

CAPACITY ESTIMATION FOR SIR-BASED POWER CONTROLLED CDMA SYSTEM WITH MIXED CELL SIZES

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ABSTRACT

In heavily populated areas, cell splitting used to increase the capacity of the cellular system. Cell splitting produces a cellular system with mixed cell sizes. Many previous studies assumed strength-based power control, which maintains received power at a desired level regardless of changes in the number of active users and in the amount of total other cells interference. However, with signal-to-interference ratio (SIR)-based power control systems, that maintain the received SIR at a desired level, the power level is a function of the above two variables. This study calculates the reverse link capacity of SIR-based power control system with mixed cell sizes.

Keywords: CDMA system capacity, power control, and cell splitting.

1 INTRODUCTION

Capacity estimation in Code Division Multiple Access (CDMA) systems is an important issue which is closely related to power control, cell sizes, and other factors. Power control is needed to minimize each user's interference on the reverse link in varying radio environments and traffic conditions [1]. Previous studies [2]- [4] considered power control systems in which each user's signal arrives at the home base station (BS) with the same signal strength. The BS measures the received power level and compares it with a desired level and then transmits power control bit(s). This system is referred to as a strength-based power control system.

The signal-to-interference ratio (SIR) is more important than signal strength in determining channel characteristics (e.g., bit error probability), where SIR-based power control determining the value of the power control bit by comparing the received SIR with the desired SIR threshold.

The received signal power level varies according to the number of active home-cell users and the amount of other cells interference. Thus, the analysis of an SIR-based power control system is significantly different from the analysis of strength-based power control systems.

On the other hand the cell size is determined based on the traffic load and population density of the service area. In heavily populated areas, cell splits are used to increase the capacity of the cellular system. After cell splitting, macro cells are split into small micro cells. The split cells have different cell sizes from those of the other cells surrounding them.

Then the cellular system is configured with cells of mixed sizes. In a uniform cell size environment, all the cells are in the identical condition and the interferences received by individual cells are equal. Therefore, every cell has the same reverse link capacity. In a mixed cell size environment, however, cells are different from each other. Thus, each cell will have a different reverse link capacity [3].

In this paper the reverse link capacity of SIR-based power control system with mixed cell sizes is calculated. Consider a macro cell is split into three micro cells, as an example, and the reverse link capacities for the three micro cells and the neighboring macro cells are calculate.

The reminder of this paper is organized as follows. In section II, the reverse link capacity of an SIR-based power control system with uniform cell size is calculated. In section III, the reverse link capacity of SIR-based power control system with mixed cell sizes is obtained. In Section IV, conclusion is presented.

2 REVERSE LINK CAPACITY OF SIR-BASED POWER CONTROL SYSTEM WITH UNIFORM CELL SIZE

In a multiple-cell CDMA system, a MS is power-controlled by the BS that sending the highest strength pilot signal to the MS. This BS is called the *home* BS of the given MS. The path loss L between the MS and the BS is described as,

$$L \propto r^{-\mu} 10^{\zeta/10} \quad (1)$$

where,

r distance from a MS to a BS;
 μ path loss exponent;
 ζ attenuation in dB due to shadowing, which is a Gaussian random variable with standard deviation σ of 8 dB and zero mean.

2.1 Calculation of Total Other Cell Interference

First, the reverse link interference from each tier to the center cell is calculated separately. Then, we can obtain the total other cell interference which is the interference produced by all users who are power-controlled by other BS's. If the interfering subscriber in another cell is located at a distance r_m from its BS and r_o from the BS of the desired user, as shown in Fig. 1, the other user when active, produces an interference to the desired user's BS given by [4],

$$I(r_o, r_m) = S \left(\frac{10^{\zeta_o/10}}{r_o^\mu} \right) \left(\frac{r_m^\mu}{10^{\zeta_m/10}} \right) = S \left(\frac{r_m}{r_o} \right)^\mu 10^{\zeta_o - \zeta_m}/10 \leq 1 \quad (2)$$

where S is the received power at the *home* BS, the first term is due to the attenuation caused by distance and blockage to the given BS, while the second term is the effect of power control to compensate for the corresponding attenuation to the BS of the out-of-cell interferer. For all values of the above parameters, the expression is less than unity, otherwise the subscriber would switch to the BS that makes it less than unity.

