Channel Allocation Techniques

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Summary

- Resource Reuse (TDMA and FDMA)
- *Fixed Channel Allocation* (FCA)
- *Dynamic Channel Allocation* (DCA)
- Performance Comparisons
- Final Considerations

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Introduction

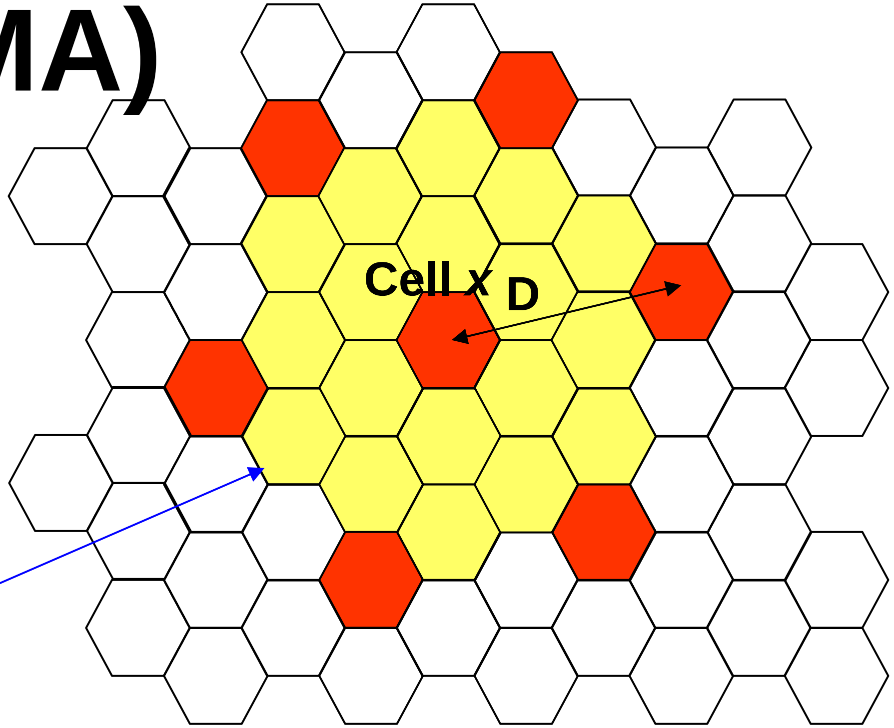
- Mobile Wireless Communication Systems experience a rapid increase in the number of subscribers

- Need for reliable and efficient operations

- Limited radio resources - channels

Channel Reuse (TDMA and FDMA)

- Two cells can reuse the same set of channels provided that they are at a suitable distance, called reuse distance, *D*, that allows tolerable levels of inter-cell interference.

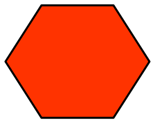


Scheme with reuse *K* = 7: *K* different colors are necessary to cover all the cells fulfilling the reuse distance constraint.

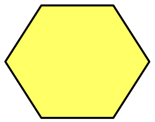
Possible values of *K*: 1, 3, 4, 7, 9, ... (**hexagonal cells**)

$$D = R\sqrt{3K^2} \quad , \quad where\ R\ is\ the\ cell\ side$$

$$\frac{C}{I} = \frac{1}{6}\left(\frac{D}{R}\right)^{\gamma} \quad for\ a\ \gamma\ path\ loss\ exponent$$



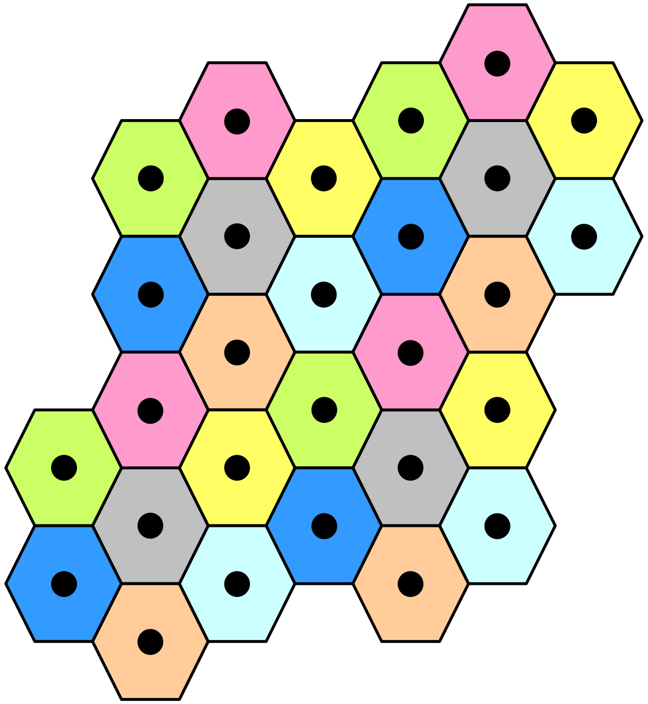
Cells that can reuse the same channel with low interference



