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

Robert Akl

Manju Hegde

Mort Naraghi-Pour

Paul Min

Relative Average Inter-Cell Interference

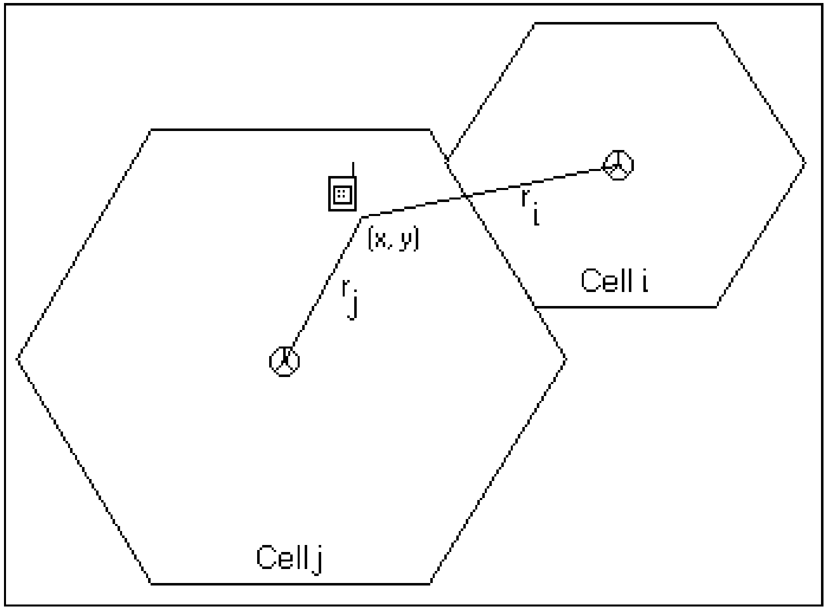
$$I_{ji} = \mathrm{E}\left[\iint_{C_j} \frac{r_j^m(x,y)10^{\zeta_j/10}}{r_i^m(x,y)/\chi_i^2}\,\omega_j\,dA(x,y)\right]$$

m is the path loss exponent.

ζ_i is the decibel attenuation due to shadowing, and has zero mean and standard deviation σ_s.

$$\mathrm{E}\left[\chi_i^2 | \zeta_i\right] = 10^{-\zeta_i/10}$$

$$\omega_j = \frac{n_j}{\mathrm{Area}(C_j)}$$



Inter-Cell Interference Factor

κ_{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

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

$$\text{for} \quad i = 1, \ldots, M.$$

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

$$\text{for} \quad i = 1, \ldots, M.$$

Our Model

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

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

where λ_i is the rate of the Poisson Process,

v_{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

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

$$N_i + \sum_{j=1}^{M} N_j \kappa_{ji} \le c_{\text{eff}} \quad \text{for } i = 1, \ldots, M.$$

Fixed Point

- Given valu es of λ_i for $i = 1,\dots,M$
- Assume initial values for v_{ij} for $i, j = 1,\dots,M$
- Calculate ρ_i for $i = 1,\dots,M$
- Calculate B_i for $i = 1,\dots,M$
- Calculate the new values of v_{ij} for $i, j = 1,\dots,M$

  and repeat

Net Revenue H

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

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

- **Finding the derivative of *H* w.r.t. the arrival rate and w.r.t. *N* is difficult.**