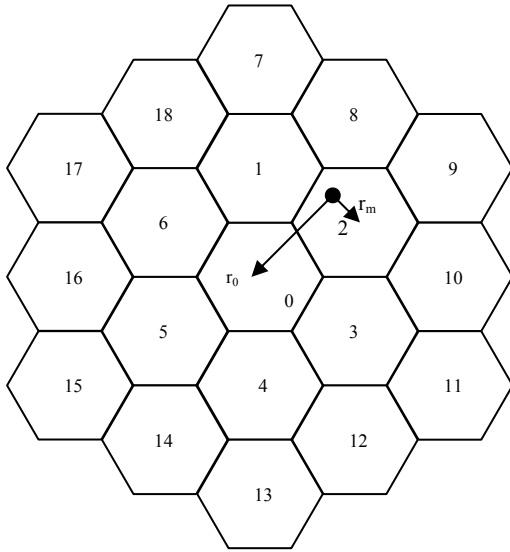


Figure 1: A hexagonal cellular

In a strength-based power control system [3], S is constant regardless of changes in the number of active users and in the total other cell interference. In SIR-based power control system, however, S is a function of the number of active home users and total other cell interference. If it is assumed that maximum received power is limited to h_{max} , then S is a random variable in the range of $[0, h_{max}]$. Since ζ_o and ζ_m are assumed to be mutually independent, the

difference has zero mean and a variance of $2\sigma^2$.

Assuming a uniform density of users and normalizing the hexagonal cell radius to unity, the user density is given by,

$$\rho = \frac{2}{3\sqrt{3}} N \quad (3)$$

where N is the number of users per cell. Then the total other cell interference can be expressed as [4], [5],

$$I_o = \iint S \left(\frac{r_m}{r_o} \right)^\mu 10^{(\zeta_o - \zeta_m)/10} Q(\zeta_o - \zeta_m, \frac{r_o}{r_m}) \rho dA \quad (4)$$

where m is the cell site index and is given by,

$$r_m^\mu 10^{-\zeta_m} = \min r_k^\mu 10^{-\zeta_k}, k \neq 0 \quad (5)$$

and

$$Q(\zeta_o - \zeta_m, \frac{r_o}{r_m}) = \begin{cases} 1, & \text{if } \left(\frac{r_m}{r_o} \right)^\mu 10^{(\zeta_o - \zeta_m)/10} \leq 1 \\ 0, & \text{otherwise} \end{cases} \quad (6)$$

For simplicity the smallest distance r_m is used rather than the smallest attenuation described in (6)

$$r_m = \min r_k, k \neq 0 \quad (7)$$

A Gaussian model is considered for I_o . Assuming that the received power S , the distances, and the shadowing are mutually independent, the mean of I_o , can be expressed as,

$$E(I_o) = E \left[\iint S \left(\frac{r_m}{r_o} \right)^\mu 10^{(\zeta_o - \zeta_m)/10} \right. \quad (8)$$

$$\left. Q(\zeta_o - \zeta_m, \frac{r_o}{r_m}) \rho dA \right] \\ = E[S] e^{\{\sigma \ln(10)/10\}^2} \iint \left(\frac{r_m}{r_o} \right)^\mu Q(x) \rho dA \quad (9)$$

where,

$$x = \left(\frac{10\mu}{\sqrt{2}\sigma^2} \log_{10}(r_o/r_m) - \sqrt{2}\sigma^2 \frac{\ln(10)}{10} \right),$$

and

$$Q(x) = \frac{1}{\sqrt{2\pi}} \int_x^\infty e^{(-y^2/2)} dy$$

The variance of I_o can be expressed as,

$$\text{Var}(I_o) = \iint \left(\frac{r_m}{r_o} \right)^{2\mu} \left\{ \begin{array}{l} E[S^2] e^{\{\sigma \ln(10)/5\}^2} \\ Q(M) - E^2[S] \\ e^{\{\sigma \ln(10)/10\}^2} Q^2(x) \end{array} \right\} \rho dA \quad (10)$$

where,

$$M = \left(\frac{10\mu}{\sqrt{2\sigma^2}} \log_{10}(r_o / r_m) - \sqrt{2\sigma^2} \frac{\ln(10)}{5} \right)$$

The integrals in (9), and (10) can be numerically obtained. Thus the mean and variance of I_0 can be obtained by calculating $E[S]$ and $E[S^2]$.