Interfering cells

Fixed Channel Allocation (FCA)

- With FCA, a set of channels is **permanently assigned** to each cell, according to the allowed reuse distance *D*.
- A call can only be served by an available channel belonging to the poll of channels of the cell.
- A call arriving in a cell, where no channel is available, is *blocked and cleared*.
- Assuming Poisson call arrivals and exponentially distributed channel holding times, call blocking probability can be derived according to the **ERLANG-B formula**.



FCA pattern for $K = 7$

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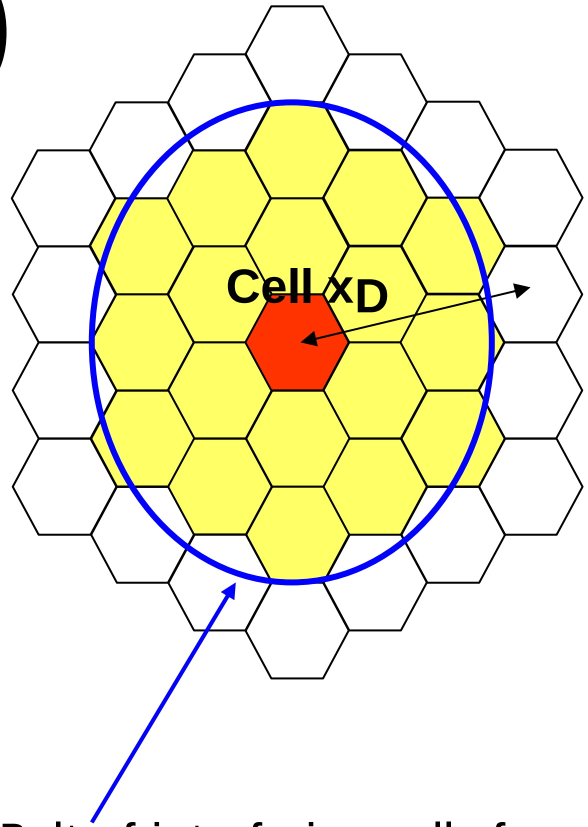
Dynamic Channel Allocation (DCA)

- DCA allows that any system channel can be **temporarily assigned** to any cell, provided that the reuse distance constraint is fulfilled.
- Different DCA techniques can be considered depending on the criterion adopted to select a channel to be assigned in a cell among all available resources.
  - *We choose to allocate in the cell x the channel that becomes locked (due to co-channel interference constraints) in the **lowest** number of interfering cells*. This selection is accomplished on the basis of a cost-function.