Maximization of Net Revenue

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

subject to

$$B(A_i, N_i) \le \eta,$$

$$N_i + \sum N_j \kappa_{ji} \le c_{eff},$$

$$\text{for} \quad i = 1, \ldots, M.$$

3 Mobility Cases

No mobility

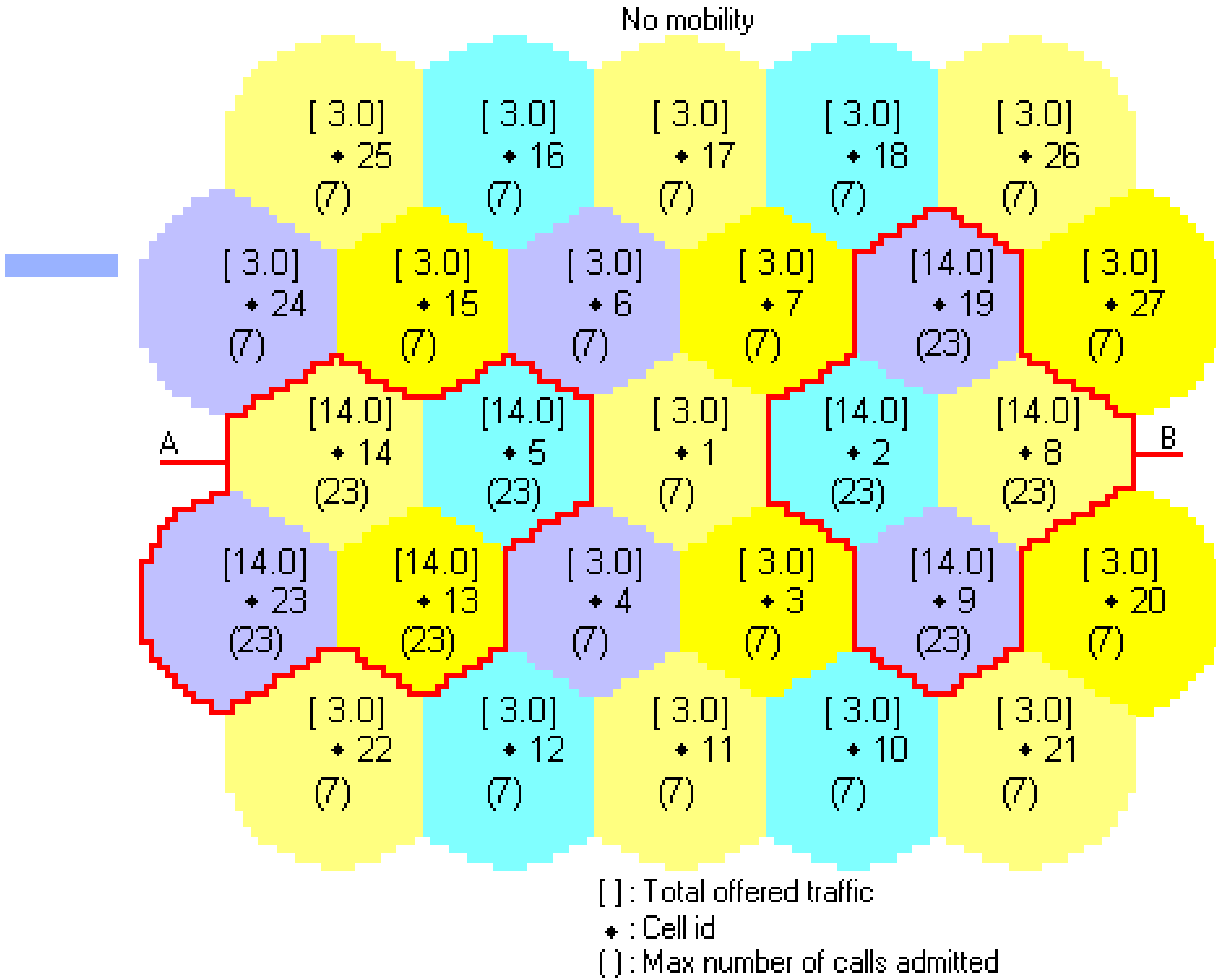
q_{ii}= 0.3 and q_i= 0.7

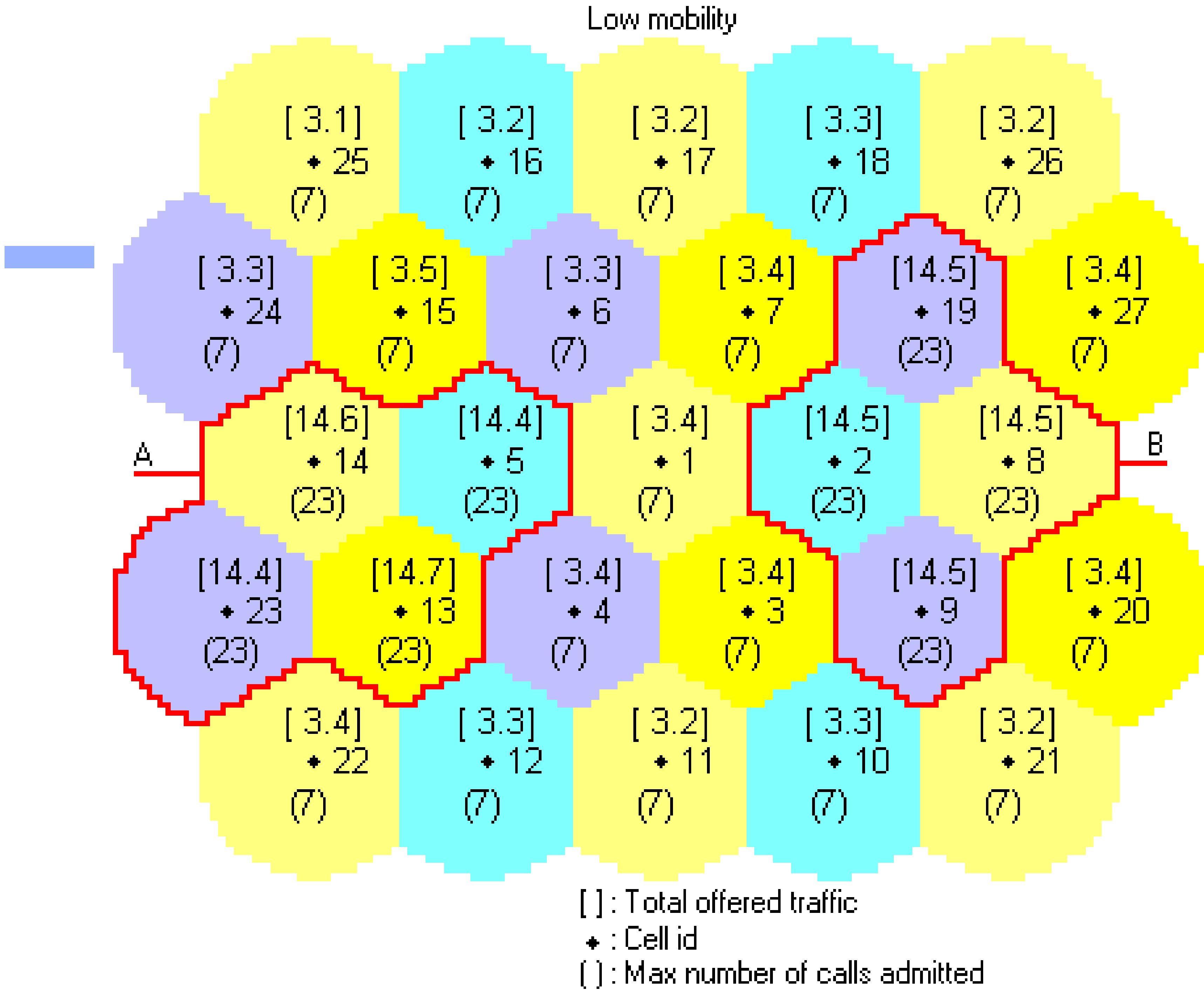
Low Mobility

$\|\|A_i\|\|$	q_{ij}	q_{ii}	q_i
3	0.020	0.24	0.7
4	0.015	0.24	0.7
5	0.012	0.24	0.7
6	0.010	0.24	0.7

High Mobility

$\|\|A_i\|\|$	q_{ij}	q_{ii}	q_i
3	0.100	0.0	0.7
4	0.075	0.0	0.7
5	0.060	0.0	0.7
6	0.050	0.0	0.7


No mobility
A
B
[3.0] 25 (7)
[3.0] 16 (7)
[3.0] 17 (7)
[3.0] 18 (7)
[3.0] 26 (7)
[3.0] 24 (7)
[3.0] 15 (7)
[3.0] 6 (7)
[3.0] 7 (7)
[14.0] 19 (23)
[3.0] 27 (7)
[14.0] 14 (23)
[14.0] 5 (23)
[3.0] 1 (7)
[14.0] 2 (23)
[14.0] 8 (23)
[14.0] 23 (23)
[14.0] 13 (23)
[3.0] 4 (7)
[3.0] 3 (7)
[14.0] 9 (23)
[3.0] 20 (7)
[3.0] 22 (7)
[3.0] 12 (7)
[3.0] 11 (7)
[3.0] 10 (7)
[3.0] 21 (7)
[ ] : Total offered traffic
: Cell id
( ) : Max number of calls admitted



