Power control: why do it?

• needed for controlling interference in cellular systems

  • **intercell** interference - occurs in all cellular systems (TDMA / FDMA/ CDMA) due to frequency reuse

  • **intracell** interference - most serious in CDMA, can also cause ISI in TDMA
    • CDMA downlink - multipath
    • CDMA uplink - “near-far” effect
Power control: current work

• current approaches:
  • maintain constant received power [Fujii 1988]
  • carrier-to-interference ratio balancing [Zander 1992]
  • BER-based negative feedback [IS-95 standard]
New directions: InfoPad

Diagram showing the High-Speed Fiber Backbone connected to Compute Servers, Video Database, Speech Recognizer, and Commercial Database (news, financial information, etc.). The diagram also includes Base Station, Wireless Multimedia Terminals (X-terminal, Video Display, Audio Input/Output).
broadband CDMA

transmitter

mux → coder → power control → spreading code → \( \sum \) → to wireless channel

mux → coder → spreading code

receiver

despread → decode → demux

from channel → substream 1 → substream n
Observations on power control, channel coding

• capacity of wireless multiple access link is interference-limited

• transmit minimum power needed to support desired reliability

• signal space coding offer redundancy without bandwidth expansion

• UEP signal space codes with high coding gain are difficult to generate
New work

- Idea: combine the strengths of power control and channel coding together for UEP
  - exploit fixed-rate coder for high coding gain
  - use power control to provide UEP

minimize total transmit power

user channel conditions

substream reliability demands

power control

substream transmit powers
Power control formulation

Minimize the total transmit power, subject to the reliability requirement of each substream:

\[
\begin{align*}
x_{i,m} &= \text{substream } i, \text{ user } m \text{ power} \\
\bar{\beta}_{i,m} &= \text{substream } i, \text{ user } m \text{ mean duty cycle} \\
\sigma^2 &= \text{intercell interference} \\
G_m &= \text{path loss} \\
f &= \text{crosscorrelation}
\end{align*}
\]

\[
\text{minimize} \quad \mathbb{E}[P] = \sum_{m \text{ users}} \sum_{i \text{ substreams}} \bar{\beta}_{i,m} x_{i,m}
\]

\[
\text{s.t.} \quad \forall \text{ substreams } i, \text{ users } m, \quad \frac{G_m x_{i,m}}{\sigma^2 + f \sum_{n \neq m} G_n \sum_j \bar{\beta}_{j,n} x_{j,n}} \geq \text{SNR}_{i,m}
\]

\[
x_i \geq 0, \quad \text{SNR}_{i,m} > 0
\]
Power control solution

Feasibility: \[ \sum_{m \text{ users}} \sum_{i \text{ substreams}} \beta_{i, m} \alpha_{i, m} < 1 \]

Optimality: \[ x_{i, m} = \frac{\text{SNR}_{k, m}}{G_m} \left( \frac{1 - \sum_k \beta_{k, m} \alpha_{k, m}}{1 - \sum_{n} \sum_k \beta_{k, n} \alpha_{k, n}} \right) \sigma^2 \]