Call Admission Control Scheme for Arbitrary Traffic Distribution in CDMA Cellular Systems

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Relative Average Inter-Cell Interference

\[ I_{ji} = E \left[ \frac{\int_{C_j} r_j^m(x,y) 10^{\zeta_j/10}}{r_i^m(x,y)/\chi_i^2} \omega_j dA(x,y) \right] \]

\( m \) is the path loss exponent.

\( \zeta_i \) is the decibel attenuation due to shadowing, and has zero mean and standard deviation \( \sigma_s \).

\[ E[\chi_i^2 | \zeta_i] = 10^{-\zeta_i/10} \]

\[ \omega_j = \frac{n_j}{\text{Area}(C_j)} \]
Inter-Cell Interference Factor

\[ \kappa_{ji} \] per user inter-cell interference factor from cell \( j \) to cell \( i \).

\[ n_j \] users in cell \( j \) produce a relative average interference in cell \( i \) equal to \( n_j \kappa_{ji} \).
Capacity Region

\[
\frac{E_b}{\alpha(n_i - 1)E_bR/W + \alpha \sum_{j=1}^{M} n_j \kappa_{ji} E_b R/W + N_0} \geq \left( \frac{E_b}{I_0} \right)_{\text{req}}
\]

for \( i = 1, \ldots, M \).

\[
n_i + \sum_{j=1}^{M} n_j \kappa_{ji} \leq \frac{W}{R} \left( \frac{1}{\left( \frac{E_b}{I_0} \right)_{\text{req}}} - \frac{1}{\frac{E_b}{N_0}} \right) + 1 = c_{\text{eff}}
\]

for \( i = 1, \ldots, M \).
Our Model

- New call arrival process to cell $i$ is Poisson.
- Total offered traffic to cell $i$ is:

$$
\rho_i = \lambda_i + \sum_{j \in A_i} \nu_{ji}
$$

where $\lambda_i$ is the rate of the Poisson Process, $\nu_{ji}$ is the handoff rate from cell $j$ to cell $i$, $A_i$ is the set of cells adjacent to cell $i$. 
Handoff Rate

\[ v_{ji} = \lambda_j (1 - B_j) q_{ji} + (1 - B_j) q_{ji} \sum_{x \in A_j} v_{xj} \]

\[ = (1 - B_j) q_{ji} \rho_j \]

where \( B_j \) is the Blocking probability for cell \( j \),

\( q_{ji} \) is the probability that a call in progress in cell \( j \), after completing its dwell time, goes to cell \( i \).
Blocking Probability

\[ B_i = B(A_i, N_i) = \frac{A_i^{N_i}}{N_i!} \frac{1}{\sum_{k=0}^{N_i} \frac{A_i^k}{k!}}, \text{ where } A_i = \frac{\rho_i}{\mu_i}, \]

\[ N_i + \sum_{j=1}^{M} N_j k_{ji} \leq c_{\text{eff}} \text{ for } i = 1, \ldots, M. \]
Fixed Point

- Given values of $\lambda_i$ for $i = 1, \ldots, M$
- Assume initial values for $v_{ij}$ for $i, j = 1, \ldots, M$
- Calculate $\rho_i$ for $i = 1, \ldots, M$
- Calculate $B_i$ for $i = 1, \ldots, M$
- Calculate the new values of $v_{ij}$ for $i, j = 1, \ldots, M$

and repeat
Net Revenue $H$

- Revenue generated by accepting a new call
- Cost of a forced termination due to handoff failure

\[
H = \sum_{i=1}^{M} \left\{ w_i \lambda_i (1 - B_i) - c_i (\rho_i - \lambda_i) B_i \right\}
\]

- Finding the derivative of $H$ w.r.t. the arrival rate and w.r.t. $N$ is difficult.
Maximization of Net Revenue

\[
\max_{(N_1,\ldots,N_M)} \sum_{j=1}^{M} \left\{ w_j \lambda_j (1 - B_j) - c_j (\rho_j - \lambda_j) B_j \right\}
\]

subject to

\[
B(A_i,N_i) \leq \eta,
\]

\[
N_i + \sum N_j \kappa_{ji} \leq c_{\text{eff}},
\]

for \( i = 1,\ldots,M \).
3 Mobility Cases

No mobility

\[ q_{ii} = 0.3 \] and \[ q_{i} = 0.7 \]

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[ ]: Total offered traffic
• : Cell id
(): Max number of calls admitted
High mobility

[ ]: Total offered traffic
♦: Cell id
(): Max number of calls admitted

A

B
Low Mobility

- **Blocking probability**
- **Cell id**

Graph showing comparison between Traditional CAC and Our CAC.