2.2 Calculation of $E[S]$ and $E[S^2]$

The received power from a user at the home BS is assumed to be a random variable H with a probability density function (pdf) of $f_H(h)$ when the MS is active. E_b/I_o is given by [1],

$$\left(\frac{E_b}{I_o} \right) = \frac{h / R}{(HK + I_o) / \frac{3}{2}W + \eta_o} \quad (11)$$

where,

R data rate;

W chip rate;

η_o background noise;

H received power of an active user;

K number of active users among $(N-1)$ users.

When MS's are power controlled to maintain the minimum power satisfying the required E_b/I_o (i.e., γ) the power level H is given by [1],

$$H = \frac{\frac{3}{2}W \eta_o + I_o}{\frac{3}{2} \frac{G}{\gamma} - K} \quad (12)$$

where $G = W/R$ is the processing gain. H in (12) is the required MS power to satisfy $E_b/I_o = \gamma$. If K exceeds $(3/2)(G/\gamma)$, the required power become negative value and system enters an outage state. With a power limit of h_{max} , the system is also in an outage state when the required power exceeds h_{max} . Thus outage occurs when the required power is higher than h_{max} , or less than 0 in a power limited system. The following variables are defined for simplicity $\eta = (3/2)W\eta_o$, $\alpha = (3/2)G/\gamma$, and $Y = I_o$.

The cumulative distribution function (cdf) of H under a condition of $K=i$, is expressed as [1],

$$F_{H|K=i}(h) = \begin{cases} 0, & h < 0 \\ A_o + A_{max} + \int_0^h |\alpha - i| \cdot f_y(x(\alpha - i) - \eta) dx, & 0 \leq h \leq h_{max} \\ 1, & h > h_{max} \end{cases} \quad (13)$$

where A_o and A_{max} denote the probabilities that H is below zero and exceeds h_{max} , respectively. These probabilities are given by [6],

$$A_o = \int_{-\infty}^0 |\alpha - i| f_y(x(\alpha - i) - \eta) dx$$

$$A_{max} = \int_{h_{max}}^{\infty} |\alpha - i| f_y(x(\alpha - i) - \eta) dx$$

Then the pdf $f_H(h)$ can be obtained as,

$$f_H(h) = \sum_{i=0}^{N-1} F_{H|K=i}(h) \pi_i \quad (14)$$

where $\pi_i = Pr\{K=i\}$, and $\sum_0^{N-1} \pi_i = 1$

Now we can define $E[S]$ and $E[S^2]$ as follow,

$$E[S] = P \int_0^{h_{max}} h f_H(h) dh = P \sum_{i=0}^{N-1} \pi_i \int_0^{h_{max}} h F_{H|K=i}(h) dh \quad (15)$$

$$E[S^2] = P \int_0^{h_{max}} h^2 f_H(h) dh = P \sum_{i=0}^{N-1} \pi_i \int_0^{h_{max}} h^2 F_{H|K=i}(h) dh \quad (16)$$

where P is the voice activity factor.

2.3 System Capacity

In the SIR-based power control system, P_{out} can be defined as [1],

$$P_{out} = Pr\{\text{The required power is higher than } h_{max} | K \leq \alpha\} + Pr\{K > \alpha\} \quad (17)$$

$$P_{out} = Pr\left\{ \frac{\eta + Y}{\alpha - K} > h_{max} | K \leq \alpha \right\} \cdot Pr\{K \leq \alpha\} + Pr\{K > \alpha\} \quad (18)$$

$$P_{out} = \sum_{k=0}^{\lfloor \alpha \rfloor} \pi_k Q\left(\frac{\alpha h_{max} - k h_{max} - \eta - E(I_o)}{\sqrt{Var(I_o)}} \right) + \sum_{k=\lfloor \alpha \rfloor + 1}^{N-1} \pi_k \quad (19)$$

where $\lfloor x \rfloor$ is the greatest integer which is less than or equal to x .

2.4 Comparison Between Strength-Based Power Control and SIR-Based Power Control

In this section, system capacities based on two different power control schemes are compared. It is interesting to note that system capacities based on two different power control schemes are identical in a single cell environment because of no other cell interference.

