IP over CDMA Digital Cellular

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Data on CDMA Cellular Channels

- IS-95 CDMA (e.g., SprintPCS, Airtouch Powerband)
  - IS-707 data standards
  - No modifications required to cell sites
    - *major* advantage given widespread IS-95 deployment
- Globalstar
  - very similar to IS-95 wrt data
  - fervent hope that packet data will avoid Iridium's fate

The IS-95 Channel

- Semi-connection-oriented

  - hardware allocated to call, but air resource is dynamically shared

- Designed for variable-data-rate vocoder

  - Frames sent at constant 50 Hz (20ms) rate

- Four fixed-size frames with raw sizes:

  - Rate set 1 ("9.6"): 24, 48, 96, 192 bits

  - Rate set 2 ("14.4"): 36, 72, 144, 288 bits

- Viterbi decoder tails and CRCs of varying sizes reduce usable payload

Data on IS-95 CDMA

- The IS-95 physical channel was designed for voice; data was an afterthought

- Voice delay considerations limit frame size

    - limited interleaving for slow fading

    - power control helps

- Typical frame loss rates: 1-2%

   - acceptable for voice

    - unacceptable for data

Performance Without RLP

- 1500 byte IP/PPP packet, IS-95 Rate Set 1:
    - 1500 bytes/22 bytes/frame = 68+ frames
    - For FER=.01, probability of packet success is $(1-.01)^{68} = 0.505$ (pretty bad)
    - For FER=.02, probability of packet success is $(1-.02)^{68} = 0.253$ (even worse)
- TCP can only recover by resending entire packet
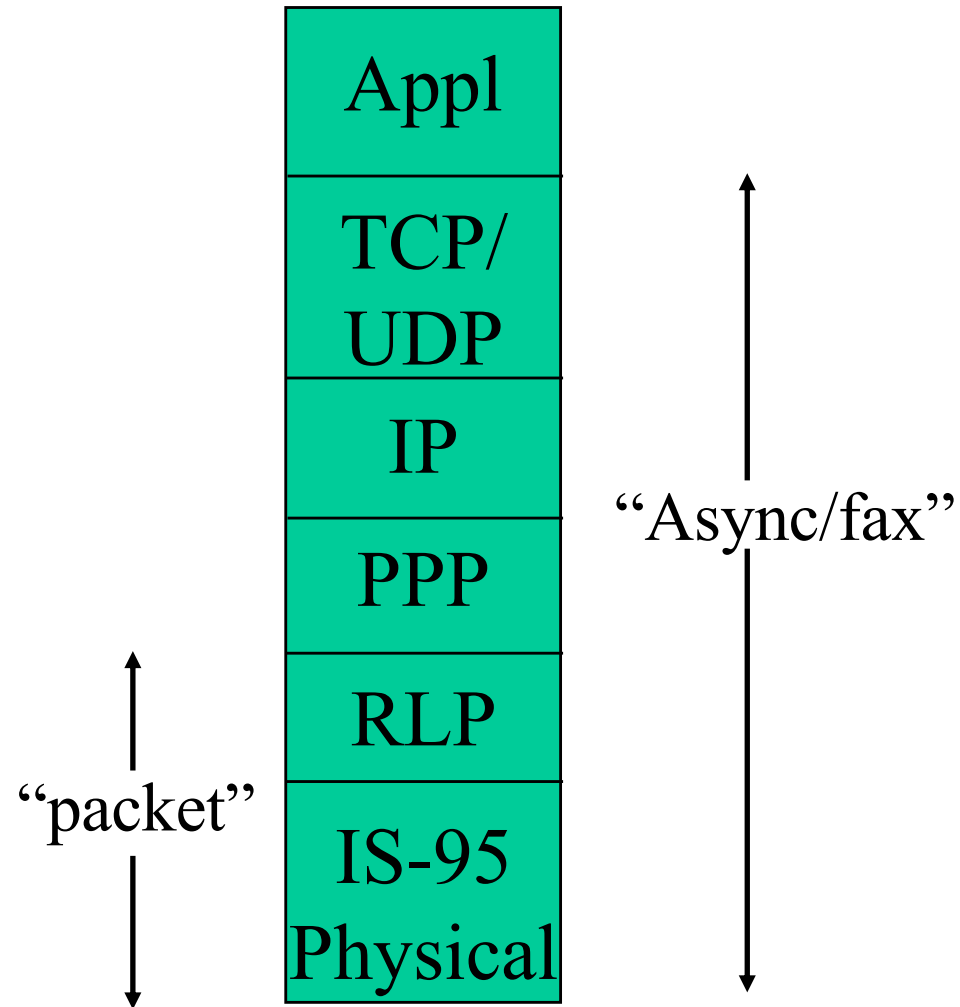   - selective link-level retransmission clearly needed

Packet Data over IS-95

- IS-99/657/707 define a *Radio Link Protocol* for sending packet data over IS-95 CDMA

- RLP breaks variable-length PPP packets into one of the 4 frame lengths supported by IS-95 Rate Set 1 or 2 traffic channels

- RLP senders add 8-bit seq numbers to frames

- RLP receivers NAK missing frames and the senders retransmit them

- RLP is "mostly" reliable; it does *not* try to provide perfect reliability

RLP Operation

sync

(rtt)

ack

0

1 (deliver)

2

3

4

5 Nak=2-3

2 (hold 4,5)

(deliver 2)

