » **Suspend/resume monitoring of RF channels in M-ES to conserve battery power**

CDPD Protocols

- **MAC Layer**
  - Arbitrate access to shared medium between M-ES and MD-BS
  - Frame recognition, frame delimiting, error detection/ correction



Forward link: scheduled by BS, signals channel idle/busy
Reverse link: contention access with back-off

13

CDPD Protocols

- **MAC Layer (continued)**
  - Forward channel:
    - » Data packets "broadcast" from BS to ES HDLC, zero insertion, frames segmented into 274 bit (+8 bit color code) blocks, extended with ECC to 378 bits
    - » Forward channel sync word, reverse channel busy/idle flag, decode failure flags, 378 RS (63, 47) block
  - Reverse channel:
    - » DSMA/CD access strategy
    - » 378 bit blocks/up to 64 of these per burst
    - » M-ES will back off and retry whenever it senses decode failure flag on the forward channel

14

CDPD Protocols

- **Mobile Data Link Protocol (MDLP)**
  - Point (MDIS) to multipoint (M-ES), connection-oriented, fully sequenced, acknowledged transfers
  - Functions provided include:
    - » One or more logical data link connections on a channel stream
    - » Sequence control
    - » Transmission/format/operational error detection and recovery—*retransmits missing blocks*
    - » Flow control
    - » Sleep function for power conservation
    - » Dynamic address assignment (Temporary Equipment ID--TEI)

15

CDPD Protocols

- **Subnetwork Dependent Convergence Protocol (SNDCP)**
  - Connectionless mode subnetwork service
  - Provides the following functions:
    - » Mapping of data primitives
    - » Segmentation/reassembly of NPDUs
    - » Compression/elimination of redundant protocol control information
    - » Encryption/decryption
    - » Network layer to data link layer multiplexing to support multiple network layer protocols on top of the data link

16

Mobile Network Registration Protocol (MNRP)

- Connectionless, exchanges configuration information between M-ES and MD-IS
  - Network Entity Identifier (NEI)
  - Subnet Point of Attachment (SNPA)
- Provides following functions:
  - Registration/deregistration of NEIs with MD-IS
  - Authentication of M-ES and its NEI
  - Admission of M-ES to services offered by MD-IS
- Mobile Home Function
  - Location Directory , redirection and forwarding
- Mobile Serving Function
  - Registration Directory, readdress “decapsulation” service

17

Radio Resource Management

- CDPD transmission is frequency agile, mobile across adjacent cells (“cell transfers”)
- In-band control, unlike AMPS cellular
- Function provided include:
  - Allocating RF channel pair to CDPD service
  - Hopping to new RF channel pair, because of analog voice demand or for CDPD channel load balancing
  - Controlling M-ES’s transmit power
  - Configuration information exchange
    - » Cell ID, channel stream, service provider, home area
    - » RF channels for CDPD use, channels to hop to
    - » This information is periodically broadcast from BS
  - Admission control to channel stream

18

M-ES Channel Hopping

- **Initiation Phase**
  - Conditions for channel hopping are met
    - » Detection of new color code
    - » Loss of sync
    - » Weak forward channel signal
    - » Excessive block errors
    - » OR “directed hop” message from the BS
- **Execution Phase**
  - Uses information from previous configuration messages
  - E.g., “in-use” RF channels, “allocated” RF channels, “in-use” and “allocated” RF channels of adjacent cells
- **Termination Phase**

19

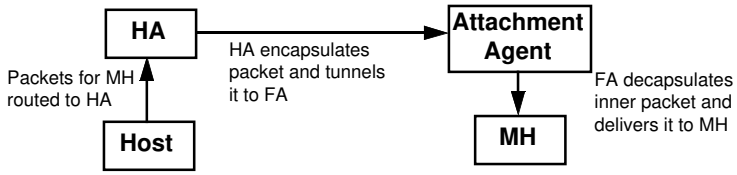
Air Link Security

- **Encrypted airlink yields data link confidentiality**
- **M-ES NEI authentication by CDPD network**
- **Authentication process based on registration history**
  - MD-IS authenticates M-ES back to its home MD-IS
  - NEI/ASN (Auhentication Sequence Number)/ARN (Authentication Random Number) are the authentication credentials
  - ASN incremented after each successful registration
  - New ARN assigned by MHF after every successful validation of credentials; obtained over encrypted link by M-ES which stores it locally