Low mobility
[3.1] ◆ 25 (7)
[3.2] ◆ 16 (7)
[3.2] ◆ 17 (7)
[3.3] ◆ 18 (7)
[3.2] ◆ 26 (7)
[3.3] ◆ 24 (7)
[3.5] ◆ 15 (7)
[3.3] ◆ 6 (7)
[3.4] ◆ 7 (7)
[14.5] ◆ 19 (23)
[3.4] ◆ 27 (7)
A
[14.6] ◆ 14 (23)
[14.4] ◆ 5 (23)
[3.4] ◆ 1 (7)
[14.5] ◆ 2 (23)
[14.5] ◆ 8 (23)
B
[14.4] ◆ 23 (23)
[14.7] ◆ 13 (23)
[3.4] ◆ 4 (7)
[3.4] ◆ 3 (7)
[14.5] ◆ 9 (23)
[3.4] ◆ 20 (7)
[3.4] ◆ 22 (7)
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[3.3] ◆ 10 (7)
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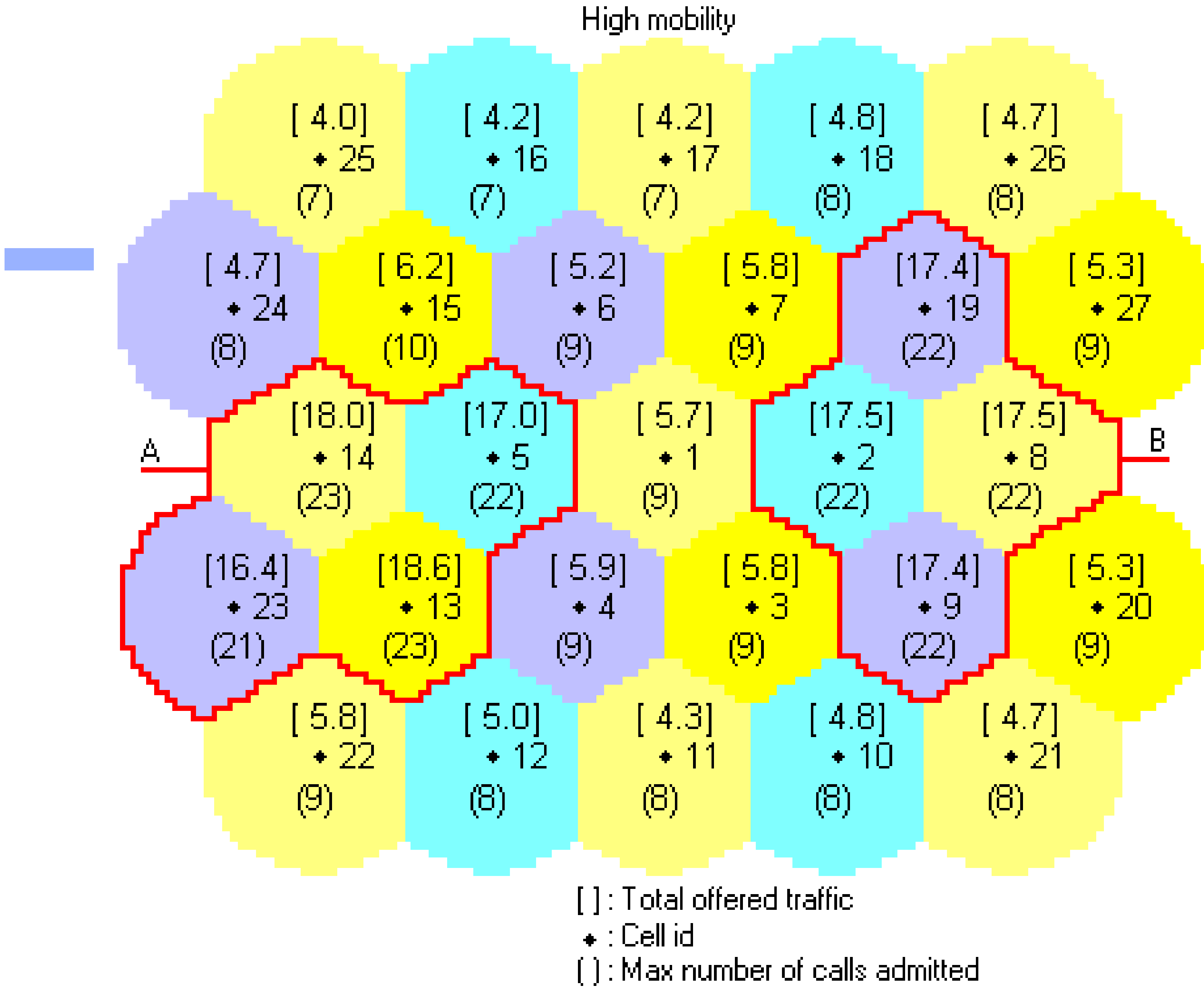
