CDMA Evolution to CDMA2000

Severino Camilo,
Sr. Manager of Development Business

September, 2001
CDMA Subscriber Statistics:

Nearly 1 Million 3G CDMA2000 1x Subscribers - Initial Launch End of 2000

Over 100 Million CDMA Subscribers Worldwide

Source: EMC, July, 2001
Key Drivers for Wireless Market

- **Global Roaming**
- **More Capacity, High Speed Data**
- **Capacity/Quality**
- **Roaming**
- **Mobility**

- **1G**
  - AMPS
  - TDMA
  - GSM
  - PDC

- **2G**
  - cdmaOne
    - IS-95A
  - cdmaOne
    - IS-95B
  - GPRS

- **2.5G**
  - CDMA2000 1xEV
  - CDMA2000 1x

- **3G**
  - WCDMA
  - Multi-Mode
  - Multi-Band
  - Multi-Network

Time
3G 1x Standard

The First 3G Technology - Available Today!

- 1x is the first IMT-2000 standard that offers high-speed Always-On wireless data at 307 kbps peak data rate today
- Doubles the capacity of IS-95 systems for voice services. Achieved through FFPC, lower code rates, and a coherent reverse link
- Offers 50% longer stand-by times
  - Supported by the Quick Paging Channel
- Backward and Forward compatible with IS-95A/B

TIA/EIA-95-A → TIA/EIA-95-B

- cdma2000 Rel 0 (IS-2000) Commercial in Korea since Oct 2000
- cdma2000 Rel A (IS-2000-A)
- cdma2000 Rel B (IS-2000-B) Standardized in 1Q2001 by 3GPP2
- 1xEV Phase 1 (IS-856, HDR)
cdma2000 Multi-Carrier Extensions

Forward Link

Reverse Link

0 1MHz 2 MHz 3 MHz 4 MHz 5 MHz

1.25 MHz

cdma2000 1X

cdma2000 3X MC FL
with cdma2000 1X RL

cdma2000 3X MC
cdma2000 Deployments

- Mix 3G CDMA cells with IS-95-A/B cells
  - Support higher data rates
  - Support enhanced capacity
- cdma2000 MC 1X and 3X cells can support IS-95-A/B mobile stations on the same frequency
- Can deploy cdma2000 MC 1X and MC 3X cells on the same or different frequency as IS-95-A/B cells
- Can deploy cdma2000 MC 1X and then migrate to cdma2000 MC 3x
1xHDR is a high-performance and cost-effective Internet access solution capable of up to 2.4 Mbps peak data rate on a 1x (1.25 MHz bandwidth) carrier. Separate 1xHDR carrier optimized for Packet Data, complements 1xMC carrier optimized for Voice, replaces fixed (DSL, Cable) Internet access... with mobility.
**HDR Air Link**

- **Spectrally efficient** air link provides 2.4 Mbps forward peak throughput per sector with a *standard* CDMA 1.25 MHz frequency carrier.

- Asymmetric forward and reverse links
  - Forward link: 670-750 kbps/sector average throughput 1.2 Mbps/sector (dual receive antennas)
  - Reverse link: 220 kbps/sector average throughput

- Identical RF characteristics as IS-95/1xMC
  - Same chip rate, link budget, and coverage area

- HDR carrier looks like an IS-95/1xMC carrier to the rest of the network
1xMC/1xHDR are “natural complements” offering enhanced voice capacity together with optimized high performance Internet access.
Wireless Internet

Wired Internet

Mobility

Location Sensitivity

Time Sensitivity

Always On, Always With You
Global Evolution to 3G CDMA

**CDMA**
- **IS-95A**
  - Voice, 14.4k
- **IS-95B**
  - Voice, 64k
- **CDMA2000 1x**
  - Nearly Doubles Voice, 307k, RF backward compatible
  - **Data only 2.4 Mbps**
  - **RF backward compatible**
- **CDMA2000 1xEV (HDR)**
  - **Data only 2.4 Mbps**
  - **RF backward compatible**