20

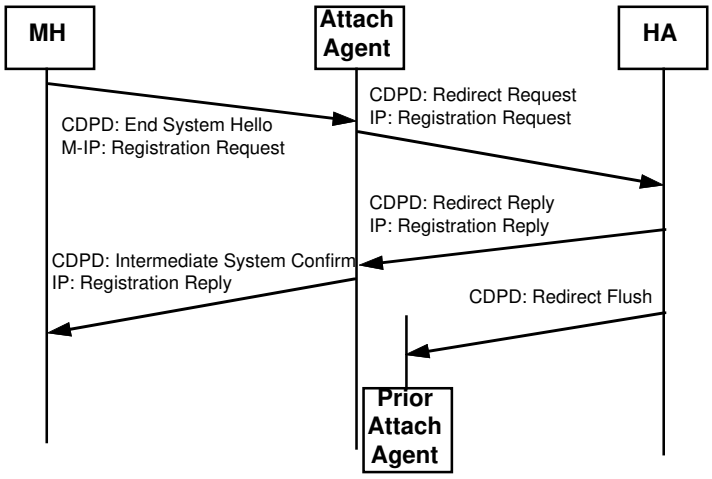
Network Layer Mobility: CDPD vs. Mobile IP

- **Home Agent**
  - **CDPD: Location Directory**
  - **Mobile IP: Configuration and Registration Table**
  - **Mobility Binding: binding between a mobile host and its attachment agent, registration lifetime, id number, etc.**
- **Attachment Agent**
  - **CDPD: Registration Directory**
  - **Mobile IP: Configuration and Registration Table**



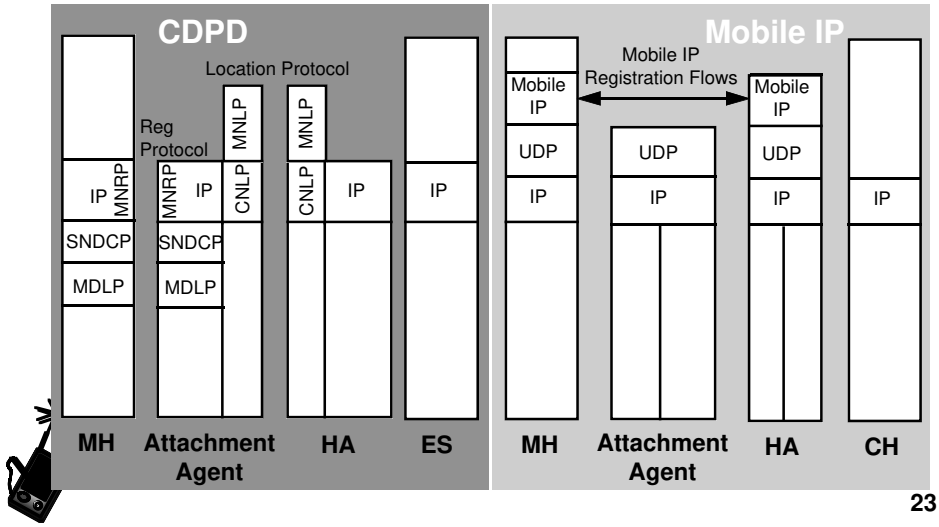
21

Network Layer Mobility: CDPD vs. Mobile IP



22

Network Layer Mobility: CDPD vs Mobile IP



Network Layer Mobility: CDPD vs. Mobile IP

- **Information sent by Mobile Nodes to Attachment Agent**

Parameter Description	Mobile IP	CDPD
Permanent IP address of mobile node	Home Address	Src Network Address
Sequence control for reg requests	Identification	Registration Count
Authentication: Mobile Node—HA	MH Authen Extension	Authentication Parameter
Identity of Mobile Node's HA	HA	
Requested Lifetime of Registration	Lifetime	
Tunnel Endpoint	Care-Of Address	
Request for HA to maintain multiple reg simultaneously*	Code	
Authentication: Mobile Node—Attach Agent	*Mobile-Foreign Authen Ext*	**Optional**
Traffic Encapsulation btwn HA and AA	*Min Encapsulation Ext*	
Non-default Authent method & crypto key	*Key ID*	