High mobility
[4.0] ◆ 25 (7)
[4.2] ◆ 16 (7)
[4.2] ◆ 17 (7)
[4.8] ◆ 18 (8)
[4.7] ◆ 26 (8)
[4.7] ◆ 24 (8)
[6.2] ◆ 15 (10)
[5.2] ◆ 6 (9)
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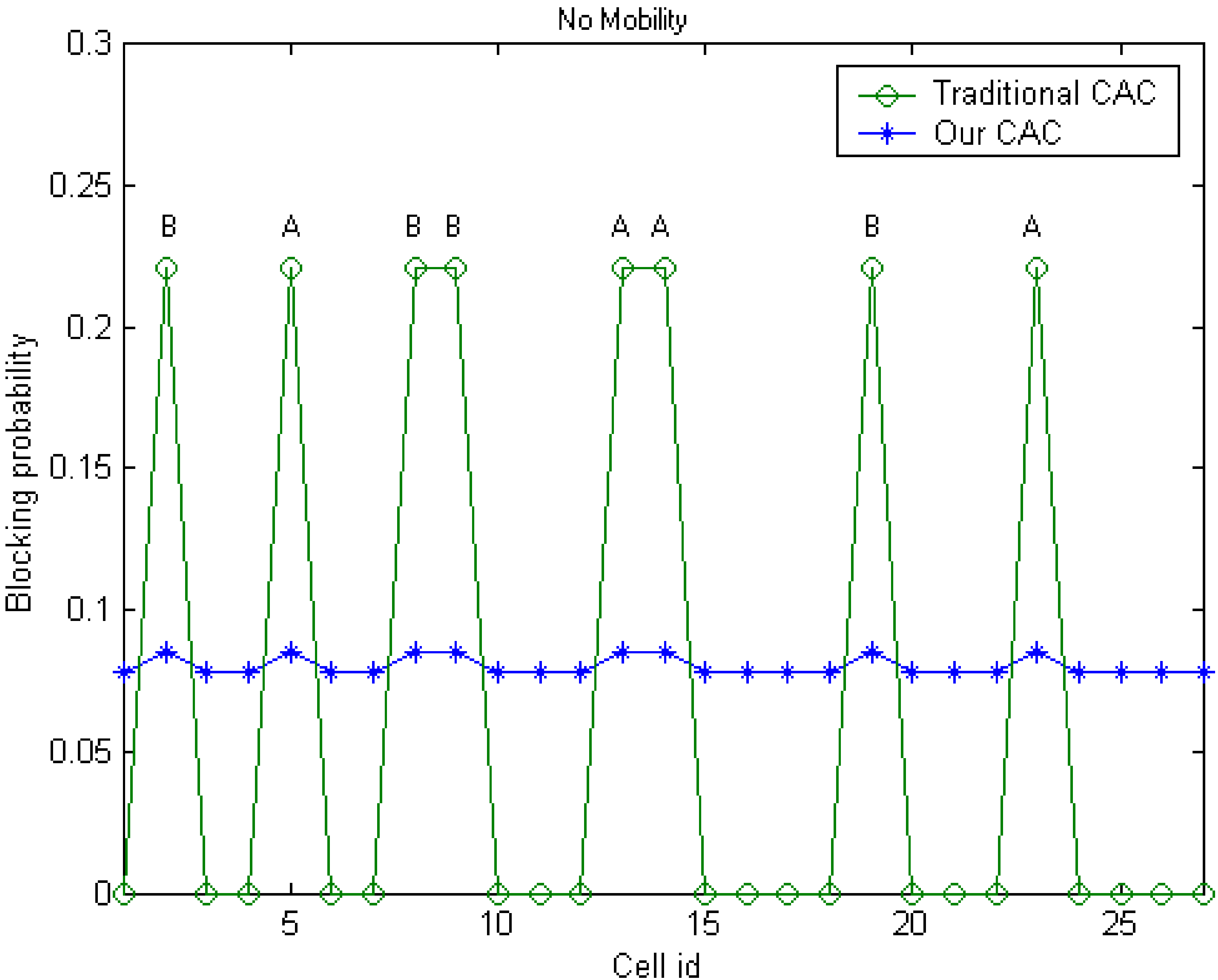
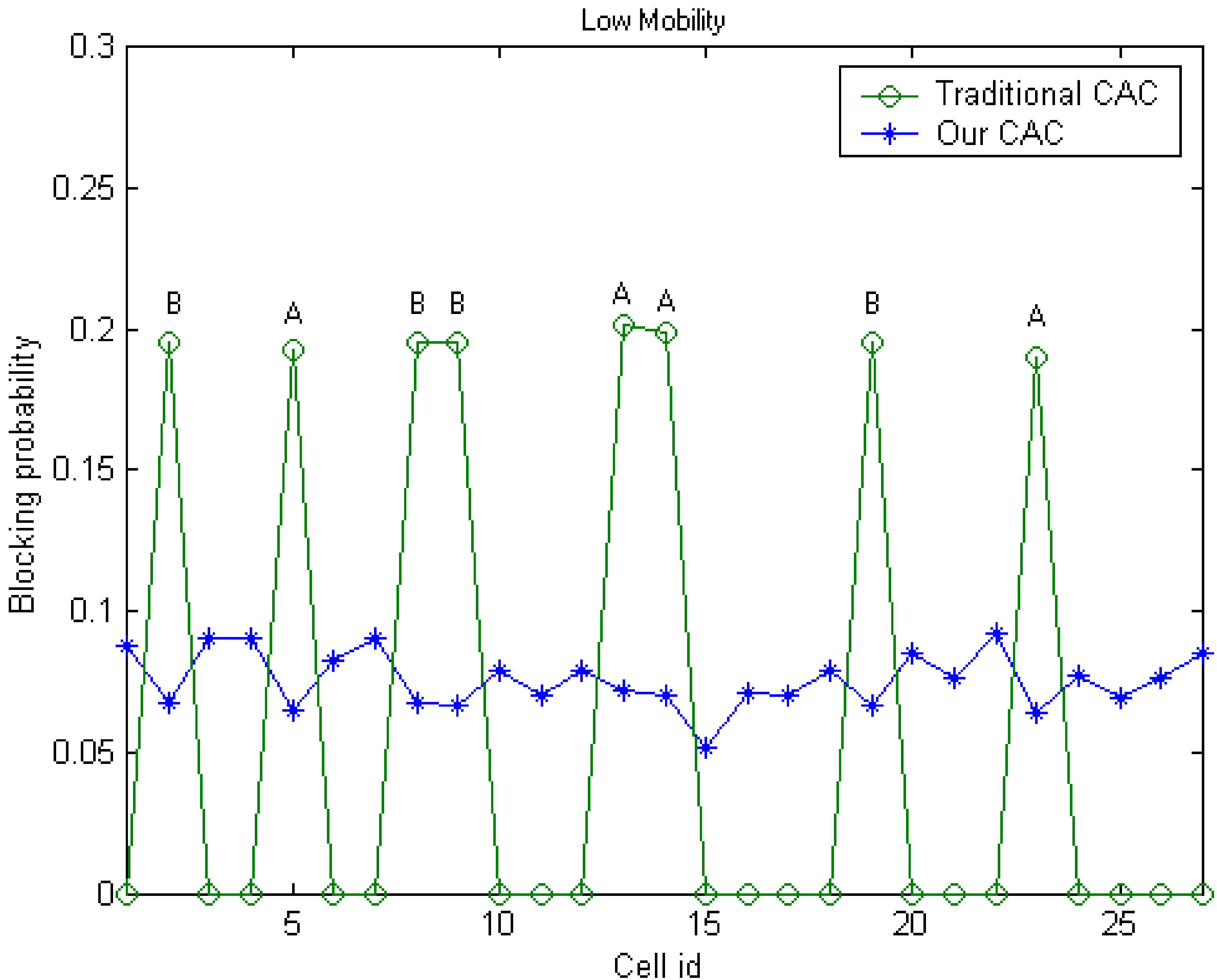