**GSM (Europe)**
- **Voice, 9.6k**
- **GPRS**
  - Data only 10-60k
- **EDGE (?)**
  - 100k

**PDC (Japan)**
- **Voice, 9.6k**
- **WCDMA (DoCoMo)**
  - Voice, 64k/384k
  - Voice, 128k/384k
  - **WCDMA**
  - Voice, 128k/384k

**Timeline**
- 1995
- 1999
- 2000
- 2001
- 2002
- 2003
- 2004
Development Process for Any New Wireless System

0. Build and test several cell prototype system (optional)

1. Set a firm specification for system and handsets
   - Significant effort even after first formal standard is set
   - Performance testing and standard releases

WCDMA

2. Optimize system and handset performance
   - Interoperability test with each system, multi-mode, multi-band
   - Final chips and software
   - Early commercial launch
   - Full deployment

CDMA2000 1xEV

CDMA2000 1x

3. Adding rich feature sets for multimedia, etc.
   - Ramp volume, decrease cost

IS-95A/B
CDMA2000 Has Volume Advantages

Full cdmaOne Replacement vs. Partial WCDMA Adoption

(Millions of Units)

Source: EMC August, 2001
Operators Have Choices to Support Voice & Data:

- **WCDMA**
  - 2 WCDMA (5 MHz) Carriers or
  - 7 1x (1.25 MHz) Carriers

- **CDMA2000**
  - 1x and 1xEV

**2 x 10 MHz spectrum Available**

Voice (Erlangs) vs. Data Throughput / sector (Mbps) proportional to number of subscribers.
Download Times for a 3-minute MP3 Song

<table>
<thead>
<tr>
<th>Air Interface</th>
<th>Data Rate</th>
<th>Download Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSM IS-95A CDMA</td>
<td>9.6 kbps</td>
<td>41 minutes</td>
</tr>
<tr>
<td></td>
<td>14.4 kbps</td>
<td>28 minutes</td>
</tr>
<tr>
<td>GPRS IS-95B CDMA</td>
<td>45.0 kbps</td>
<td>9 minutes</td>
</tr>
<tr>
<td></td>
<td>64.0 kbps</td>
<td>6 minutes</td>
</tr>
<tr>
<td>CDMA2000 1X WCDMA</td>
<td>307.0 kbps*</td>
<td>78 seconds – 1.25 MHz</td>
</tr>
<tr>
<td></td>
<td>2.0 Mbps</td>
<td>12 seconds – 5 MHz</td>
</tr>
<tr>
<td></td>
<td>2.4 Mbps</td>
<td>10 seconds – 1.25 MHz</td>
</tr>
<tr>
<td>CDMA2000 1xEV</td>
<td>307.0 kbps*</td>
<td></td>
</tr>
</tbody>
</table>

Note: ~ 3 Mbytes size

* Peak data rate for first commercial release of 1X terminals will be 153.8 kbps
CDMA is Better Positioned Than Any Other Mobile Cellular Technology To Deliver Low Cost Bits

<table>
<thead>
<tr>
<th>Technology</th>
<th>Network Cost per Mbyte**</th>
<th>Network Cost per Month (200 Mbyte data)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPRS</td>
<td>$.42</td>
<td>$83</td>
</tr>
<tr>
<td>WCDMA</td>
<td>$.07</td>
<td>$14</td>
</tr>
<tr>
<td>CDMA2000 1x</td>
<td>$.06</td>
<td>$12</td>
</tr>
<tr>
<td>CDMA2000 1xEV</td>
<td>$.02</td>
<td>$4</td>
</tr>
</tbody>
</table>

Note: i-Mode revenues $23.44 per Mbyte; $.003 i-Mode packet (128Bytes)

GPRS max 20 kpbs, rate achieved per time slot
Assumes capacity vs. coverage conditions
**15% traffic volumes at busy hour
Internet Launchpad™ Adds Built-in Services