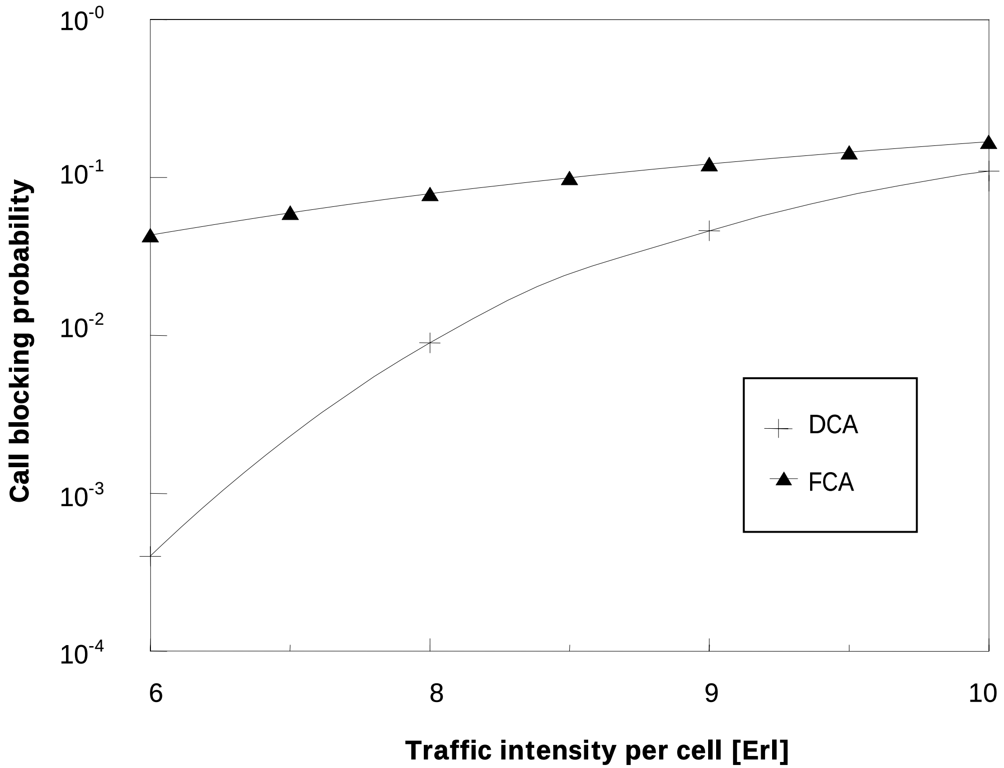


Belt of interfering cells for cell x for $K = 7$ (i.e., two tiers of cells surrounding cell x)

Performance Comparisons between DCA and FCA

- Parameter values adopted for performing simulations:
  - Reuse factor $K = 7$
  - 70 channels totally available to the system
  - Users do not change their cells
  - Average call duration of 3 minutes
  - Hexagonal cells
  - A parallelogram-shaped cellular system has been simulated with 7 cells per side. This cellular system has been wrapped around, so that also border cells have a complete belt of interfering cells.

Performance Comparisons between DCA and FCA (cont’d)



- These results clearly prove the superior performance of our DCA scheme in terms of call blocking probability with respect to the classical FCA approach.

Final Considerations

- DCA
  - One transmitter for every frequency in any cell
  - Management of a distributed allocation problem with updated information exchanged among cells (within the reuse distance) at each channel allocation event.
  - Well suited to support non-uniform traffics.

- FCA
  - Complex frequency planning to allocate permanently resources
  - Not well suited for varying traffic conditions (typically, a worst-case capacity allocation is performed).

- Reference
  - E. Del Re, R. Fantacci, G. Giambene, "Handover Queuing Strategies with Dynamic and Fixed Channel Allocation Techniques in Low Earth Orbit Mobile Satellite Systems", *IEEE Trans. Comm., Vol. 47, No. 1, pp. 89-102, January 1999.*

DCA in Multilayer Cellular Systems

- New System Model
  - Multiple Base Stations (BSs) are used to serve the same area
  - Different antenna heights
  - Different channels frequencies allocated
  - Variable transmission power levels

