CDMA 2000 1X RTT
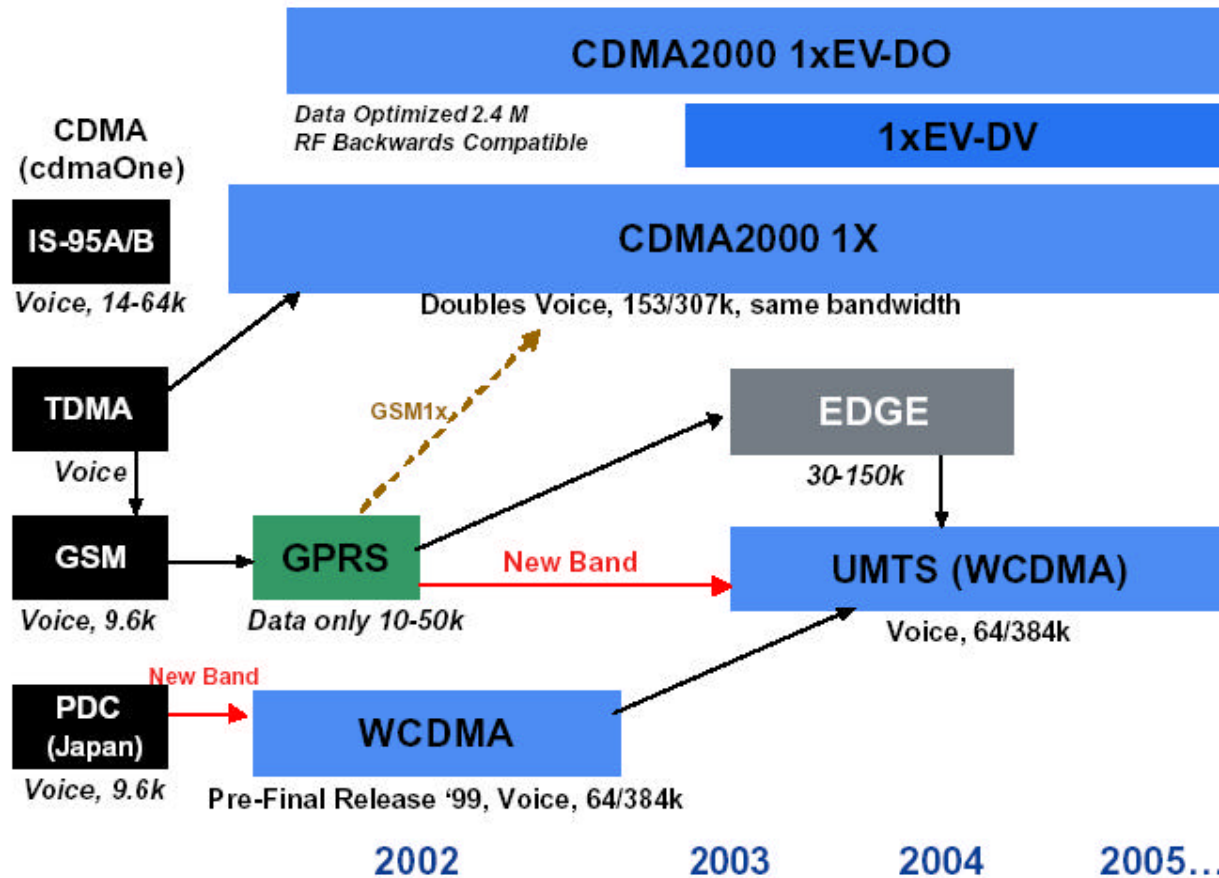
Overview