**Multimedia**
- Qtunes™
  - MP3, MPEG-AAC
- QTV™
  - MPEG-4
- Qsynth™
  - 128-sound/MIDI support
- MIDI player
  - 16-voice polyphony
- Still image (PNG, JPEG…)
- CMX™ (Compact Media Extension)
  - Text/animation
- IP voice chat

**User Interface**
- Color screen
- Voice recognition
  - SD and SI voice
  - Digit dialing
- SIM/UIM card interface
- PureVoice Recorder™
  - Voice memo
  - Answering machine
- PureVoice Audio AGC™
- CMOS/CCD image sensor

**Connectivity**
- USB
- Bluetooth
- JAVA engine
- Security Software (SSL)
- PureVoice Mail™
  - Attachments
- IP protocol stack
- WAP interface

**Positioning**
- SnapTrack/gpsOne™
  - Hybrid wireless digital compass

**Storage**
- MMC
- SD-Card
CDMA Terminals Today Compare to Desktop PCs in the 1990s

Intel 80486 based Desktop Computer
Date: 1992
Processor: 486
Speed: 33 - 66 MHz
RAM/Flash: 8 MB
Drive/Storage: 80 - 300 MB

Sony C404S cdmaOne Phone
Date: 2001
Processor: ARM7
Speed: 50 - 110 MHz*
RAM/Flash: 8 - 16 MB
Drive/Storage: 32 - 128 MB

* Based on ARM7 specifications

Plus Connectivity, Multimedia and Authentication
New Devices Improve the User Experience

- Samsung SCH-X200
- Kyocera QCP-6035 Smartphone
- Sony C404S (Japan)
Easy Migration from cdmaOne to 3G cdma2000

cdmaOne Handsets  ➔  Pin Compatibility:  ➔  3G Handsets

- IS-95A to 1x
- IS-95A/B to 1x
- IS-95A/B to 1x
- 1x to 1xEV

RF Compatibility: No changes required for RF Front-end

First commercial cdma2000 1x handsets available now

Over 45 manufacturers
CDMA2000 1X Handsets Available Now

Over 40 Customers Have Commercial Agreements & Growing...

More Than 12 Handset Models Capable of Supporting Up To 144 kbps Have Been Produced Since October 2000...

- SK Telech SKY IM-3100
- LG Cyber X-1
- Samsung SCH-X100
- Samsung SCH-X110
- Samsung SCH-X120
- Samsung SCH-X200

- Samsung SPH-X1000
- Motorola V671C
- Samsung SCH-X2000
- Samsung SCH-X130
- SK Telech IM-2300
- SK Telech IM-2400
Number of Exciting CDMA2000 1x Terminals Are Entering the Market*

Video Phone

Web PDA

Navigator

Web Phone

Handset + PDA

PCMCIA Card

* SK Telecom presentation to 2000 CDMA Americas Congress, San Diego, CA, USA
<table>
<thead>
<tr>
<th>Date</th>
<th>Chip Type</th>
<th>Technology</th>
<th>Manufacturer</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 CY00</td>
<td>CDMA2000 1x (entry level) cdmaOne AMPS</td>
<td></td>
<td>cdmaOne</td>
<td></td>
</tr>
<tr>
<td>*Q3 CY00</td>
<td>CDMA2000 1x (entry level) cdmaOne AMPS</td>
<td></td>
<td>cdmaOne</td>
<td></td>
</tr>
<tr>
<td>Q1 CY01</td>
<td>CDMA2000 1x (high end) cdmaOne AMPS</td>
<td></td>
<td>cdmaOne</td>
<td></td>
</tr>
<tr>
<td>*Q2 CY01</td>
<td>CDMA2000 1x (high end) cdmaOne AMPS</td>
<td></td>
<td>cdmaOne</td>
<td></td>
</tr>
<tr>
<td>Q4 CY00</td>
<td>CDMA2000 1x (low cost) cdmaOne AMPS</td>
<td></td>
<td>cdmaOne</td>
<td></td>
</tr>
<tr>
<td>*Q1 CY01</td>
<td>CDMA2000 1x (low cost) cdmaOne AMPS</td>
<td></td>
<td>cdmaOne</td>
<td></td>
</tr>
<tr>
<td>Q3 CY01</td>
<td>WCDMA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q2 CY01</td>
<td>CDMA2000 1x/ 1xEV cdmaOne AMPS</td>
<td></td>
<td>cdmaOne</td>
<td></td>
</tr>
<tr>
<td>Q1 CY02</td>
<td>CDMA2000 1x (entry level) cdmaOne</td>
<td></td>
<td>cdmaOne</td>
<td></td>
</tr>
<tr>
<td>*Q2 CY02</td>
<td>CDMA2000 1x (entry level) cdmaOne</td>
<td></td>
<td>cdmaOne</td>
<td></td>
</tr>
</tbody>
</table>