System Model

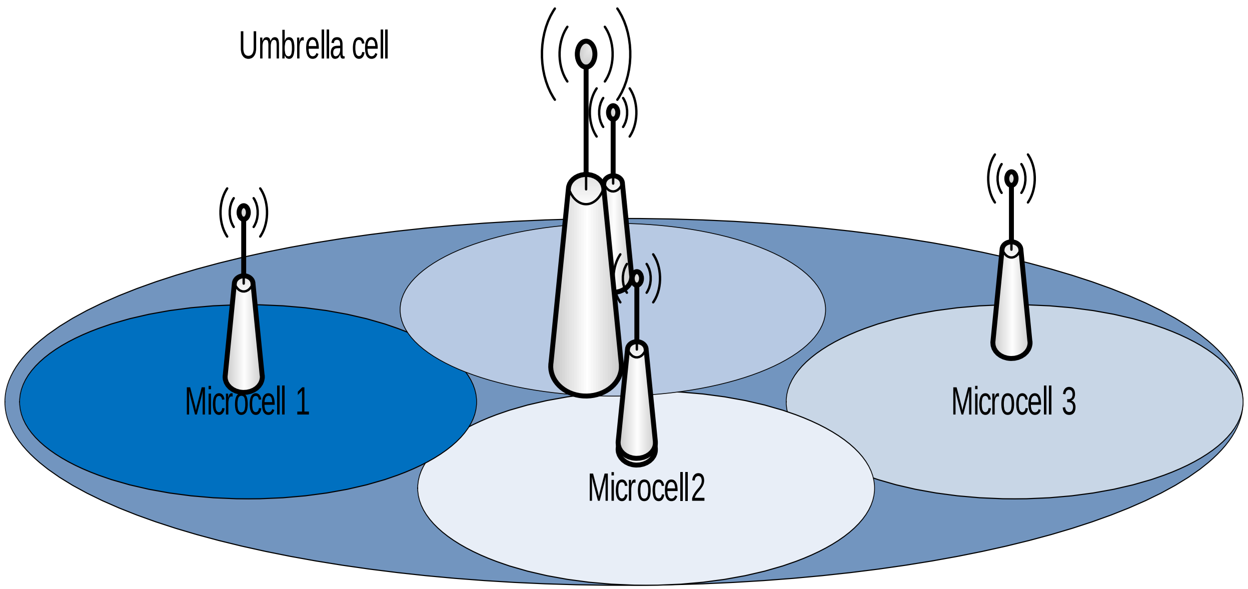
- Multi-Layer Cellular Wireless Systems

  - Co-existence of microcells and macrocells in the same area

  - Umbrella Cell Solution –> microcells embeded in a macrocell

System Model

❑Two-Layer Wireless Cellular System



- n microcells
- 1 macrocell→umbrella cell

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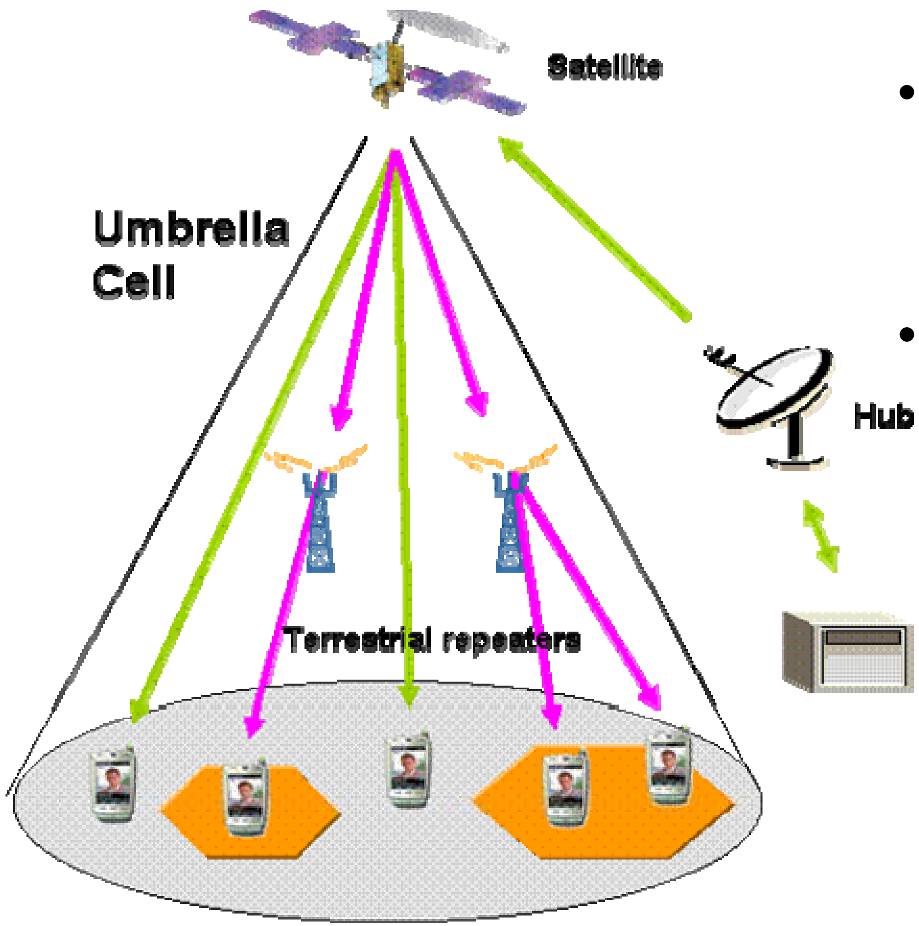
Microcell n

System Model



- Unidirectional nature and provide point to multipoint services.
- National wide Umbrella cell achieved with high power GEO satellite + terrestrial repeaters

Goal of the channel allocation techniques

- Guarantee Low Call Blocking Probability for Handoff Calls of HSMT

- Manage the Channels of the System Adaptively

Channel Allocation Techniques

❑Assumptions

- Two classes of users
  - HSMT
  - LSMT

- Two types of calls
  - Handoff Calls
  - New Calls

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Channel Allocation Technique

Generation rate for HSMT

- $\lambda_R^H(i)$
- $\lambda_{Rh}^H(i)$

➢ Generation rate for LSMT

- $\lambda_R^L(i)$
- $\lambda_{Rh}^L(i)$

➢ Channel holding time is constant :

