What is CDMA

- Both an access method and air-interface
- Rest of the network is very similar
  - Radio resource management, mobility management, security are similar
  - Power control and handoffs are different
- Uses DSSS and ECC
- Frequency reuse factor is 1
- 3 systems
  - IS-95 2G, W-CDMA, and CDMA2000
Advantages of CDMA Cellular

- Higher capacity
- Improves voice quality (new coder)
- Soft-handoffs
- Less power consumption (6-7 mW)
- Choice for 3G systems
Advantages of CDMA Cellular

- Frequency diversity – frequency-dependent transmission impairments have less effect on signal
- Multipath resistance – chipping codes used for CDMA exhibit low cross correlation and low autocorrelation
- Privacy – privacy is inherent since spread spectrum is obtained by use of noise-like signals
- Graceful degradation – system only gradually degrades as more users access the system
Drawbacks of CDMA Cellular

- Self-jamming – arriving transmissions from multiple users not aligned on chip boundaries unless users are perfectly synchronized
- Near-far problem – signals closer to the receiver are received with less attenuation than signals farther away
- Soft handoff – requires that the mobile acquires the new cell before it relinquishes the old; this is more complex than hard handoff used in FDMA and TDMA schemes
Drawbacks of CDMA Cellular

- Air-interface is the most complex
- Not symmetrical (unlike TDMA)
  - Forward and reverse channels are different
  - Forward channel (1→Many) synchronized
  - Forward channel uses orthogonal spreading codes
  - Reverse channel transmissions are not synchronized
  - Orthogonal codes are used for orthogonal waveform coding
Mobile Wireless CDMA Design Considerations

- RAKE receiver – when multiple versions of a signal arrive more than one chip interval apart, RAKE receiver attempts to recover signals from multiple paths and combine them
  - This method achieves better performance than simply recovering dominant signal and treating remaining signals as noise
- Soft Handoff – mobile station temporarily connected to more than one base station simultaneously
Figure 10.18 Principle of RAKE Receiver [PRAS98]
IS-95 CDMA Forward Channel

- The forward link uses the same frequency spectrum as AMPS (824-849 Mhz)
- Each carrier 1.25MHz
- 4 types of logical channel: A pilot, a synchronization, 7 paging, and 55 traffic channels
- Channels are separated using different spreading codes
- QPSK is the modulation scheme
- Orthogonal Walsh codes are used (64 total)
- After orthogonal codes, they are further spread by short PN spreading codes
- Short PN spreading codes are M sequences generated by LFSRs of length 15 with a period of 32768 chips.
Why we have two spreading codes?
The orthogonal codes are used to differentiate between the transmissions within a cell
The PN spreading codes are used to isolate different cells (BSs) that are using the same frequencies.
The same PN sequence is used in all BSs.
The offset for each BS is different. Of course, this requires synchronization
Synchronization is achieved by GPS.
One Forward CDMA Link, 1.25 MHz in the 824 – 849 MHz bands

Figure 8.4: IS-95 Forward Channel
Figure 8.5: Basic Spreading Procedure on the Forward Channel in IS-95
The pilot channel

- Provide a reference signal for all MSs that provides the phase reference for COHERENT demodulation
- 4-6 dB stronger than all other channels
- Used to lock onto other channels
- Obtained using all zero Walsh code; i.e., contains no information except the RF carrier
- Spread using the PN spreading code to identify the BS. (512 different BS*64 offsets)
- No power control in the pilot channel
Figure 8.6: (a) Pilot and (b) Sync Channel Processing in IS-95
Sync channel

- Used to acquire initial time synchronization
- Synch message includes system ID (SID), network ID (NID), the offset of the PN short code, the state of the PN-long code, and the paging channel data rate (4.8/9.6 Kbps)
- Uses W32 for spreading
- Operates at 1200 bps
Figure 8.6: (a) Pilot and (b) Sync Channel Processing in IS -95
Paging channels

- Used to page the MS in case of an incoming call, or to carry the control messages for call set up
- Uses W1-W7
- There is no power control
- Additionally scrambled by PN long code, which is generated by LFSR of length 42
- The rate 4.8 Kbps or 9.6Kbps
I Pilot PN at 1.2288 Mcps

Walsh Code W_{1,7}

19.2 kbps

BBF

Q Pilot PN at 1.2288 Mcps

19.2 kbps

BBF

The figure shows the processing of the Paging Channel in IS-95. The process starts with the Convolutional Encoder for the Paging Channel Message, which operates at a rate of 1/2. The encoded symbols are then repeated by 9.6 or 19.2 kbps. The resulting symbol repetition is then interleaved by 19.2 kbps, and this process is repeated at 19.2 kbps. The final output is modulated and transmitted at 1.2288 Mcps.

Figure 8.7: Paging Channel Processing in IS-95
The traffic channels

- Carry user information
- Two possible date rates
  - RS1=\{9.6, 4.8, 2.4, 1.2 \text{ Kbps}\}
  - RS2=\{14.4, 7.2, 3.6, 1.8 \text{ Kbps}\}
- RS1 is mandatory for IS-95, but support for RS2 is optional
- Also carry power control bits for the reverse channel
Figure 8.8: Forward Traffic Channel Processing in IS–95 (Rate Set 1)
Convolutional Encoder → Symbol Repetition → Voice Traffic

Puncture 2 of Every 6 inputs → Block Interleaver → Long Code Mask

Long Code Generator → Long Code Decimator

1.2288 Mcps

64:1

24:1

800 bps

Power Control Bits 800 bps

Walsh Code Wi

1.2288 Mcps

1.2288 Mcps

BBF

I Pilot PN at 1.2288 Mcps

Q Pilot PN at 1.2288 Mcps

BBF

Figure 8.9: Forward Traffic Channel Processing in IS–95 (Rate Set 2)
IS-95 CDMA Reverse Channel

- Fundamentally different from the forward channels
- Uses OQPSK for power efficiency
- QPSK demodulation is easy
- 869-894 MHz range.
- No spreading of the data using orthogonal codes
- Same orthogonal codes are used for WAVEFORM encoding
- Two types of logical channels: The access channels and the reverse traffic channels
One Reverse CDMA Link, 1.25 MHz in the 869 – 894 MHz

Figure 8.10: IS-95 Reverse Channel
Figure 8.11: Mapping data bits to Walsh encoded symbols
Figure 8.12: Access Channel Processing in IS-95