1H CY02: CDMA2000 1x (low cost) cdmaOne
2H CY02: CDMA2000 1x (high end) cdmaOne
1H CY02: CDMA2000 1x cdmaOne
1H CY02: WCDMA GSM/GPRS
1H CY02: WCDMA GSM/GPRS
CY03: CDMA2000 1x/ 1xEV cdmaOne
CY03: CDMA2000 1x cdmaOne
CY03: WCDMA cdmaOne

Solves Global Roaming!

Sampling Date
*Production Date
Chips are not drawn to scale
**MSM Roadmap**

- **MSM5000**
  - CDMA2000 1x
  - 153 kbps
  - Up to 2X Voice Cap.
  - 3000 based
  - 3000 pin comp.

- **MSM5100**
  - CDMA2000 1x
  - gpsOne (int Position Location)
  - Int Bluetooth, USB
  - MP3, MIDI Ringer/CMX, MMC
  - R-UIM
  - 307kbps FL

- **MSM5105**
  - CDMA2000 1x
  - 3100 based
  - MIDI Ringer CMX
  - 153kbps FL

- **MSM5200**
  - WCDMA

- **MSM5010**
  - CDMA2000 1x
  - Voice Only
  - No Data
  - 2Way SMS

- **MSM5500**
  - CDMA2000 1x +1xEV-DO
  - MSM5100 based
  - 2.4Mbps

- **MSM6050 – Low End**
  - CDMA2000 1x Rel A
  - gpsOne (Optimized Pos Loc)
  - 153kbps FL/RL
  - MP3, MIDI Ringer/CMX
  - New Memory Interface

- **MSM6000 – Entry Level**
  - CDMA2000 1x
  - EVRC Only
  - 2Way SMS
  - 14.4kbps

- **RadioOne™ (ZIF) Architectures**

- **MSM6000**
  - CDMA2000 1x
  - WCDMA
  - GSM/GPRS

- **MSM6100 – Mid Tier**
  - CDMA2000 1x Rel A
  - 5100 based
  - 307kbps FL/RL
  - gpsOne (Optimized Pos Loc)
  - Java H/W Accelerator
  - New memory interface

- **MSM6200**
  - WCDMA
  - GSM/GPRS

- **MSM6300**
  - CDMA2000 1x
  - 1xEV-DO
  - GSM/GPRS

- **MSM6400**
  - CDMA2000 1x
  - 1xEV-DO
  - GSM/GPRS

- **MSM6600**
  - CDMA2000 1x
  - WCDMA
  - GSM/GPRS

*Chips are not drawn to scale*
CSM Roadmap

- Highest Integration of Channels Per Chip
- Lowest Power Consumption
- Smallest Footprint Base Stations
- Only End-to-End Solution for Wireless

Multi-chip solution
- CSM Modulation
- CSM Demod
- Viterbi Decoder

CSM 1.0
- IS-95 A/B
- Integrated Solution
- Adds 14.4 kbps
- Improved Rcvr

CSM 1.5
- Size, Cost & Power Reduction

CSM 2000
- IS-95 A/B
- 8 Channels

CSM 5000
- CDMA2000 1x
- IS-95 A/B
- 307.2 kbps
- 32 Channels

CSM 5500
- CDMA2000 1x EV
- 2.4 Mbps

CSM 5200
- WCDMA
- 16 Channels
- 384+ kbps

1991 1994 1997 1998 Q1 ‘00 Q2 ‘01 Q4 ‘01

*Chips are not drawn to scale
CDMA2000 1x 3G - Staying Well Ahead of the Competition