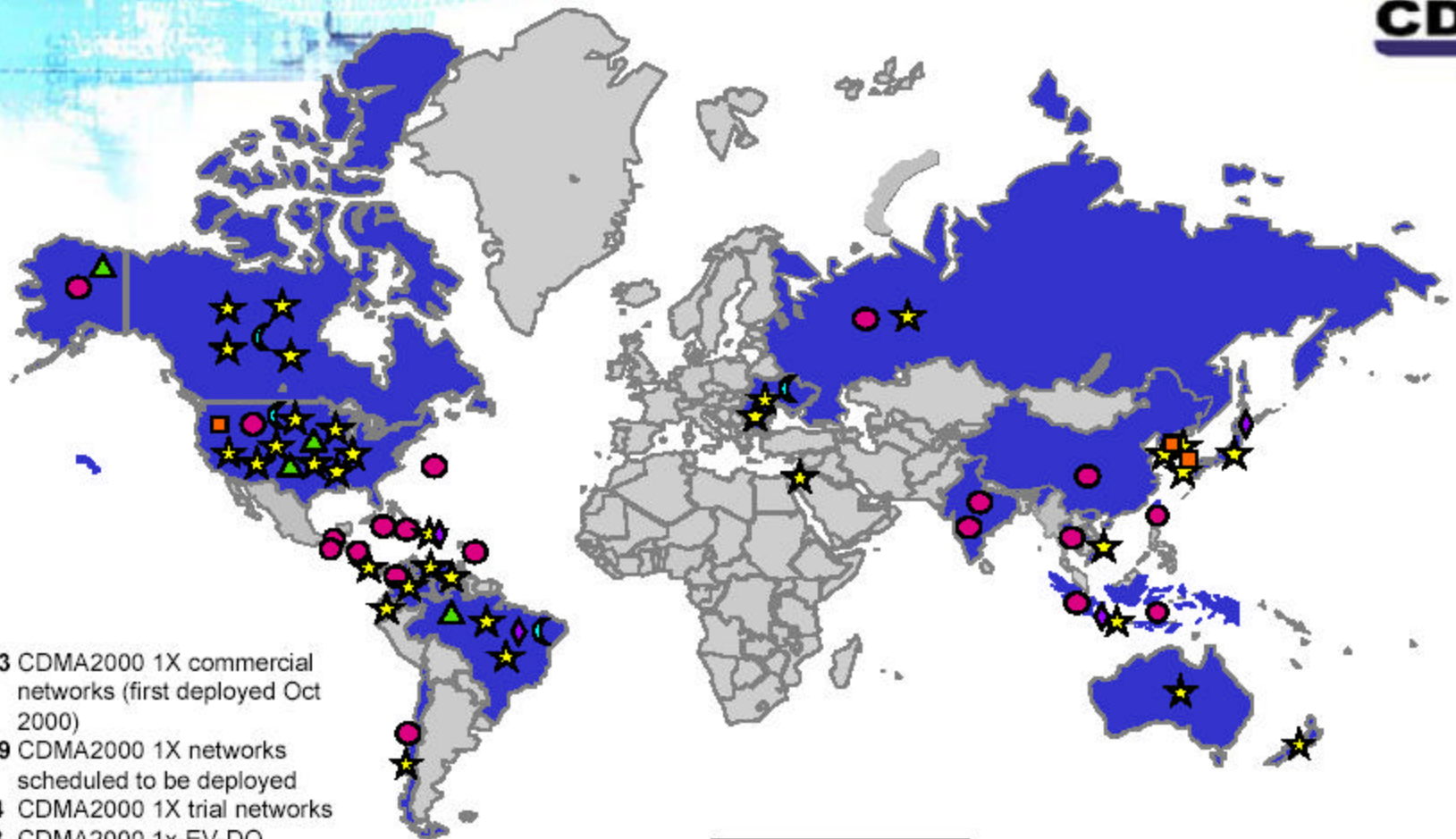
Global 3G Evolution