- T_h

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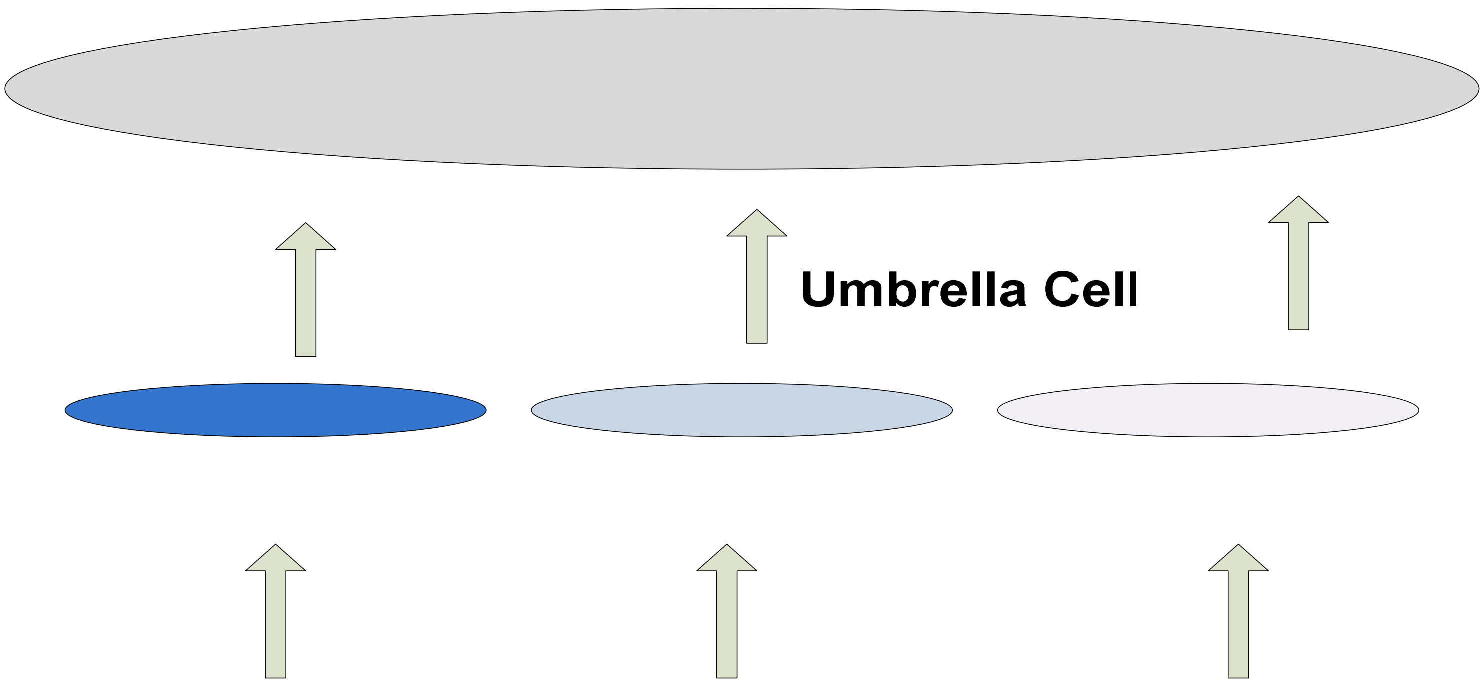
Proposed Channel Management Scheme



