CDMA Evolution

CDMA2000 RADIO TECHNOLOGY
UNIT LESSONS

- CDMA2000 Forward Radio Carrier (Downlink)
  - Pilot, Sync, Paging, and Fundamental Channels
  - Supplemental Channels
    - Packet Mode Operation
    - Configuration and Data Rate Options
  - Multi-Carrier Operation
- CDMA2000 Reverse Radio Carrier (Uplink)
- **CDMA2000 Evolution to 1xEV-DO and 1xEV-DV**

CDMA2000 EVOLUTION



- IS-2000 (The TIA name for the CDMA2000 standards document)
  - Standards first published in March, 2000 for 1.25 MHz (1x) and 3.75 MHz (3x) RF carriers
  - First commercial service for 1x was by SK Telecom in Korea
    - In October, 2000
    - Packet and circuit data up to 144 Kb/s*
    - Voice capacity enhancements (50-100% increase)
  - 3G 3x development is deferred
- 1xEV-DO (1x Evolution-Data Optimized**, aka High Data Rate or HDR)
  - Published as IS-856 Release 0 in November, 2000
  - Packet data up to 2.4 Mb/s downlink and 153 Kb/s uplink
  - Commercial service began in Jan, 2002 in Korea
  - 1xEV-DO Revision A (TIA-856 Revision A), approved in April, 2004 supports up to 3.1 Mb/s downlink and 1.8 Mb/s uplink
- 1xEV-DV (1x Evolution-Data and Voice)
  - Standardized in Release C of IS-2000 in 2Q2002
  - Supports up to 3.1 Mb/s downlink and 307.2 Kb/s uplink
  - 1xEV-DV Release D (TIA-2000 Release D), approved in March, 2004, supports up to 3.1 Mb/s downlink and 1.8 Mb/s uplink

* Later deployments of IS-2000 may support data rates up to 288 Kb/s in a 307.2 Kb/s channel (including overhead)
** Formerly, 1x Evolution Data Only

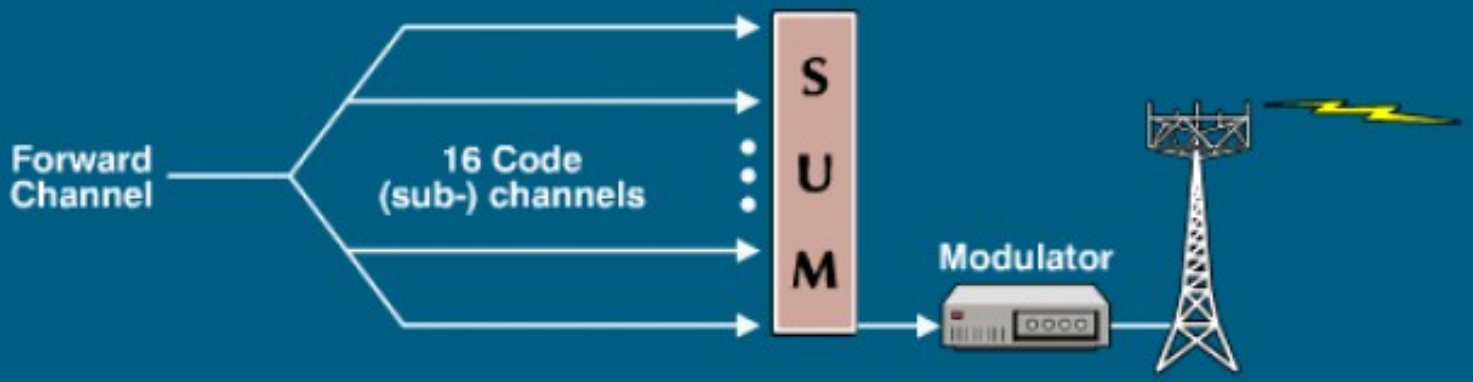
1x EV-DO (1x EVOLUTION-DATA OPTIMIZED**)
a.k.a. HDR (HIGH DATA RATE)

- Up to 2.4 Mb/s downlink and 153 Kb/s uplink in a 1.25 MHz carrier
  - With the instantaneous data rate dynamically adjusted according to the current SIR
- Optimized for data (no voice, initially), with 16 codes aggregated into a single packet channel
- Supports 8-PSK and 16-QAM modulation* in addition to QPSK, allowing the higher bit rates with the higher level modulation methods if the SIR is good enough
- Compatible with cdmaOne and CDMA2000
  - Can be used in same sector with same coverage
- Proposed by Qualcomm initially in 1998
- Standardized as TIA/EIA/IS-856 in November, 2000
- Commercial service in the U.S. offered by Verizon and Sprint
  - The first step in evolution beyond CDMA2000 1x
- 1xEV-DO Revision A (TIA-856 Rev A), approved in April, 2004, supports up to 3.1 Mb/s downlink and 1.8 Mb/s uplink