Footnotes:

*** Mobile IP allows MH to be registered with multiple FAs; CDPD does not**

CDPD: End System Hello message
Mobile IP: Registration Request message

Network Layer Mobility: CDPD vs. Mobile IP

- **Information sent by Attachment Agent to Home Agent**

Parameter Description	Mobile IP	CDPD
Permanent IP address of mobile node	Home Address	Src Network Address
Sequence control for reg requests	Identification	Registration Count
Authentication: Mobile Node—HA	MH Authen Extension	Authentication Parameter
Identity of Mobile Node's HA	HA	
Requested Lifetime of Registration	Lifetime	
Tunnel Endpoint	Care-Of Address	Foreign Network Address
Request for HA to maintain multiple reg simultaneously*	Code	
Authentication: Mobile Node—Attach Agent	*Mobile-Foreign Authen Ext*	
Traffic Encapsulation btwn HA and AA	*Min Encapsulation Ext*	
Non-default Authent method & crypto key	*Key ID*	
Carrier affiliation of Attachment Agent		*Location Info*

AA forwards registration request to Home Agent
CDPD: Redirect Request message
Mobile IP: Registration Request agent

25

Network Layer Mobility: CDPD vs. Mobile IP

- **Information sent by Home Agent to Attachment Agent**

Parameter Description	Mobile IP	CDPD
Permanent IP address of mobile node		Dst Network Address
Sequence control for reg requests	Identification	Registration Seq Count
Authentication: Mobile Node—HA	MH Authen Extension	Authent Update Parameter
Assigned Lifetime of Registration	Lifetime	*Configuration Timer*
Disposition of Request	Code	Result Code
Authentication: Mobile Node—Attach Agent	*Mobile-Foreign Authen Ext*	
Authentication: HA—AA	*Foreign-Home Authen Ext*	
Filter to limit range of addrs handled by HA		Address Mask
Usage Information		Home Info

HA receives registration request from Mobile Node
HA decides whether to confirm or deny request
Result is forwarded to AA, who forwards it to the Mobile Node
CDPD: Redirect Confirm message
Mobile IP: Registration Reply message

26

Network Layer Mobility: CDPD vs. Mobile IP

- **Information sent by Attachment Agent to Mobile Host**

Parameter Description	Mobile IP	CDPD
Permanent IP address of mobile node		Dst Network Address
Sequence control for reg requests	Identification	
Authentication: Mobile Node—HA	MH Authen Extension	Authent Update Parameter
Assigned Lifetime of Registration	Lifetime	*Configuration Timer*
Disposition of Request	Code	Result Code
Authentication: Mobile Node—Attach Agent	*Mobile-Foreign Authen Ext*	

AA passes confirmation or rejection to MH
CDPD: Hello Confirm message
Mobile IP: Registration Reply message

27

Network Layer Mobility: CDPD vs. Mobile IP

- **CDPD:**
  - \+ **Complete lower layer solution for mobility**
  - – **Limited scalability to support more than seven carriers**
  - – **Lack of hooks to accommodate comprehensive security and authentication protocols (airlink secure, but backbone is not!)**
- **Mobile IP:**
  - \+ **Can accommodate robust set of security protocols (end-to-end security is possible)**
  - \+ **Can scale to handle mobility across many routing domains**
  - – **Failure of the AA to participate actively in registration process**
  - – **No well defined wireless link**
  - – **No network management functions defined**

28