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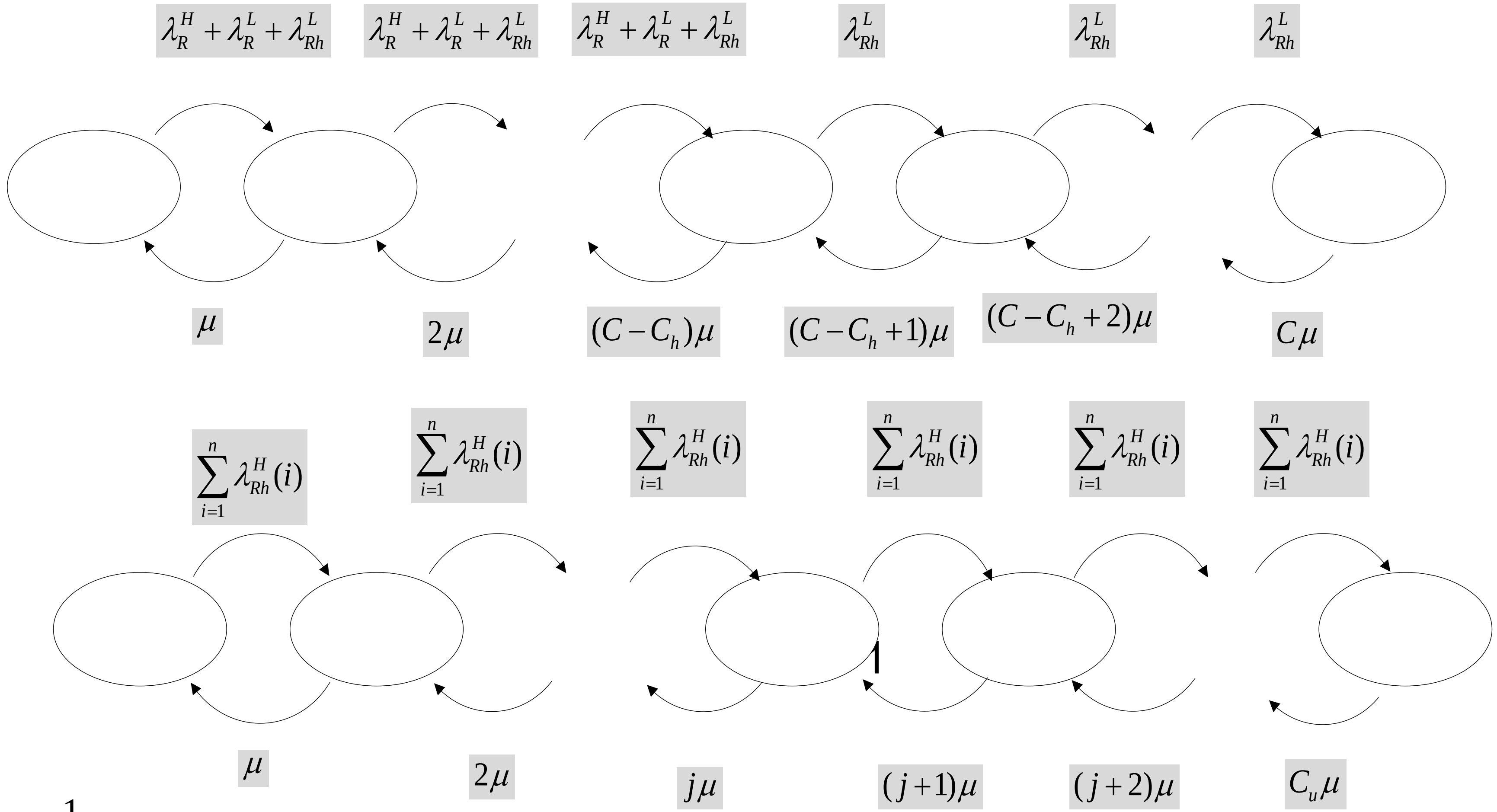
Proposed Channel Management Scheme



C-C

$$\mu = \frac{1}{T_h}$$

Proposed Channel Management Scheme

- Steady state Probabilities for microcell *i*

$$P_j^m(i)=\begin{cases}\dfrac{\left(\lambda_R^H(i)+\lambda_R^L(i)+\lambda_{Rh}^L(i)\right)^j}{j!\mu^j}P_0^m & for\ j=1,2,\ldots,C(i)-C_h(i)\\ \dfrac{\left(\lambda_R^H(i)+\lambda_R^L(i)+\lambda_{Rh}^L(i)\right)^{C-Ch}\lambda_{Rh}^L(i)^{j-(C-Ch)}}{j!\mu^j}P_0^m & for\ j=C(i)-C_h(i)+1,\ldots,C(i)\end{cases}$$

where...

$$P_0^m=\left[\sum_{k=0}^{C(i)-C_h(i)}\frac{\left(\lambda_R^L+\lambda_R^H+\lambda_{Rh}^L\right)^k}{k!\mu^k}+\sum_{k=C-C_h+1}^{C}\frac{\left(\lambda_R^L+\lambda_R^H+\lambda_{Rh}^L\right)^{C(i)-C_h(i)}\left(\lambda_{Rh}^L\right)^{k-(C(i)-C_h(i))}}{k!\mu^k}\right]^{-1}$$

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Proposed Channel Management Scheme

- Steady state Probabilities for macrocell

$$P_j^u = \frac{\left(\sum_{i=1}^{n} \lambda_{Rh}^{H}(i)\right)^j}{j!\,\mu^j} P_0^u \quad \text{for} \quad j = 1, 2, \ldots, C_u$$

where...

$$P_0^u = \left[\sum_{k=0}^{Cu} \frac{\left(\sum_{i=1}^{n} \lambda_{Rh}^{H}(i)\right)^k}{k!\,\mu^k} \right]^{-1}$$

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Results

- Blocking Probability for microcell *i*

$$P_B^m(i) = \sum_{j=C(i)-Ch(i)}^{C(i)} P_j^m(i)$$

- Handoff Failure Probability for microcell *i*

$$P_{fh}^m(i) = P_C^m(i)$$

- Blocking Probability for umbrella cell

$$P_{fh}^u = P_{Cu}$$

Results

- Blocking Probability in microcellular Layer

$$P_{nl} = \frac{\sum_{i=1}^{n}\left(\left(\lambda_{R}^{H}(i)+\lambda_{R}^{L}(i)\right)\cdot P_{B}^{m}(i)+\lambda_{Rn}^{L}(i)\cdot P_{fh}^{m}(i)\right)}{\sum_{i=1}^{n}\left(\lambda_{R}^{H}(i)+\lambda_{Rn}^{L}(i)+\lambda_{R}^{L}(i)\right)}$$