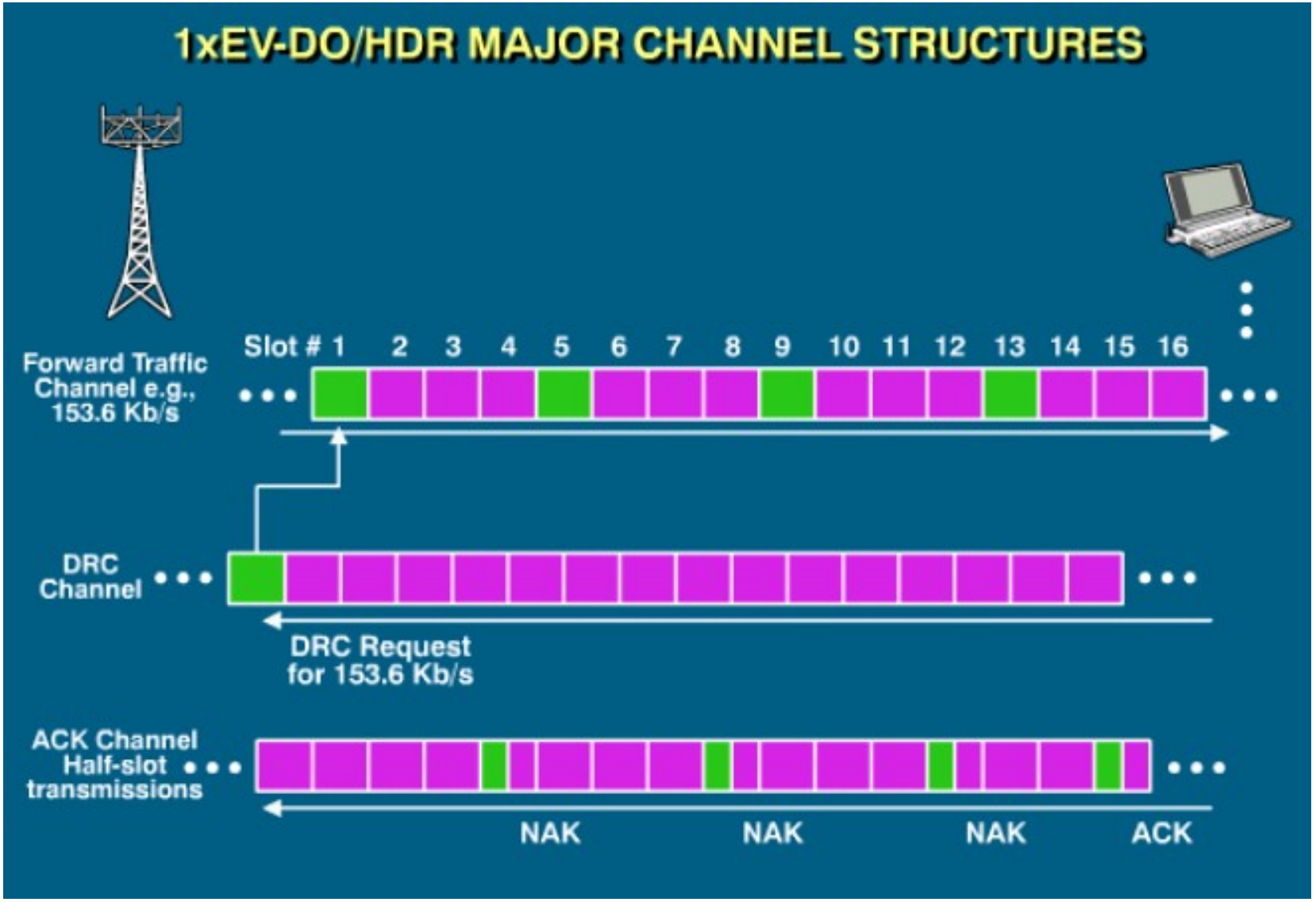
a.k.a. = also known as
TIA = Telecommunications Industry Association
SIR = Signal-to-Interference Ratio
QPSK = Quadrature Phase Shift Keying
8-PSK = 8-Phase Shift Keying
16-QAM = 16-Quadrature Amplitude Modulation

*QPSK, 8-PSK, and 16-QAM transmit 2, 3, and 4 bits respectively per modulation symbol (waveform)
**Formerly 1x Evolution - Data Only

1xEX-DO/HDR USES 16 CODE CHANNELS



- The high bit rate Forward Channel is carried by 16 Code (sub-) Channels each running at 1/16th the bit rate
- The modulation may be changed dynamically from QPSK to 16-QAM, at the extremes, to optimize performance with the correct environment