No Mobility
Traditional CAC
Our CAC
B
A
B B
A A
B
A
Blocking probability
0.3
0.25
0.2
0.15
0.1
0.05
0
5
10
15
20
25
Cell id


Low Mobility
Traditional CAC
Our CAC
Blocking probability
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0.25
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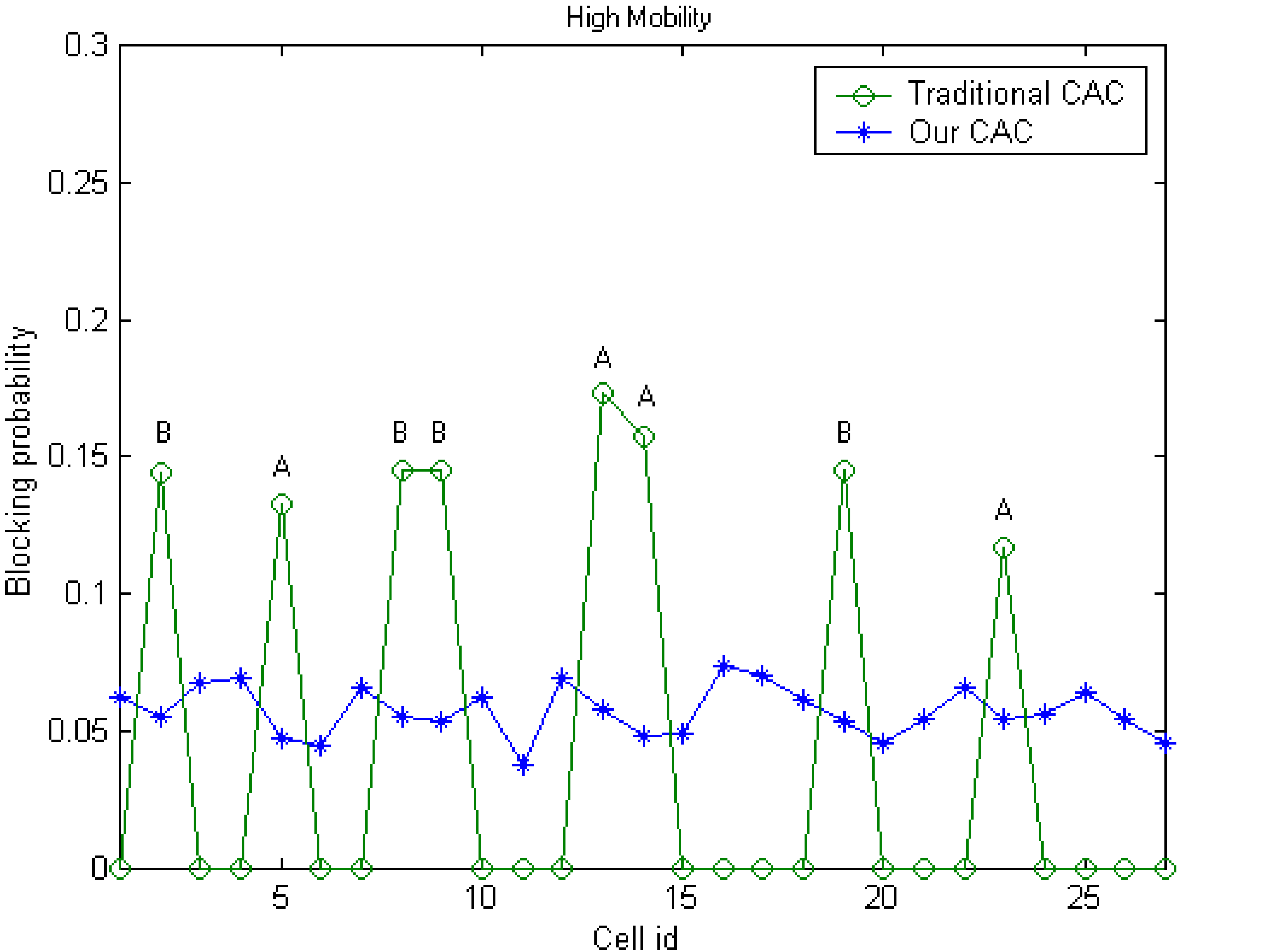
5
10
15
20
25
B
A
B
B
A
A
B
A


High Mobility
Traditional CAC
Our CAC
Blocking probability
Cell id
0
0.05
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B
A
B
B
A
A
B
A