CDMA2000 Deployments

33 CDMA2000 1X commercial networks (first deployed Oct 2000)

19 CDMA2000 1X networks scheduled to be deployed

4 CDMA2000 1X trial networks

3 CDMA2000 1x-EV-DO commercial networks (first deployed Jan 2002)

4 CDMA2000 1xEV-DO networks scheduled to be deployed

4 CDMA2000 1xEV-DO trial networks

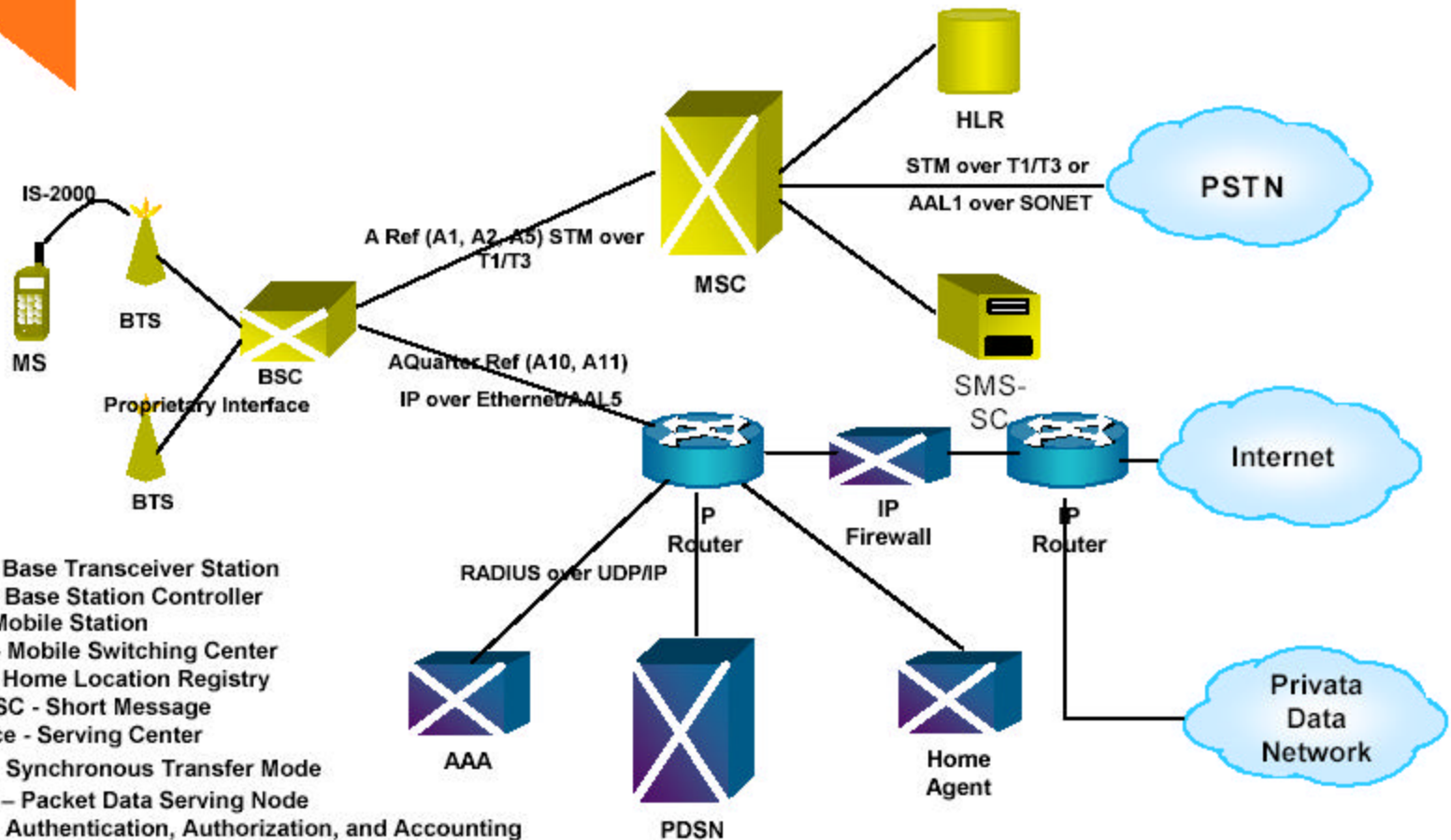|	
★	1X Commercial
●	1X Deployment
☾	1X Trial
■	1xEV-DO Commercial
◆	1xEV-DO Deployment
▲	1xEV-DO Trial

Enhancement by CDMA 2000 1X RTT

- Increasing voice capacity

- "Always On" peak packet data rate of 153 kbps (current phase), increasing to 307 kbps in 2003/2004

- Connectivity to ANSI-41, GSM-MAP, and All-IP networks

- Various bands and bandwidths of operation in support of different operator needs

- Fully backward compatible with cdmaOne systems

- Improved service multiplexing and QoS management

- Flexible channel structure in support of multiple services with various QoS and

- variable transmission rates

CDMA2000 1x Network

IS-2000

MS

BTS

BSC

BTS

Proprietary Interface

A Ref (A1, A2, A5) STM over T1/T3

AQuarter Ref (A10, A11)

