ON DOWNLINK INTERCELL INTERFERENCE IN A CELLULAR SYSTEM

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ABSTRACT

The main difference between a non-cellular and a cellular communication system is the intercell interference. Therefore, modelling the intercell interference and analyzing its effects is of particular interest for cellular communication systems. On the one hand, the intercell interference can be modeled by system level simulations. On the other hand, it is also meaningful to assess the intercell interference without performing exhaustive simulations which nonetheless at the same time still capture the major effects that determine the interference. To this end, we consider the intercell interference as a random variable composed of many other random variables. In this paper, we present a semi-analytical method to analyze the downlink intercell interference in a cellular system. Through such an approach a quick and reliable assessment of the downlink intercell interference can be obtained. Our focus is on the methodology and we consider basic access schemes: WCDMA, TDMA, FDMA, and random OFDMA. However, our model can be extended to include other access schemes and other features.

I INTRODUCTION

Intercell interference arises in *cellular* communication systems like UMTS and GSM. The downlink in *non-cellular* communication systems like WLAN, can be modeled by a Gaussian broadcast channel [1]. However, when one considers the intercell interference, the Gaussian broadcast channel cannot be used to model the downlink of a *cellular* communication system [2], i.e. single-cell models cannot be applied in multi-cell evaluations. Thus, modeling the intercell interference and analyzing its effects is of particular interest in cellular communication systems.

For the sake of early assessment of emerging new technologies, it would be extremely helpful to have downlink intercell interference models which allow for simpler evaluation compared with exhaustive multi-cell system level simulations. To this end, we have devised a semi-analytical model for the downlink intercell interference. In this paper we follow a similar approach as done for the uplink in [3]. However, in contrast to the uplink the intercell interference in the downlink depends on the position of the user in the cell. Additionally, we have a transmit power constraint at the base station.

In this paper we consider the intercell interference in a *multi-user single input single output* (MU-SISO) system for different multiple access schemes, such as WCDMA, TDMA, FDMA and random OFDMA. However, our model can be extended to multiple antennas and other access schemes. The focus of this paper is on methodology rather than on results. This paper is organized as follows. In Section II the semi-analytical model is presented and its components are described. The evaluation method is summarized in Section III and an example is given in Section IV. Finally, in Section V we conclude the paper and provide an outlook.

II DOWNLINK INTERCELL INTERFERENCE

We consider a cellular network topology with sectorization, i.e. we have three base stations (BS) located at one position. Each BS serves an hexagonal cell and together the three cells form a site. Considering S sites, then a particular BS (and cell) is denoted by the tuple

$$(i,j) \in \{1,2,\ldots,S\} \times \{1,2,3\} \tag{1}$$

where $i \in \{1,2,\ldots,S\}$ is the index of the site and $j \in \{1,2,3\}$ is the index of the cell which the BS is serving. The minimum distance between two sites is denoted by inter-site distance (ISD). Furthermore, we assume that there is the same number of users in each cell and that the users are uniformly distributed over the cell.

In the uplink, the intercell interference is produced from sources which have non-fixed positions (users) onto receivers which have fixed positions (base stations). Thus, the intercell interference in the uplink is not conditioned on the position of the user [3]. However, in the downlink we have the opposite situation: the sources are the base stations and the receivers are the users, which do not have a fixed position. Therefore, for the downlink we have intercell interference depending on the position of the receiving user.

Let us now consider the intercell interference in the downlink produced on a user of interest u located at a distance d_u from its serving BS and at an angle θ_u with respect to the boresight of its serving BS as shown in Fig. 1. The position of the user of interest is denoted by the plus sign and we show just the first tier of interfering base stations, which are depicted by the dots. Each dot represents three co-located base stations, each BS serving a hexagonal cell. We refer to the cell where the user is located as the cell of interest.

The interference in the downlink results from the summation of the interfering powers from all the other base stations on the user of interest u. Let us denote, the users $k = 1,\ldots,K$ connected to the interfering BS (i,j) with the tuple (i,j,k). The intercell interference I_u^{inter} for a given codeword at a user of interest u can be represented as a summation of interferences

$$\begin{aligned} I_u^{\text{inter}} &= P_{\text{T}} \sum_{i=1}^{S} \sum_{j=1}^{3} L^{\text{P}}(d_{i,j,u}) \cdot L^{\text{S}}_{i,j} \cdot L^{\text{F}}_{i,j} \cdot B(\theta_{i,j,u}) \cdot \\ &\quad \sum_{k=1}^{K} \epsilon_{i,j,k} \cdot o_{i,j,k,u}, \qquad (2) \\ &= P_{\text{T}} \sum_{i=1}^{S} \sum_{j=1}^{3} L^{\text{P}}(r_{i,j,u}) \cdot B(\theta_{i,j,u}) \cdot S_{i,j,u} \qquad (3) \end{aligned}$$