In the signal strength-based power control system, S is a constant [4]. P_{out} is given by,

$$P_{out} = P_r \{E_b / I_o < \gamma\} \quad (20)$$

Fig. 2 shows P_{out} versus the number of users for two different power control schemes. By considering the first and second tiers for $\mu = 4$, $\sigma = 8dB$, $W = 1.2288$ Mcps, $R = 9.6Kbps$, $\eta_o = 1.3 \times 10^{-20}$ W/Hz, $h_{max} = 2 \times 10^{-14}$ W, $\gamma = 7dB$, $P = 3/8$ [1]. The values of $E(I_0)$ and $Var(I_0)$ are numerically obtained as $0.06175 \times N$ and $0.004875 \times N$ respectively.

The reverse link capacity N is defined as the maximum integer N satisfying the outage probability P_{out} less than or equal to the threshold. For $P_{out} = 0.01$, an SIR-based power control system can support

approximately 30% more users than a strength-based power control system according to Fig. 2.

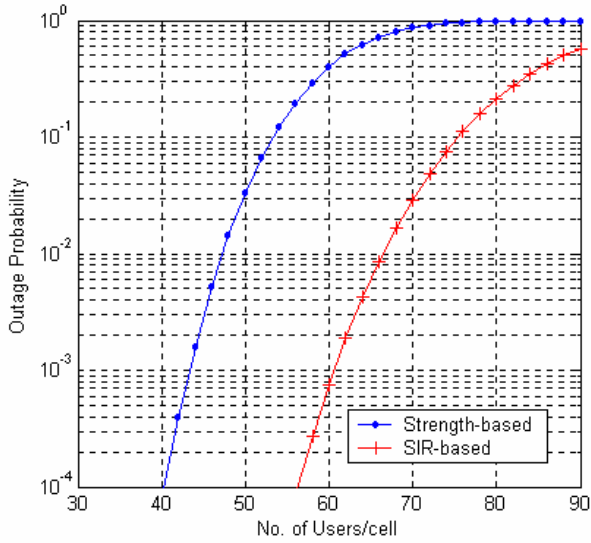


Figure 2: Outage probability of strength-based and SIR-based power control systems.

Fig. 3 shows the effect of activity factor P , where as P decreases, more users can be accommodated by SIR-based power control system. As an example, the capacity of SIR-based power control system for $P_{out} = 0.01$, is 36 and 66 users for $P = 1$ and $P = 3/8$, respectively.

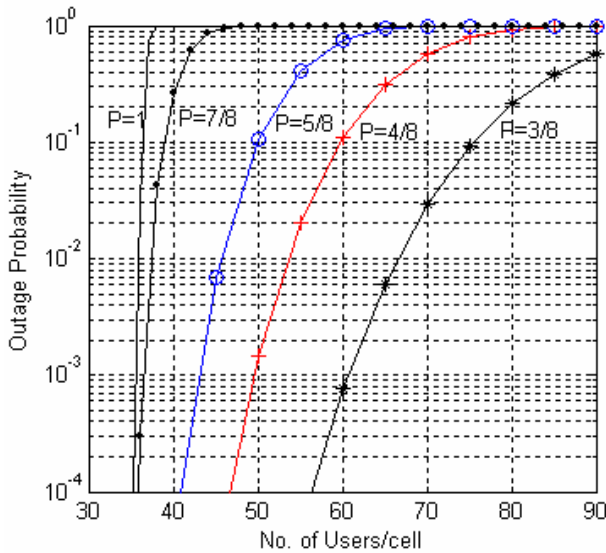


Figure 3: Outage probability versus the number of users for various values of P .

3 REVERSE LINK CAPACITY OF SIR-BASED POWER CONTROL SYSTEM WITH MIXED CELL SIZE

In a uniform cell environment, individual cell has identical $E(I_0)$ and $Var(I_0)$ since every cell is in the same condition. In a mixed cell environment, however, the individual cell does not have the same cell size and outside environment and receives a distinct amount of interference from outer cells. Furthermore, due to different cell sizes, each cell has a different received signal power. Thus, each cell will have different values of $E(I_0)$ and $Var(I_0)$ from the other cells. Each cell will have a different reverse link capacity. In order to calculate the reverse link capacity for each cell, we should know $E(I_0)$ and $Var(I_0)$ for each cell.