1xEV-DO/HDR MAJOR CHANNEL STRUCTURES
Forward Traffic Channel e.g., 153.6 Kb/s
Slot # 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
DRC Channel
DRC Request for 153.6 Kb/s
ACK Channel Half-slot transmissions
NAK
NAK
NAK
ACK

1xEV-DO/HDR OPERATION
MAJOR FEATURES

- Forward Channel is divided into 16 time slots each of 1.67 msec duration
  - Traffic Channel data or Control is carried within the time slots
  - Pilot and MAC (Medium Access Control) channels are also time multiplexed within each time slot
- Data is carried in "blocks" called "Physical Layer Packets"
  - Using 4 time slots, for the 153.6 Kb/s data transmission illustrated
- DRC (Data Rate Control) Channel is used to request transmission
  - Mobile requests the max data rate consistent with its current signal quality
- Time slots for a given user are every fourth time slot, until the user's physical layer packet is complete
  - Other user's packets use the other slots
- After each slot, the receiver replies on the ACK Channel
  - With an ACK if the complete physical layer packet has been received
  - With a NAK if the packet is not complete... or in error

1x EV-DV (1x EVOLUTION-DATA AND VOICE)

- Packet data up to 3.092 Mb/s on the downlink and 307.2 Kb/s on the uplink in 1.25 MHz
- Supports a mixture of data and voice
- Higher data rates possible with more aggressive* adaptive modulation
  - BPSK (1 bit per waveform/symbol)
  - QPSK (2 bits per waveform/symbol)
  - 8-PSK (3 bits per waveform/symbol)
  - 16-QAM (4 bits per waveform/symbol)
  - Where the higher bit rates (and higher levels of modulation) require better SIR (typically closer to the BS)
- Included in Release C of IS-2000 for CDMA2000 in May, 2002 by incorporating a new Forward-Packet Data Channel (F-PDCH)
- 1xEV-DV Release D (TIA-2000-D), approved March, 2004, increases the peak uplink bit rate to 1.8 Mb/s using a new Reverse-Packet Data Channel (R-PDCH)

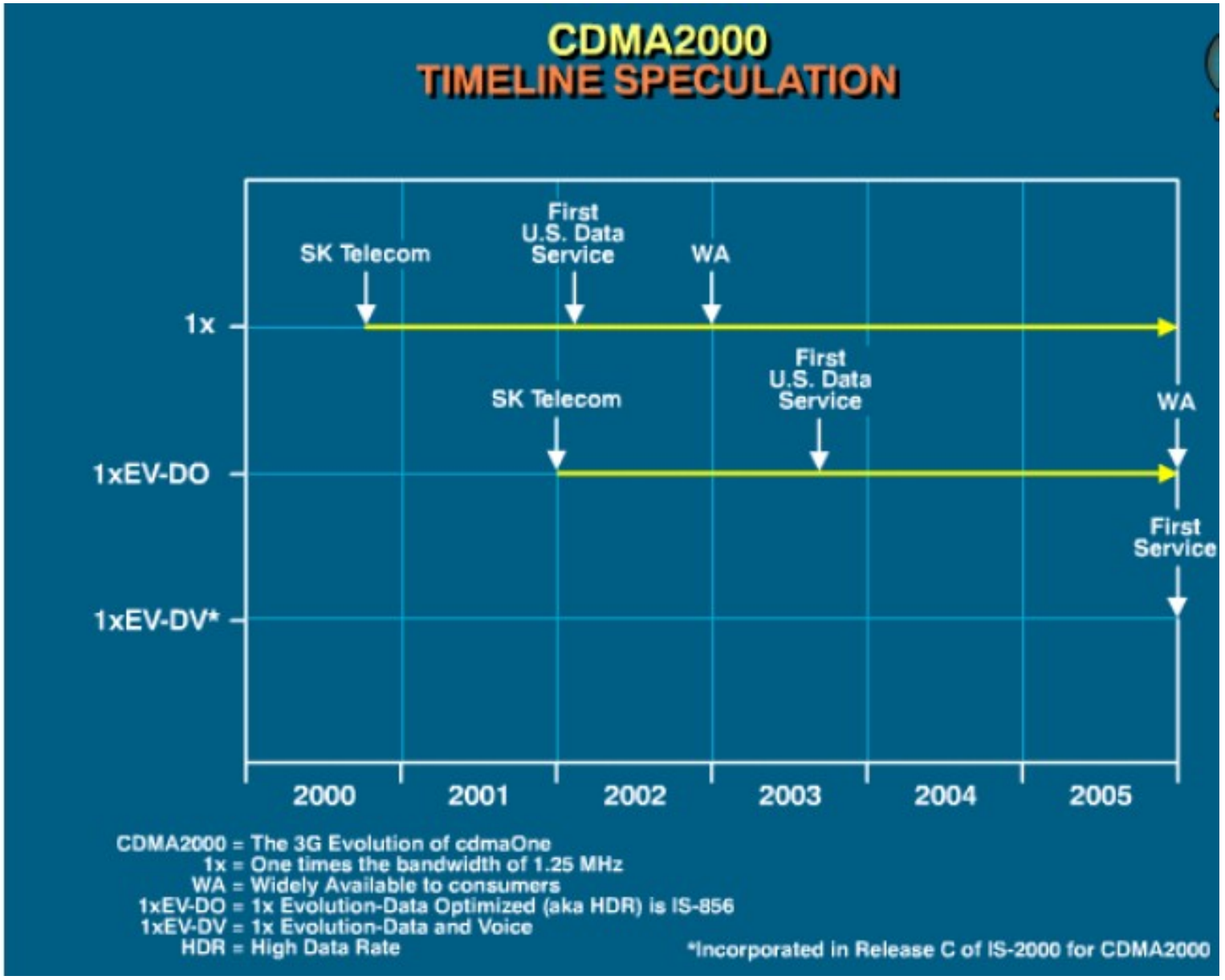
3GPP2 = 3G Partnership Project for CDMA2000
HDR = High Data Rate
QPSK = Quadriture Phase Shift Keying
8-PSK = 8-Phase Shift Keying
16-QAM = 16-Quadrature Amplitude Modulation
64-QAM = 64-Quadrature Amplitude Modulation
SIR = Signal-to-Interference Ratio