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Results

❑ Parameters

- Number of microcells *n=3*
- Channels of wireless system $C_s = 45$
- Channels exclusive for handoff calls in microcells $C_h(i) = 0.1C(i)$
- $a_{HL} = 0.46$, $a_{HL} = \left(\lambda_{Rh}^{H} + \lambda_{Rh}^{L}\right) \Big/ \left(\lambda_{Rh}^{H} + \lambda_{R}^{H} + \lambda_{Rh}^{L} + \lambda_{R}^{L}\right)$
- $20 \le T_{off}^{tot} \le 150$
- $T_h = 80s$

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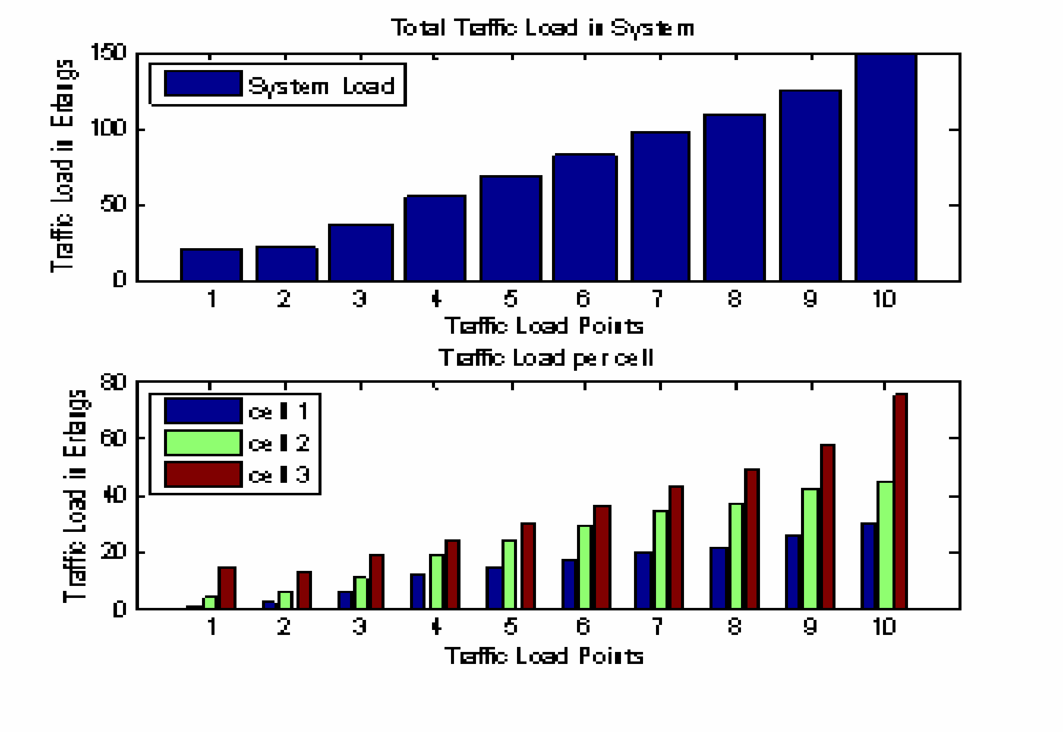
Results