IP over Ethernet/AAL5

MSC

HLR

STM over T1/T3 or

AAL1 over SONET

PSTN

SMS-SC

IP Router

IP Firewall

IP Router

Internet

RADIUS over UDP/IP

AAA

PDSN

Home Agent

Privata Data Network

BTS - Base Transceiver Station
BSC - Base Station Controller
MS - Mobile Station
MSC - Mobile Switching Center
HLR - Home Location Registry
SMS-SC - Short Message
Service - Serving Center

STM – Synchronous Transfer Mode
PDSN – Packet Data Serving Node
AAA – Authentication, Authorization, and Accounting
Home Agent – Mobile IP Home Agent

A10 – Bearer interface between BSC (PCF) and PDSN for packet data
A11 – Signaling interface between BSC (PCF) and PDSN for packet data

NMS COMMUNICATIONS

Packet Data Serving Node (PDSN)

- **Establish, maintain, and terminate PPP sessions with mobile station**

- **Support simple and mobile IP services**
  - Act as mobile IP Foreign Agent for visiting mobile station

- **Handle authentication, authorization, and accounting (AAA) for mobile station**
  - uses RADIUS protocol

- **Route packets between mobile stations and external packet data networks**

- **Collect usage data and forward to AAA server**

NMS COMMUNICATIONS

AAA Server and Home Agent
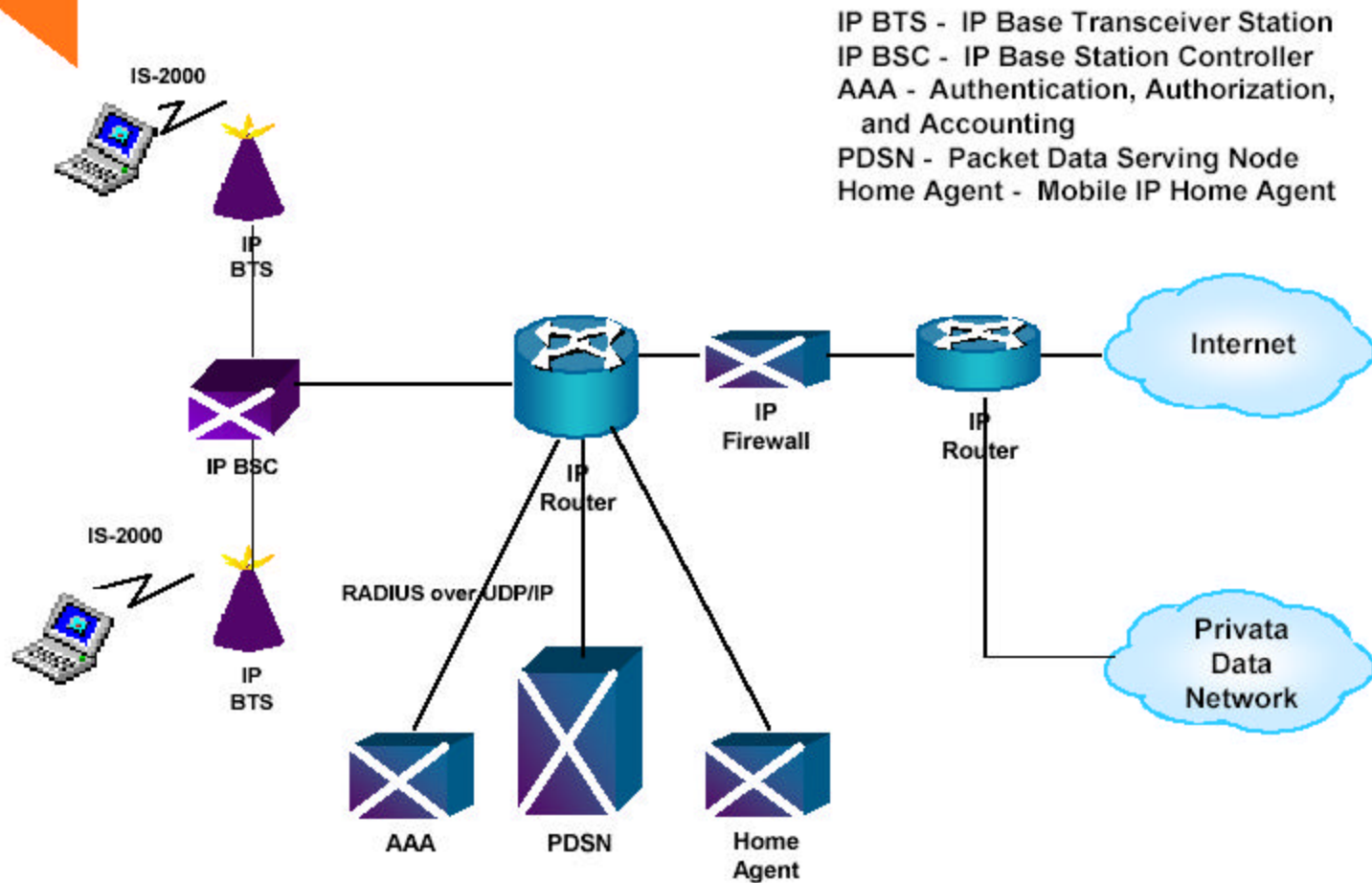
- **AAA server**
  - Authentication: PPP and mobile IP connections
  - Authorization: service profile and security key distribution and management
  - Accounting: usage data for billing
- **Mobile IP Home Agent**
  - Track location of mobile IP subscribers when they move from one network to another
  - Receive packets on behalf of the mobile node when node is attached to a foreign network and deliver packets to mobile's current point of attachment