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where P_{T}, $L^{\text{P}}(d_{i,j,u})$, $L^{\text{S}}_{i,j}$, $L^{\text{F}}_{i,j}$, $B(\theta_{i,j,u})$ are the available transmit power at the BS, the pathloss, shadowing, small scale fading and the antenna beam pattern from the interfering BS (i,j) to the user of interest u. In addition, $\epsilon_{i,j,k}$ is the fraction of transmit power P_{T} from BS (i,j) to user k and $o_{i,j,k,u}$ is the suppression factor, which accounts for the fraction of the transmit power $\epsilon_{i,j,k} \cdot P_{\text{T}}$ which will be visible as interference for the code word detection of the user of interest u [4, 5]. Furthermore, $d_{i,j,u}$ is the distance between the interfering BS (i,j) and user u and $\theta_{i,j,u}$ is the angle with respect to the boresight of the interfering BS (i,j). Also, since we are only considering intercell interference and not intracell interference, then for the cell of interest we denote $\epsilon_{1,1,k} = 0$ for $k = 1, \ldots, K$.

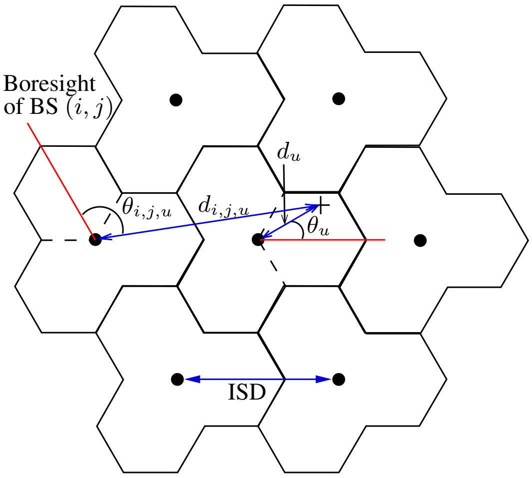


Figure 1: Cellular network topology.

Moreover, we have substituted

$$S_{i,j,u} = L^{\text{S}}_{i,j} \cdot L^{\text{F}}_{i,j} \sum_{k=1}^{K} \epsilon_{i,j,k} \cdot o_{i,j,k,u}, \tag{4}$$

which, given the position of the user of interest u, is the only random part of (2) and is independent of the position of the user of interest u. If BS (i,j) is not interfering at all or completely interfering with user u, then $S_{i,j,u} = 0$ or $S_{i,j,u} = 1$, respectively. Thus, $0 \leq S_{i,j,u} \leq 1$. In addition, notice that in (2), the pathloss and antenna pattern are deterministic functions of the position of the user of interest u. In the following each of these components are described.

A User Distribution

For convenience, we consider a discrete set of user's positions in the cell, which are uniformly located over the cell. The users' discrete position at the interfering cells and the cell of interest are generated at random from a distribution which is uniform and discrete in the area of the cell. Thus, d_u and θ_u, and consequently $d_{i,j,u}$ and $\theta_{i,j,u}$, are random variables.

B Pathloss, Shadowing and Small Scale Fading

1. The pathloss is a deterministic function of the distance $d_{i,j,u}$, which is a random variable and is described by the exponential pathloss law:

   $$10 \cdot \log_{10}\left(L^{\text{P}}(d_{i,j,u})\right) = -A - B \cdot \log_{10}(d_{i,j,u}/d_0), \tag{5}$$

   where d_0 is a reference distance and A and B are constants depending on the propagation model.
2. The shadowing $L^{\text{S}}_{i,j}$ is typically modeled as a random variable with a log-normal distribution with zero mean and variance σ^2_{s} [6].
3. The small scale fading $L^{\text{F}}_{i,j}$ is also assumed to be a random variable. With 1-path Rayleigh fading, then $L^{\text{S}}_{i,j}$ is exponentially distributed.

C BS Antenna Beam Pattern

We have assumed sectorization with the BS placed at one edge of a cell. Thus, the BS antenna beam pattern must be chosen such that it matches the assumed cellular grid. In order to generate roughly a hexagonal pattern, we consider commercially available antenna elements with a 3dB beamwidth in the range of approximately 70° (only half of the distance has to be covered at the sector edge ±60°). Furthermore, it is important to notice that there is a non-zero backward attenuation which cannot be neglected.