Let S_i denote the received signal power at the cell site of cell i . We calculate S_i for a given cell size, after that, calculate I_0/S_i , mean, and variance. Finally, obtain the reverse link capacity for the given cell. A cell size in a CDMA cellular system is mainly determined by the path loss and the pilot signal power transmitted at the cell site.

When a mobile user transmits a signal at a cell boundary, the received signal power at the cell site depends mainly on the cell size is shown in Fig. 4 [7].

If a mobile user belonging to cell j is located at the cell boundary, the received signal power S can be expressed as [3],

$$S = S_t \frac{1}{R_j^\mu} 10^{-\xi_j/10} \quad (21)$$

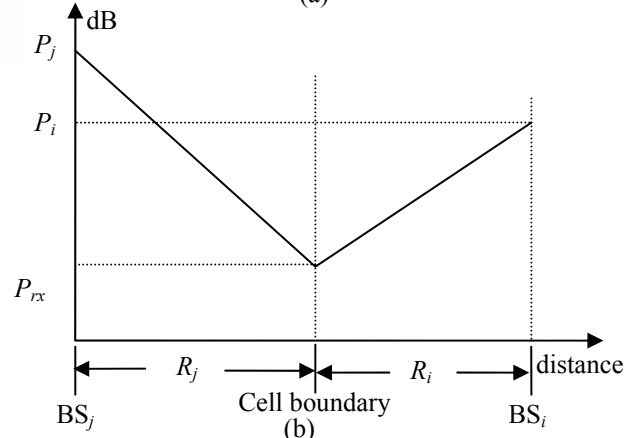
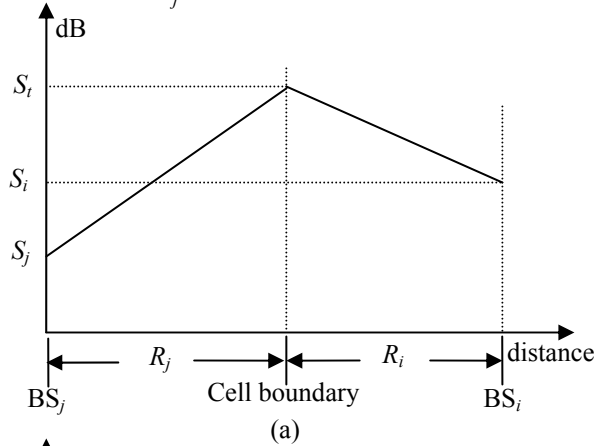


Fig.4. Cell boundary condition (a) Reverse link (b) Forward Link.

where S_i is the transmitted signal power of the mobile user, which has a range from zero to S_{max} , and R_j and ζ_j are the radius of cell j and the corresponding shadowing factor (zero mean and σ_j dB standard deviation), respectively. From (19), we have;

$$10 \log S_i = 10\mu \log R_j + 10 \log S + \zeta_j \quad (22)$$

Since the received power S varies according to the number of active home cell users and the amount of other cell interference in SIR-based power control system, with mean $E[S]$ and mean square $E[S^2]$ as in (15) and (16) respectively. Then the standard deviation of S can be expressed as,

$$\sigma_s = \sqrt{E[S^2] - E^2[S]} \quad (23)$$

It is clear that $10 \log S_i$ is a Gaussian random variable with a mean of $(10\mu \log R_j + 10 \log E[S])$ and a standard deviation of $10 \log \sigma_s + \sigma_j$ dB. In CDMA cellular systems, the interference received at a cell site is proportional to the number of other users. Therefore, as the number of other users increases, S should be increased so that $10 \log S_i$ will be increased.

