CDMA Key Technology

ZTE Corporation
CDMA Division
CDMA Key Technology

- Spread Spectrum Communication
- Code Division Multiple Access
- Power Control
- Diversity
- Soft Handoff
- Rake Receiver
- Variable Rate Vocoder
Why power control is needed for CDMA

Near-far problem
If all mobiles transmitted at the same power level, the base station would receive unnecessarily strong signals from mobiles nearby and extremely weak signals from mobiles that are far away. This will reduce the capacity of the system.

Power Control
Power control is a CDMA feature that enables mobiles to adjust the power at which they transmit. This ensures that the base station receives all signals at the appropriate power. Both forward and reverse links uses power control techniques.
The Need for Power Control

- CDMA is an Interference-limited system (not frequency-limited)
- Same frequency transmission: system internal interference critical to system capacity and voice quality
- Transmit power of each mobile should be controlled to limit interference
- Changes of RF environment: fast and slow fading, shadowing, external interference.
- Near and Far effect: mobile closer to the base station transmit less power than those far away

Objective: Reducing interference by limiting transmitted power on the forward and reverse links while maintaining link quality

- Meet user-defined performance objectives: BER, FER, capacity, dropped-call rate, coverage
Power Control (2)

Reverse Link Power Control: on the basis of E/I ratio

- Open Loop Power Control:
  No involvement of BS, MS determines initial power transmitted on the access and traffic channels, adjustment for path loss

- Closed loop control: inner loop control/outer loop control:
  MS seizes a forward traffic channel and receives control bits, MS and BS engage in closed-loop power control
  - Inner loop control: Keeps the mobile as close to its target E/I ratio as possible
  - Outer loop control: Adjust the base station target E/I ratio for a given mobile

Forward Link Power Control: on the basis of FER

- Reducing both in-cell interference and other cell/sector interference
- FERs are measured instead of E/I
**Power Control (3)**

**Reverse Open Loop Power Control**

- Transmitting Power, Control range: ±32 dB
- Receiving Power

**Reverse Closed Loop Power Control**

- BS
- Target $\frac{E_b}{I_o}$
- Power control algorithm
- Adjustment instruction
- Transmitting Power
- MS
- Inner loop
- Outer loop
- Error rate algorithm
- $\frac{E_b}{I_o}$
- Information packet
- Adjustment of Target E/I

- Constant $\frac{E_b}{I_o}$
Power Control (4)

Forward Link Power Control

Base Station

Transmitting Power

FER

MS
Reverse Open Loop

Reverse Link Open Loop Power Control

- An initial estimation of required transmission power by the mobile
- Coarse measure of path loss based upon total receive power at mobile
  \[ \text{Receive Power} + \text{Transmitted Power} = -73 \text{ (dbm)} + \text{Parameter} \]
Reverse Closed Loop Power Control

- Used to compensate for asymmetries in forward/reverse links
- Up/down commands sent to mobile based upon SNR measured at Base Station compared to a specified threshold
- Transmitted 800 times per second at 1dB increments
Reverse Outer Loop Power Control

- **Setpoint** is varied according to FER on reverse link (measured at the Base Station Controller)
- Sampled at 50 frames per second rate (20msec)
- Setpoint adjusted every 1-2 seconds
Power Control (Continued)

Stat. Backward link
FER

Outer-loop adjustment
Closed-loop control

Outer loop adjustment
algorithm, new \( \frac{E_b}{N_0} \)

Power control (bit) 0
Transmit

Power control (bit) 1

\[ \frac{E_b}{N_t} > \frac{E_b}{N_0} ? \]

1%

\[ \frac{E_b}{N_t} \]

BS measurement

BS
MS

Transmit power adjustment

Power control command detection
Forward Link Power Control (Continued)

- **Forward Link Power Control**
  - Base station slowly decreases power to each mobile
  - As FER (measured at the mobile) increases, the mobile requests a raise in forward link power
CDMA Power Control Summary

All types of power control work simultaneously to minimize transmit power.
Diversity

Three types of diversity in CDMA.

- Time Diversity
- Frequency Diversity
- Space Diversity
**Definition:**

- Simultaneous reception of multiple input signals. Combining and correlation of the signals help reduce multi-path fading.

**Types of Diversity:** compensation for fading factors of frequency, space and time

- Frequency diversity reception: spread spectrum transmission
- Space diversity reception
  - Two or more separate antennas for reception and transmission to guarantee separate propagation fading/loss
  - Two BTS: in case of soft handoff
Time Diversity Reception

- RAKE receivers of both BS and MS. When the delay of the signals is larger than 1μs, RAKE receiver extract them without confusion.
The rake receiver is a CDMA feature that turns what is a problem in other technologies into an advantage for CDMA.

Signals sent over the air can take multi-paths to the receiver. It can result in the receiving getting serveral versions of the same signal but at slightly different times. Multi-paths can cause a loss of signal through cancellation in other technologies.

CDMA rake receiver is multiple receivers in one. The rake receiver identifies the three strongest multi-path signals and combines them to produce one very strong signal.
Diversity (Continued)

Time Diversity

Convolutional

Interleaving

Output

$C_0$

$C_1$

$C_2$

The diagram shows a convolutional encoder with input and output nodes connected by convolutional and interleaving processes. The numbers represent data points or states in the encoder process.
Diversity (Continued)

Frequency Diversity

Bandwidth of Traditional Signal: 200~300 KHz

Bandwidth of CDMA Signal: 1.25MHz

50 times
Diversity receiver is useful in reducing multipath fading
A soft handoff establishes a connection with the new BTS prior to breaking the connection with the old one. This is possible because CDMA cells use the same frequency and the mobile uses a rake receiver.

The CDMA mobile assists the network in the handoff. The mobile detects a new pilot as it travels to the next coverage area. The new BTS then establishes a connection with the mobile. This new communication link is established while the mobile maintains the link with the old BTS.

Soft handoffs are also called “make-before-break”. It reduces call drop.
Features:
- First establish target connection, then cut off the original connection
- Seamless communication, less call dropping, high voice quality

Types of soft handoff:
- Inter sector: softer handoff, performed by BTS
- Inter BS: soft handoff, performed by BSC

Inter BSC/MSC Soft Handoff
- CDMA system with High-speed packet switching functions
Soft Handoff (2)
Soft Handoff Process (3)

Soft Handoff from BS A to BS B
Variable Rate Vocoder

Three types of vocoder
8K QCELP
13K QCELP
8K EVRC (Enhanced variable rate codec)

Four kinds of speed for 8K QCELP
9.6 Kbps - High Speed
4.8 Kbps - Middle Speed
2.4Kbps - Low Speed
1.2Kbps - Not Talk or Noise

It reduces the transmitted power, so its interference to all CDMA system is reduced and the capacity of all system increases.
Voice Coding

Q-CELP Voice Coder with variable rate

- Voice quality of CDMA 8K Vocoder equals that of GSM 13K Vocoder
- CDMA 13K Vocoder has good Voice quality close to that of wire telephone with strong background noise reduction
- CDMA EVRC very close to CDMA 13K Vocoder
Q-CELP Coding

- Voice
- Sampling
- 8KHz
- 20 ms
- 160 Sampled Value
- Tone parameter Sub-frame
- LPC Filter parameter Sub-frame
- Code table Para Sub-frame
- Para Frame
- Refresh
- Refresh 20 ms (Fixed)
- Data rate

Noise
- Self-adaptive Threshold

Multiplex
Data rate
- Channel
Thank you