1xEVDO -- IP Data Only

IS-2000

IP
BTS

IS-2000

IP BSC

IP
BTS

RADIUS over UDP/IP

IP BTS - IP Base Transceiver Station
IP BSC - IP Base Station Controller
AAA - Authentication, Authorization,
  and Accounting
PDSN - Packet Data Serving Node
Home Agent - Mobile IP Home Agent

IP
Router

IP
Firewall

IP
Router

Internet

Privata
Data
Network

AAA

PDSN

Home
Agent

Overview of Key Features

- **Frequency Bands**
  - CDMA2000 physical layer includes several modes of operation
  - CDMA2000 networks have already been deployed in the 450 MHz, 800 MHz, 1700 MHz, and 1900 MHz bands
  - CDMA2000 standards specify two rates:
    - 1.25 MHz full duplex bandwidth referred to as "Spreading Rate 1" (SR1), or "lX"
    - 3.75 MHz full duplex bandwidth referred to as "Spreading Rate 3" (SR3), or "3X"

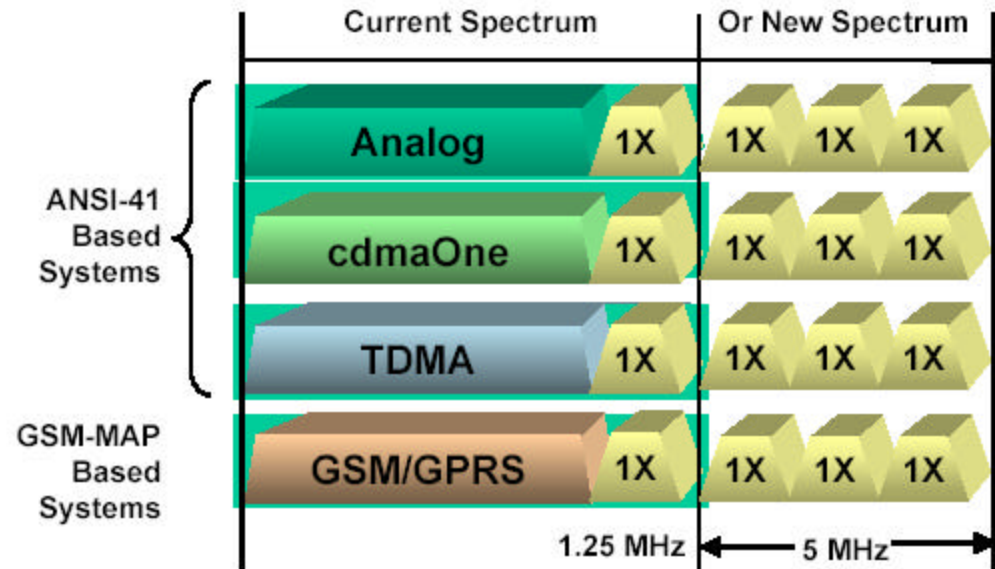# CDMA 2000's Spectrum Flexibility

✓ CDMA2000 can be deployed in any existing cellular, PCS and IMT-2000 spectrum

✓ CDMA2000 can be deployed in a small amount of spectrum

CDMA2000 is not constrained to only the IMT-2000 band. It is defined to operate in existing and IMT-2000 spectrum:

- 450 MHz
- 700 MHz
- 800 MHz
- 900 MHz
- 1700 MHz
- 1800 MHz
- 1900 MHz
- 2100 MHz

Current Spectrum   Or New Spectrum

ANSI-41 Based Systems
- Analog   1X   1X 1X 1X
- cdmaOne   1X   1X 1X 1X
- TDMA   1X   1X 1X 1X

GSM-MAP Based Systems
- GSM/GPRS   1X   1X 1X 1X

1.25 MHz ← 5 MHz →

Overview of Key Features

- **Spectrum Requirements**
  - ► fundamental spreading rate is 1.2288 Mcps for SR1.
  - ► 1.25 MHz of bandwidth when the adjacent RF carriers are other CDMA carriers.
  - ► 1.8 MHz of bandwidth when both adjacent RF carriers are narrow band GSM or TDMA carriers.

- **Battery Life Enhancing Features**
  - ► Quick paging channel operation
  - ► Improved reverse link performance
  - ► New common channel structure and operation
  - ► Reverse link gated transmission
  - ► New MAC states for efficient and ubiquitous idle time operation

Overview of Key Features

- **Synchronization**
  - CDMA2000 is synchronized with Universal Coordinated Time (UTC)
  - All CDMA 2000 base stations are synchronized within a few ms
  - Base station synchronization methods include:
    - self-synchronization, radio beep, satellite-based systems such as GPS, Galileo, or GLONASS.
  - Benefits from synchronization of all base stations
    - Common time reference improves acquisition of channels and handoff procedures
    - Enables the system to operate some of the common channels in soft handoff,
    - Common network time reference allows implementation of a very efficient "position location" technique such as gpsOne.

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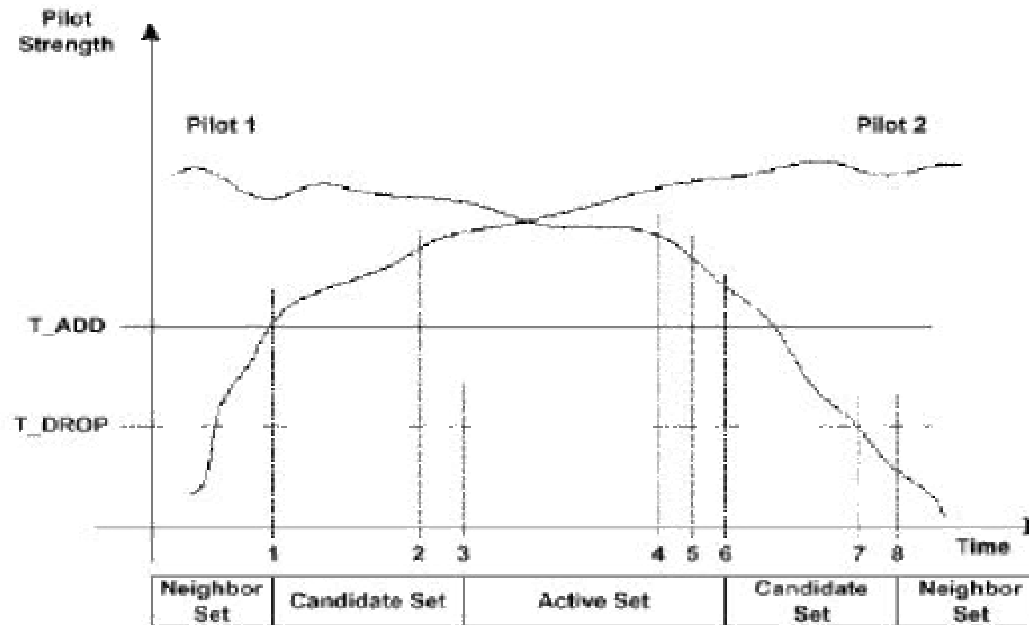
Overview of Key Features

- **Power Control**
  - The basic frame length is 20 ms divided into 16 equal power control groups.
  - A 5 ms frame structure, essentially to support signaling bursts
  - 40 and 80 ms frames offer additional interleaving depth and diversity gains for data services.
  - CDMA2000 channels can be power controlled at up to 800 Hz in both reverse and forward links.