❑ Offered Traffic Load



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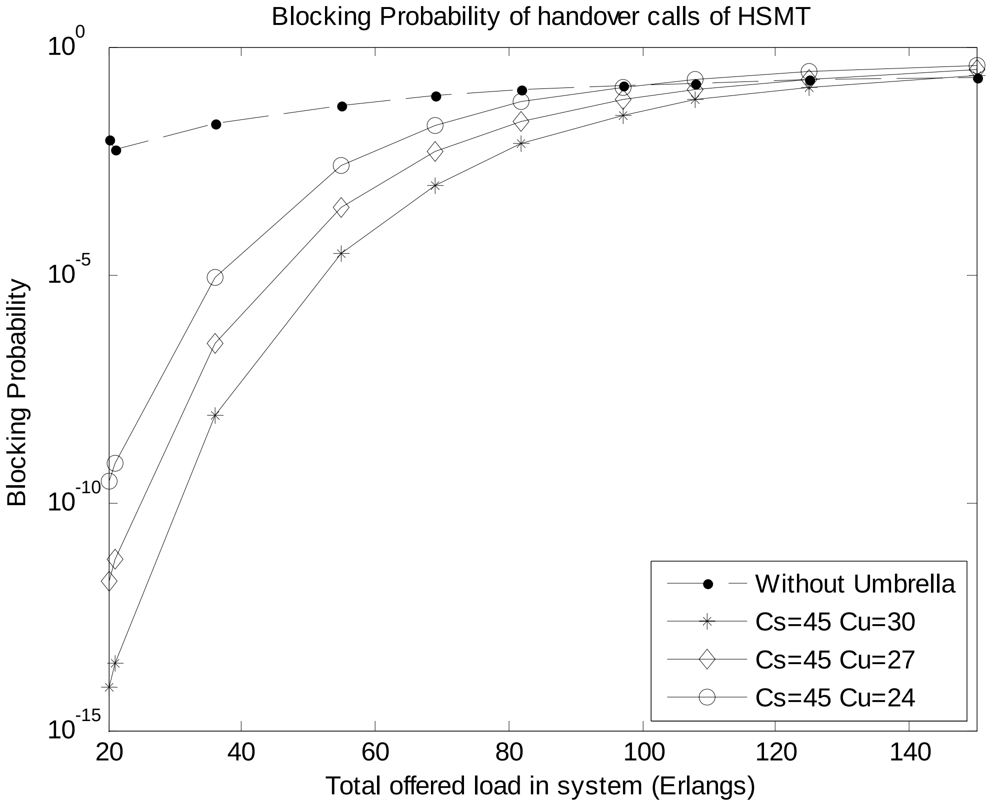
Results

❑ Blocking Probability of handoff calls of HSMT



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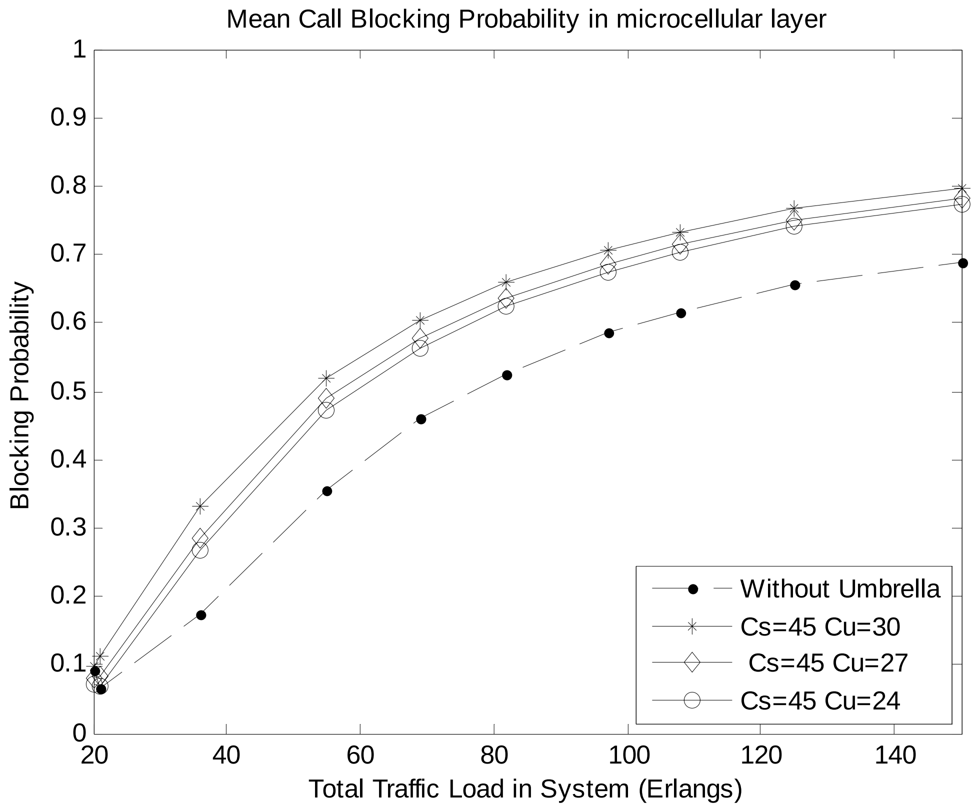
Results

❑ Blocking Probability in microcellular Layer



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WTL

Results

❑ Typical Channel Distribution Assignment for *Cu=30 Cs=45*

Time period	1	2	3	4	5	6	7	8	9	10
C(1)	3	2	3	3	3	3	3	3	4	3
C(2)	1	3	3	4	3	3	3	3	5	5
C(3)	11	10	9	8	9	9	9	9	6	7

Conclusion

- A New Channel Management Scheme Proposed

  - Guarantees Low Call Blocking Probability for Handoff HSMT calls

  - Dynamic Channel Management

Thank you for your attention

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