An outage occurs when $10 \log S_{max} < 10 \log S_i$. If the system requires that the outage probability P_{out} be less than or equal 0.01, then,

$$P_r(10 \log S_{max} < 10 \log S_i) = Q\left(\frac{10 \log S_{max} - (10\mu \log R_j + 10 \log E[S])}{10 \log \sigma_s + \sigma_j}\right) \leq 0.01 \quad (24)$$

The received signal power at the cell site of cell j , S_j , can be defined as the maximum S satisfying $P_{out} \leq 0.01$. The cell site of cell j will require S_j when the cell is in fully loaded state. It is important to note that if cell j requires S larger than S_j due to the increase of the number of other users, the call of the mobile user will be forced terminated. The S_j (in dB) is given as [3],

$$10 \log S_j = -\sigma_j Q^{-1}(0.01) + 10 \log S_{max} - 10\mu \log R_j \quad (25)$$

In a similar manner, the received signal power at cell i , S_i can be expressed as,

$$10 \log S_i = -\sigma_i Q^{-1}(0.01) + 10 \log S_{max} - 10\mu \log R_i \quad (26)$$

The logarithmic ratio of S_j to S_i is

$$10 \log \frac{S_j}{S_i} = (\sigma_i - \sigma_j) Q^{-1}(0.01) + 10 \mu \log \frac{R_i}{R_j} \quad (27)$$

$$\frac{S_j}{S_i} = \left(\frac{R_i}{R_j}\right)^\mu 10^{((\sigma_i - \sigma_j) Q^{-1}(0.01)) / 10} \quad (28)$$

If ζ_j and ζ_i are assumed to have an equal probability distribution, then S_j / S_i can be simplified to,

$$\frac{S_j}{S_i} = \left(\frac{R_i}{R_j}\right)^\mu \quad (29)$$

When a mobile user is located at the cell boundary between cell i and cell j , the average received pilot signal power from the cell site of cell i is equal to that from the cell site of cell j , which is

$$\frac{1}{R_i^\mu} P_i = \frac{1}{R_j^\mu} P_j \quad (30)$$

where P_j and P_i are the pilot signal power transmitted by cell site of cell j and cell i , respectively. From (30), P_i can be expressed as,

$$P_i = \left(\frac{R_i}{R_j}\right)^\mu P_j \quad (31)$$

If a mobile user is located at a distance of r_i from the cell site of cell i and r_j from the cell site of cell j . From (21) and (31) the mobile user will select cell j as the serving cell if,

$$\frac{10^{-\xi_i/10}}{r_i^\mu} P_j \left(\frac{R_i}{R_j}\right)^\mu < \frac{10^{-\xi_j/10}}{r_j^\mu} P_j \quad (32)$$

Since the received power at cell j is S_j , the signal power transmitted by the mobile user can be expressed as,

$$S_i = S_j r_j^\mu 10^{\xi_j/10} \quad (33)$$

Then the interference produced by the mobile user to the cell site i , when active is,

$$I(r_i, r_j) = S_j \left(\frac{10^{\xi_j/10}}{r_i^\mu}\right) \left(\frac{r_j^\mu}{10^{\xi_i/10}}\right) \quad (34)$$

From (29) $I(r_i, r_j)$, can be expressed as,

$$I(r_i, r_j) = S_i \left(\frac{10^{\xi_j/10}}{r_i^\mu}\right) \left(\frac{r_j^\mu}{10^{\xi_i/10}}\right) \left(\frac{R_i}{R_j}\right)^\mu \leq 1 \quad (35)$$

If a CDMA system consists of M non-uniform cells and there are N_j users for cell j , then the total other user interference-to-signal ratio at the cell site of cell i is,

$$I_o = S_i \sum_{j=1, j \neq i}^M \sum_{k=1}^{N_j} \frac{x_{k,j} I_{k,j}(r_i, r_j)}{S_j} \left(\frac{R_i}{R_j}\right)^\mu \quad (36)$$

where $x_{k,j}$ is a random variable to represent voice activity for the user $x=1$ with probability α and $x=0$, with probability $1-\alpha$, and $I_{k,j}(r_i, r_j)$ denotes the interference produced by the k^{th} user in cell j . $E(I_o)$ and $Var(I_o)$ for cell i can be evaluated by using (36), (9), and (10). Then the reverse link capacity of cell i can be calculated by using (19).

As an example for mixed cell sizes, we assume that the center macro cell BS0 in Fig. 1 is split into three micro cells (BS0₍₁₎, BS0₍₂₎, and BS0₍₃₎) and the new cell sites are located at the center of the split cells as

shown in Fig. 5.