3

6 (deliver 3,4,5)
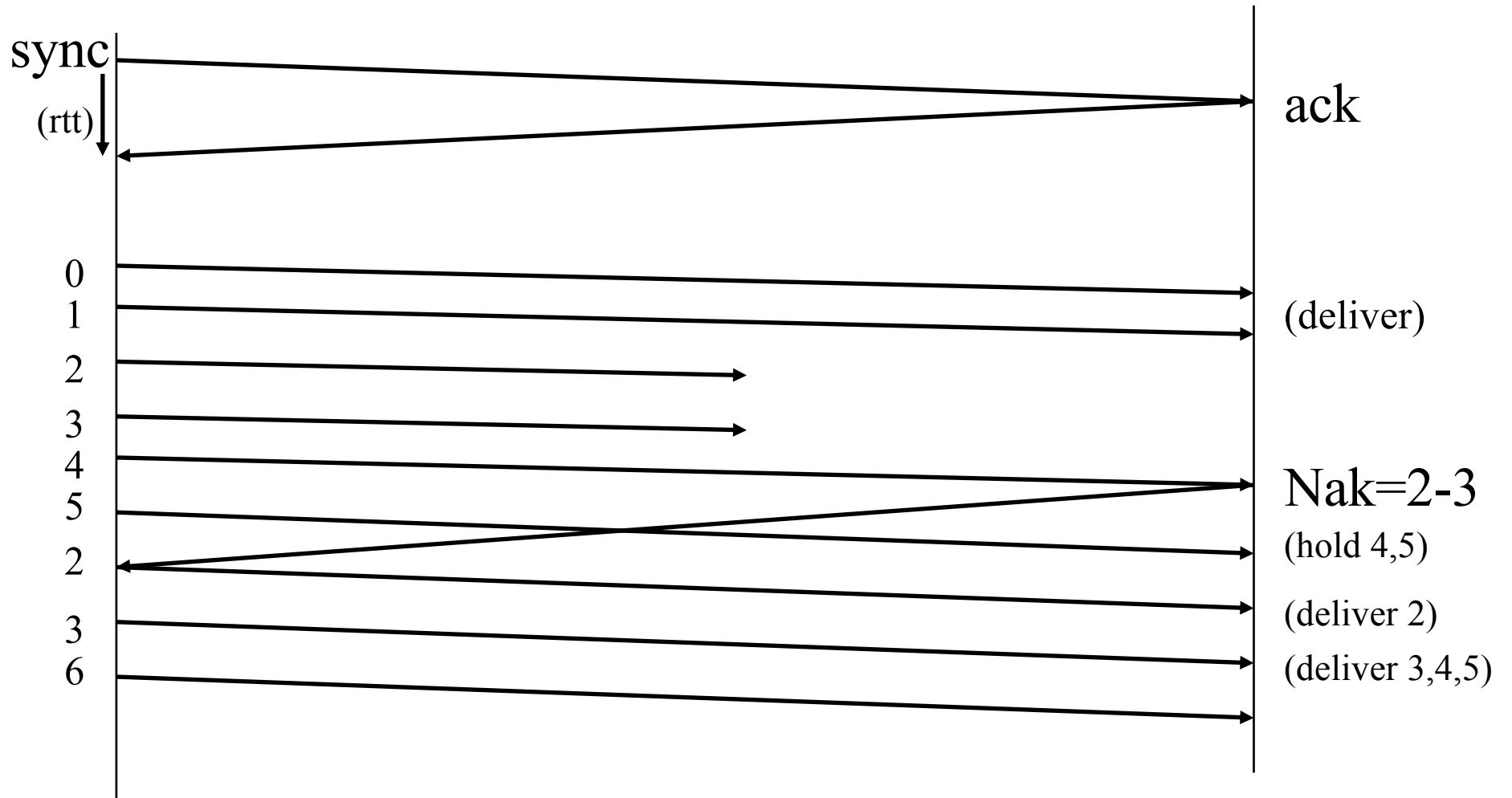
IS-95 Data Protocol Stack

Appl
TCP/ UDP
IP
PPP
RLP
IS-95 Physical

"Async/fax"

"packet"

Quick Net Connect (QNC)

- Original concept: IP packet data support with "dormant mode"
  - similar to demand-dialed ISDN
- Political obstacles to CDMA packet data
  - lackluster carrier interest
  - vendor resistance (CDPD competition?)
  - inability to appreciate importance of Internet
    - some telcos still think "data" == "modems"
- Asynch data/fax service based on TCP/IP
  - this was the "hook" for QNC

HDR

- High speed wireless packet data system under development at Qualcomm
- Physical layer borrows from IS-95, but redesigned specifically for packet data
  - will require BTS overlays (like CDPD)
- 1.2288 MHz spread BW (same as IS-95)
- Semi-connection-oriented (like IS-95)
- Throughput depends on loading and distance
  - somewhat like ADSL

HDR Forward Link

- Single stream of 128-byte frames
  - somewhat like ATM
- Fixed symbol rate
- Modulation alphabet and FEC code rate determine user data rate
- Constant transmit power
- Data rate controlled by mobile request
  - 38.4kb/s up to 2.4Mb/s
  - rate depends on SNR

HDR Reverse Link

- Fixed-time 53ms frames

- Pilot subchannel

- Data rate varies from 4.8kb/s - 307kb/s

  - depends again on link margin

- Closed loop power control

  - similar to IS-95

Speed Considerations

- The higher the data rate, the slower the relative fading

    - larger packets are good

    - higher data rates are bad (unfortunately)

- Ergo, ARQ link protocol still required

- HDR RLP similar to IS-707/IS-95

    - byte-numbered vs frame-numbered

Cellular Data Summary

- IS-95 is inherently cellular-based
  - asymmetric fwd & rev links on different frequencies
  - no direct mobile-to-mobile communication
  - systems centrally managed
- Service model: telephone company or ISP
- Unanswered question: proper role of cellular data vs. wireless LANs on unlicensed spectrum (e.g., IEEE 802.11)