CDMA2000 1x Chip Shipments (Millions)

- MSM 5000
  - Up to 153 kbps
  - Production volumes

- MSM 5105
  - On time sampling Q2 CY’01

- MSM 5100
  - Up to 307 kbps
  - Full Multimedia

- MSM 5500
  - On time sampling Q2 CY’01
  - Up to 2.4 Mbps
  - Data Optimized

5000 Series Shipping Now
CSM - Base Station
Volumes Increasing

On-time Sampling of 1xEV CSM 5500
Up to 2.4 kbps

CSM Shipments Include
- CSM 1.5
- CSM 2000
- CSM 5000
- 3G CDMA2000 1x
BREW Enables Access to Devices for Wireless Applications and Content

BREW

UI Interface

ASIC Software
Wireless Internet Launchpad™ Suite
Multimedia, Connectivity, Positioning, User Interface, Storage

Browser
Instant Messenger
AVATARS
Position Location
Video Games
E-mail
Group Chat
Music
Info. Services
Java Applet
Java Applet
Java Applet
Java Applet
Java VM
A Wide Variety of Applications. . .

Mobile Text Communications
- Enhanced email
- Enhanced instant messaging

Position Location Services
- Navigation assistance
- Friend finder
- Emergency services

Entertainment
- Downloadable & streaming music
- Internet radio
- Streaming video
- Info. services
- e-Books

Mobile Chat
- Group conferencing/voice chat
- Video conferencing

Games
- Off- and on-line
- Multiple-player
- 3D motion, video, music

Avatars
- Personalized agents
Mobile Application Users

Source: ARC Group
BREW Partners

Target Market: 69,625,500 Subscribers

<table>
<thead>
<tr>
<th></th>
<th>January</th>
<th>March</th>
<th>April</th>
<th>August</th>
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<tbody>
<tr>
<td>Carriers</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>OEMs</td>
<td>2</td>
<td>6</td>
<td>10</td>
<td>12</td>
</tr>
</tbody>
</table>
More Than 3,300 Developers Signed Up For BREW

Developer Alliance Program Site Launched Aug, 2001
CDMA in China

- China Unicom Roaming Agreements
  - Bell Mobility (Canada)
  - Sprint PCS (US)
  - Lusacell (Mexico)
  - Hutchison (So. Korea)
  - KT Freetel (So. Korea)
  - KDDI (Japan)
  - SK Telecom (So. Korea)
  - Telstra (Australia)
  - NZ Telecom (New Zealand)

- CDMA Development Center - China's Silicon Valley

- ZTE Becomes First CDMA subscriber licensee

- Great Dragon enters into CDMA infrastructure license

300 Major Cities

<table>
<thead>
<tr>
<th>Vendor</th>
<th>License</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lucent</td>
<td>4.6</td>
</tr>
<tr>
<td>MOT</td>
<td>3.6</td>
</tr>
<tr>
<td>ERIC</td>
<td>3.0</td>
</tr>
<tr>
<td>Nortel</td>
<td>2.0</td>
</tr>
<tr>
<td>Samsung</td>
<td>1.0</td>
</tr>
<tr>
<td>ZTE</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>15.1 Lines</strong></td>
</tr>
</tbody>
</table>

Network Capacity for Over 15 Million Customers by Early 2002

Source: June 14, 2001 Reuters Limited
Digital Cinema

- Transforming the cinematic experience with digital technology
- World’s first end-to-end solution for processing and delivering digitized motion pictures and other programming to theatres
- Through a joint venture with Technicolor, QDM’s Digital Cinema meets the needs and economies of cinema distribution worldwide
Thank You

Severino Camilo,
Sr. Manager of Development Business

September, 2001