Overview of Key Features

- **Soft Handoff**
  - The terminal keeps searching for new cells as it moves across the network
  - In addition to the active set, neighbour set, and remaining set, the terminal also maintains a candidate set

Overview of Key Features

- **Transmit Diversity**

    - De-multiplexing and modulating data into two orthogonal signals, each of them transmitted from a different antenna at the same frequency.

    - Another transmission option is directive transmission.
        - The base station directs a beam towards a single user or a group of users in a specific location
        - space separation in addition to code separation

    - Transmit diversity techniques may improve the link performance by up to 5 dB.
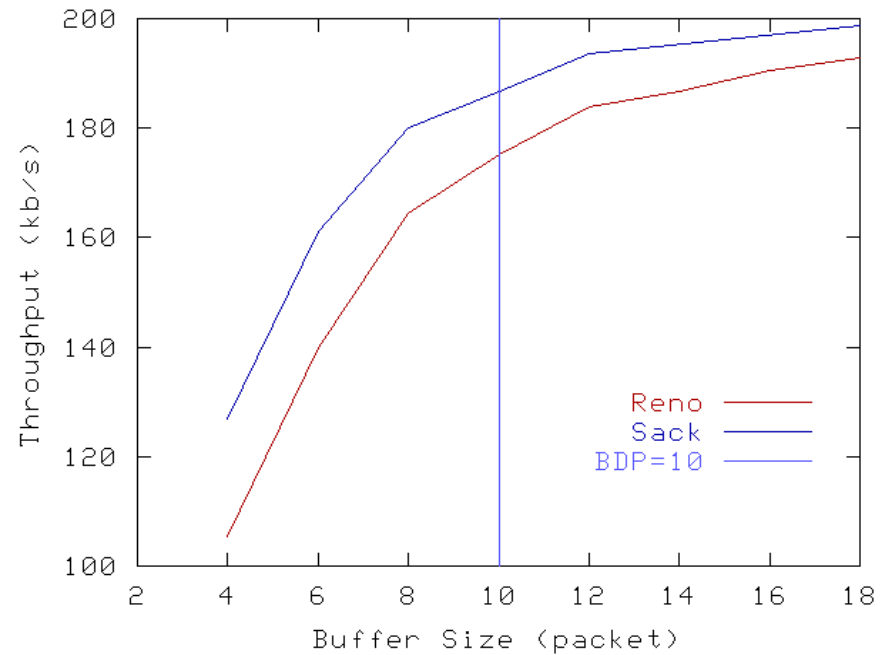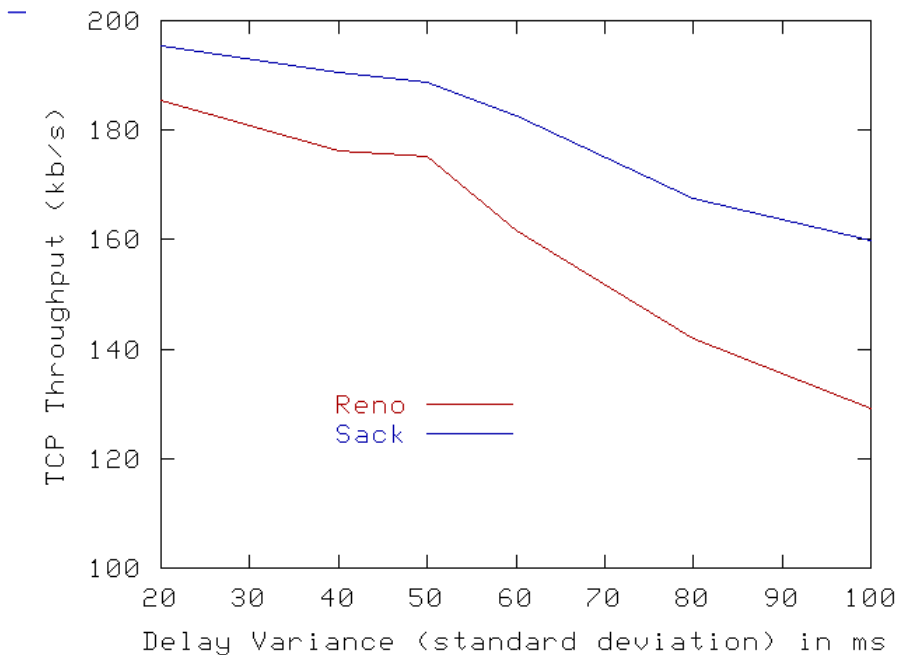
3G1X RTT Link Delay Variability
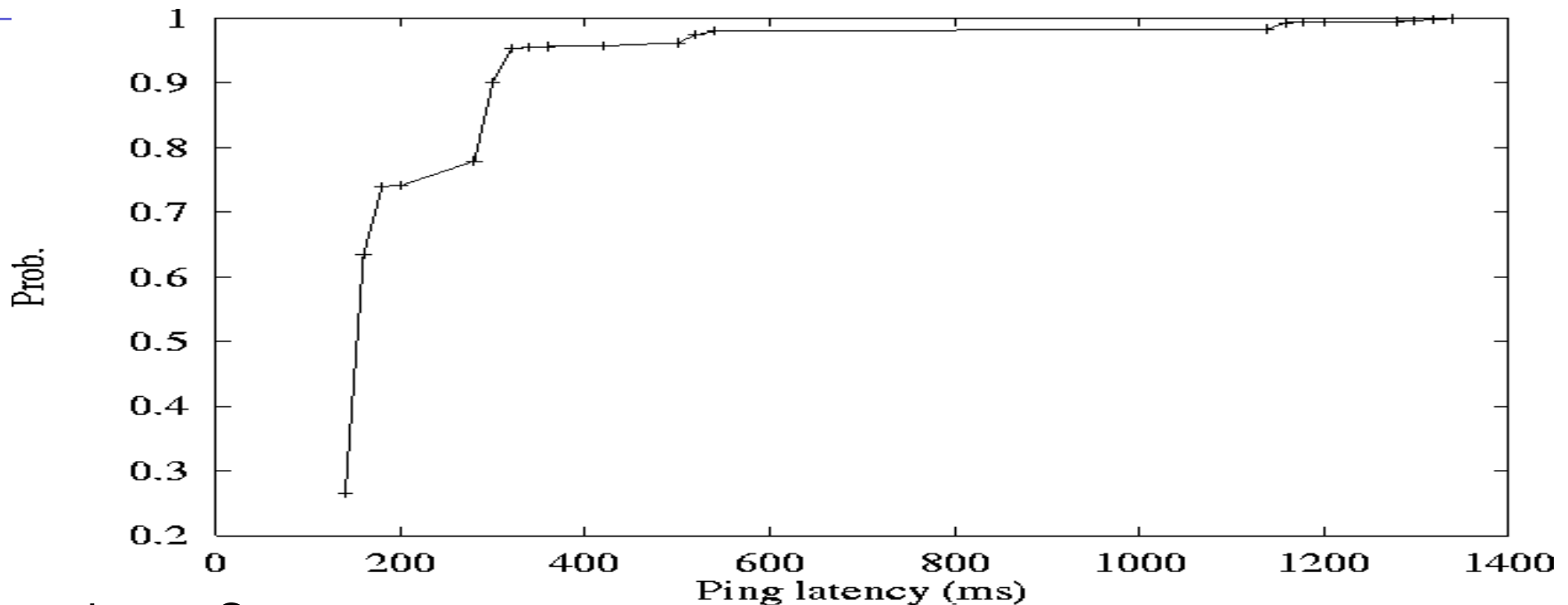
- Experiment Setup:
    - 3G1X RTT system and mobile device with 3G1X modem
    - 144 kbps downlink in infinite burst mode and 8 kbps uplink

- Results:
    - No loss observed in ping packets
    - 75% of ping latency values are less than 200ms and
    more than 20% of ping latency varies between 200ms and 500ms

Simulation: Variable Delay

- Simulation set-up:
  - Constant rate of 200kb/s, delay variation is exponentially distributed
  - Simulate only congestion loss

- **Larger variation causes larger degradation in TCP throughput**

- Increasing buffer size increases throughput at the expense of larger RTT

CDMA2000 Pros and Cons

- **Evolution from original Qualcomm CDMA**
  - now known as cdmaOne or IS-95

- **Better migration story from 2G to 3G**
  - cdmaOne operators don't need additional spectrum
  - 3x promises higher data rates than UMTS, i.e. W-CDMA

- **Better spectral efficiency than W-CDMA(?)**
  - arguable (and argued!)

- **CDMA2000 core network less mature**
  - cmdaOne interfaces were vendor-specific
  - hopefully CDMA2000 vendors will comply w/ 3GPP2

NMS COMMUNICATIONS