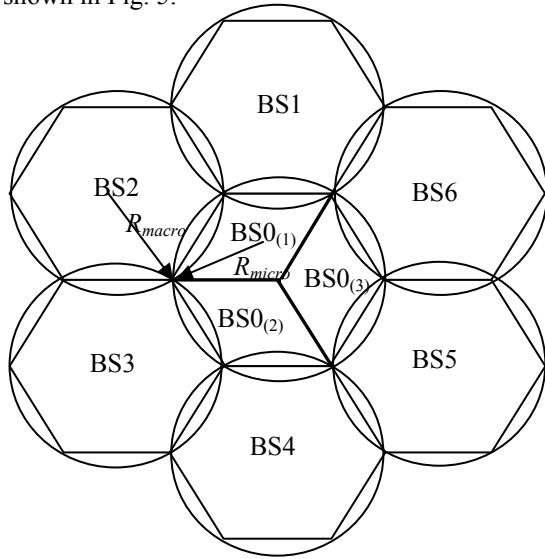


Fig. 5. A cellular system with mixed cell sizes.

The reverse link capacity of the first tiered macro cell is heavily affected and is likely to be reduced by the new micro cells. However, that of the second tiered macro cell is affected very little because of the enough distance between the second tiered macro cells and the micro cells. Now the reverse link capacity of the micro cell (*i.e.* I_{o1}) will be calculated first. After that, the reverse link capacity of the first tiered macro cell (*i.e.* I_{o2}) will be calculated.

As shown in Fig. 5, micro cell $BS_{0(1)}$ receive interference not only from the 18 outer macro cells but also from two neighboring micro cells $BS_{0(2)}$ and $BS_{0(3)}$. If an interfering user is located at distance r_m from its cell site and distance r_o from micro cell $BS_{0(1)}$, the total interference received at $BS_{0(1)}$ from other cells is expressed as [3],

$$I_{o1} = S_{micro} \left(\begin{aligned} & \sum_{j=7}^{18} \sum_{i=1}^{N_c} \frac{x_{i,BSj} I_{i,BSj}(r_o, r_m)}{S_{macro}} \left(\frac{R_{micro}}{R_{macro}} \right)^\mu \\ & + \sum_{j=1}^6 \sum_{i=1}^{N_{macro}} \frac{x_{i,BSj} I_{i,BSj}(r_o, r_m)}{S_{macro}} \left(\frac{R_{micro}}{R_{macro}} \right)^\mu \\ & + \sum_{k=2}^3 \sum_{i=1}^{N_{micro}} \frac{x_{i,BSj} I_{i,BS0(k)}(r_o, r_m)}{S_{micro}} \end{aligned} \right) \quad (37)$$

where N_c is reverse link capacity before cell split, N_{macro} and N_{micro} are the reverse link capacity for the first tiered macro cells and the micro cells after cell split, and R_{macro} and R_{micro} are the radius of the macro cell and the micro cell, respectively.

Similarly, if an interfering user is located at distance r_m from its cell site and distance r_o from macro cell $BS1$, which is one of the first tiered cells, the total interference received at $BS1$ from the other cells is

expressed as,

$$I_{o2} = S_{macro} \left(\begin{aligned} & \sum_{j=7}^{18} \sum_{i=1}^{N_c} \frac{x_{i,BSj} I_{i,BSj}(r_o, r_m)}{S_{macro}} + \\ & \sum_{j=2}^6 \sum_{i=1}^{N_{macro}} \frac{x_{i,BSj} I_{i,BSj}(r_o, r_m)}{S_{macro}} \\ & + \sum_{k=1}^3 \sum_{i=1}^{N_{micro}} \frac{x_{i,BSj} I_{i,BS0(k)}(r_o, r_m)}{S_{micro}} \left(\frac{R_{micro}}{R_{macro}} \right)^{-\mu} \end{aligned} \right) \quad (38)$$

From Fig. 5, $R_{micro}/R_{macro} = \sqrt{3}/2$ and from Fig. 2 for $P_{out} = 0.01$, $N_c = 66$. $E(I_{o1})$ and $Var(I_{o1})$ for the micro cell and $E(I_{o2})$ and $Var(I_{o2})$ for the macro cell can be numerically obtained by using (9) and (10).