BS = Base Station
BPSK = Binary Phase Shift Keying
1xEV-DO = 1x Evolution - Data Only
1xEV-DV = 1x Evolution - Data and Voice

HOW DOES 1xEV OBTAIN SUCH HIGH DATA RATES ?
SOME MAJOR REASONS

- Smart scheduling of queued downlink packets
  - Packets queued for the mobile with the BEST SIR at the moment will be sent NEXT*, allowing maximum bit rate
  - Packets queued for mobiles with lower SIR will be held momentarily hoping that their SIR improves**
- No Soft Handoff required... when a mobile has multiple acceptable BS pilot signals in its "Active Set"
  - The network selects the BS with the instantaneous BEST SIR to transmit the next block of data to the mobile
  - Allows other BSs in the Active Set to transmit concurrently to OTHER mobiles, thus increasing capacity
- New and improved HARQ (Hybrid Automatic Repeat reQuest) re-transmission schemes
  - Minimize the overhead for FEC on the initial transmission
  - Transmit incremental additional FEC bits as needed to allow correction of errors
  - Avoids re-transmission of an entire block of data while also avoiding excessive, and unnecessary, FEC overhead

*If all else is equal, including relative priorities
**Within a tolerable delay


CDMA2000
TIMELINE SPECULATION
SK Telecom
First U.S. Data Service
WA
1x
SK Telecom
First U.S. Data Service
WA
1xEV-DO
First Service
1xEV-DV*
2000
2001
2002
2003
2004
2005
CDMA2000 = The 3G Evolution of cdmaOne
1x = One times the bandwidth of 1.25 MHz
WA = Widely Available to consumers
1xEV-DO = 1x Evolution-Data Optimized (aka HDR) is IS-856
1xEV-DV = 1x Evolution-Data and Voice
HDR = High Data Rate
*Incorporated in Release C of IS-2000 for CDMA2000

CDMA2000 EVOLUTION
SUMMARY

CDMA2000 is evolving in the following steps:

- CDMA2000 1x with packet data up to 144 Kb/s
  - First commercial service in Korea in October, 2000
  - First commercial service in the U.S. in 2002 by Verizon and Sprint
- 1xEV-DO (IS-856) with packet data up to 2.4 Mb/s downlink and 153.6 Kb/s uplink, initially*
  - First commercial service in Korea in Jan, 2002
  - First commercial service in the U.S. in 2003 by Verizon
  - Verizon and Sprint deploying nationally in 2004-2005
- 1xEV-DV (IS-2000 Rel C) with packet data up to 3.09 Mb/s downlink and 307.2 Kb/s, initially**
  - First application schedule pending

1x = One times the bandwidth of 1.25 MHz
1xEV-DO = 1x Evolution-Data Optimized
1xEV-DV = 1x Evolution-Data and Voice

* 1xEV-DO Revision A, approved in April, 2004, supports up to 3.1 Mb/s downlink and 1.8 Mb/s uplink
** 1xEV-DV Release D, approved in May, 2004, supports up to 3.1 Mb/s downlink and 1.8 Mb/s uplink

END OF LESSON 5