As shown in table 1, the values of $E(I_{o1})$, $Var(I_{o1})$, $E(I_{o2})$ and $Var(I_{o2})$ are functions of N_c , N_{micro} , and N_{macro} . The reverse link capacities are obtained by substituting the values of $E(I_{o1})$, $Var(I_{o1})$, $E(I_{o2})$ and $Var(I_{o2})$ into (19), under the same condition used in section II.

The reverse link capacities (RLC) for cell $BS1$ and $BS_{0(1)}$ are the maximum N_{macro} and N_{micro} satisfying $\Pr(\text{BER} > 10^{-3}) < 0.01$ at $BS1$ and $BS_{0(1)}$ respectively. The reverse link capacities are given in Table 1, with that when R_{micro}/R_{macro} equals $\sqrt{3}/4$. From the results, we can see that, cell radius is one of the factors affecting the reverse link capacity of the cell. Note that the reverse link capacity of the micro cell increases as R_{micro}/R_{macro} decreases. On the other hand, the reverse link capacity of the first tiered macro cell significantly decreases as R_{micro}/R_{macro} decreases. As R_{micro} decreases, S_{micro} increases, as shown in Fig. 4 (a). Then the reverse link capacity increases since I_{o1}/S_{micro} decreases. The results show that the reverse link capacity of the first tiered macro cells is decreased by cell split. This is due to the increased interference resulted from the increased number of users in the split cell area. In FDMA cellular systems, channel capacity is simply increased as much as frequency reuse by cell split. Also in CDMA cellular systems, reverse link capacity in a service area can be increased by cell split. When $R_{micro}/R_{macro} = \sqrt{3}/2$ after the cell split, the reverse link capacity in the split cell area is undoubtedly increased from 66 channels to $65 \times 3 = 195$ channels. However, the capacity increase is obtained at the expense of the reverse link capacity decrease at the first tiered macro cells surrounding the split cells. That is, the reverse link capacity in the first tiered cells decreases from 66 to 54 channels.

Table 1. a Mean and Variance for I_{o1} and Reverse link capacity for micro cell.

R_{micro}/R_{macro}	$E(I_{o1})$	$Var(I_{o1})$	RLC for micro cell
$\sqrt{3}/2$	$0.01238 \times N_c +$ $0.02868 \times N_{macro} +$ $0.03053 \times N_{micro}$	$0.000675 \times N_c +$ $0.00249 \times N_{macro} +$ $0.0035 \times N_{micro}$	65
$\sqrt{3}/4$	$0.1132 \times N_c +$ $0.03807 \times N_{macro} +$ $0.04405 \times N_{micro}$	$0.01238 \times N_c +$ $0.00360 \times N_{macro} +$ $0.00540 \times N_{micro}$	80

Table 1. b Mean and Variance for I_{o2} and Reverse link capacity for macro cell.

R_{micro}/R_{macro}	$E(I_{o2})$	$Var(I_{o2})$	RLC for macro cell
$\sqrt{3}/2$	$0.00394 \times N_c +$ $0.0487 \times N_{macro} +$ $0.03053 \times N_{micro}$	$0.000102 \times N_c +$ $0.00447 \times N_{macro} +$ $0.00413 \times N_{micro}$	54
$\sqrt{3}/4$	$0.00035 \times N_c +$ $0.0124 \times N_{macro} +$ $0.0289 \times N_{micro}$	$0.000038 \times N_c +$ $0.00123 \times N_{macro} +$ $0.0040 \times N_{micro}$	40

4 CONCLUSION

From the above analysis it is clear that; in a uniform cell size environment, all cells are in identical conditions and the interferences received by individual cells are equal. Therefore, every cell has the same reverse link capacity. The results show that, with $P_{out} = 0.01$, an SIR-based power control system can support approximately 30% more users than a strength-based power control system in a uniform cell size environment.

Also, calculating the reverse link capacity of SIR-based power control system with mixed cell sizes when splitting a macro cell into three micro cells, as an example, and calculate the reverse link capacities for the three micro cells and the neighboring macro cells. The results show that, the radius of the cell is one of the factors that affecting the reverse link capacity of the cell, where, the reverse link capacity of the micro cell increases as R_{micro}/R_{macro} decreases. On the other hand, the reverse link capacity of the first tiered macro cell significantly decreases as R_{micro}/R_{macro} decreases.

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