D Transmit power

BS (i,j) transmits to user k with power $\epsilon_{i,j,k} \cdot P_{\text{T}}$, where $\epsilon_{i,j,k}$ is the fraction of transmit power. Additionally, we have the transmit power constraint $\sum_{k=1}^{K} \epsilon_{i,j,k} \leq 1 \quad \forall\ i,j$. Let us consider that the $\epsilon_{i,j,k}$'s are computed in order to achieve two different types of fairness:

1. *Transmit balancing*: The available power at the BS is shared equally among the users, i.e. $\epsilon_{i,j,k} = \frac{P_{\text{T}}}{K}$.
2. *SINR balancing*: The $\epsilon_{i,j,k}$'s are computed such that all the users have the same *signal to interference and noise ratio* (SINR), i.e. same service/rate.

Transmit balancing is a best effort approach with users having distinct SINR's, depending on their channel conditions. With transmit balancing the users with the best conditions are favored and with SINR balancing the users with the worst conditions are favored.

However, in order to compute $\epsilon_{i,j,k}$ for receive SINR balancing, we need the intercell interference, which we are trying to model in the first place. Therefore, we need a workaround and to this end, we assume instead *average SINR balancing*. Then, in order to approximate the intercell interference for a given user k at BS (i,j), we make use of the geometry or f-factor $F_{i,j,k}$ which is defined as the ratio of the average intercell interference power to the average total received power at the position of the user k. Notice that $F_{i,j,k}$ only depends on the position of the user k and can be obtained from measurements in the downlink. Then, we approximate the SINR for user k connected to BS (i,j) as:

$$\begin{aligned} \text{SINR}_{i,j,k} &= \frac{\epsilon_{i,j,k} \cdot P^{\text{total-rec}}_{i,j,k}}{\sigma^2_{\text{noise}} + I^{\text{intra}}_{i,j,k} + I^{\text{inter}}_{i,j,k}} \\ &= \frac{\epsilon_{i,j,k}}{\dfrac{\sigma^2_{\text{noise}}}{P^{\text{total-rec}}_{i,j,k}} + o^{\text{intra}}_{i,j,k} \cdot (1 - \epsilon_{i,j,k}) + F_{i,j,k}}, \end{aligned} \tag{6}$$

where $P^{\text{total-rec}}_{i,j,k}$, $I^{\text{intra}}_{i,j,k}$, $I^{\text{inter}}_{i,j,k}$ and $F_{i,j,k}$ are the intracell interference, the intercell interference and the f-factor or geometry of user k served by BS (i, j). In addition, σ^2_{noise} and $o^{\text{intra}}_{i,j,k}$ are the noise variance and the intracell suppression factor for user k served by BS (i, j) [4, 5], respectively. With this approximation based on $F_{i,j,k}$'s, the $\epsilon_{i,j,k}$'s required to achieve average SINR balancing can be computed.

E Suppression Factor

The suppression factor $o_{i,j,k,u}$ expresses the fraction of the transmit power $\epsilon_{i,j,k} \cdot P_{\text{T}}$ which will be visible as interference for the code word detection of the user of interest u [4, 5]. We have that $\sum_{k,u} o_{i,j,k,u} \leq 1 \quad \forall\ i, j$. Equality is achieved if the system is fully loaded. The suppression factors are determined depending on the access scheme employed. To this end, we consider four access schemes: WCDMA, TDMA, FDMA and Random OFDMA.

1) WCDMA

The simplest case is WCDMA, where every user in the system produces interference to the code word. Considering the pseudo-orthogonal cell-specific scrambling code with spreading factor SF, despreading leaves exactly $\frac{1}{SF}$ of the power of any user in the code word. Note that we are looking only at inter-cell users, where no orthogonality can be maintained by the spreading codes. Hence, $o_{i,j,k,u}$ is deterministic and simply becomes [7]

$$o_{i,j,k,u} = \frac{1}{SF} \ \forall\ i, j, k, u. \tag{7}$$

2) TDMA

For simplification, we will consider a pure TDMA system without frequency hopping during a codeword. The code word covers a single timeslot, and the system is driven with the load factor η, i.e. the fraction η of the available time slots are occupied $(0 \leq \eta \leq 1)$. Furthermore the BS's are synchronized. In TDMA only one user transmits at a time, and thus only one transmission from BS (i, j) to one of its users can interfere, with probability η, with the user of interest u. Hence, for the transmission of a single user k^* (chosen at random) served at each BS (i, j), then $o_{i,j,k^*,u}$ is random and the distribution is given as

$$f_{o_{i,j,k^*,u}}(o_{i,j,k^*,u}) = \begin{cases} \eta & \text{for} \quad o_{i,j,k^*,u} = 1, \\ 1-\eta & \text{for} \quad o_{i,j,k^*,u} = 0, \\ 0 & \text{for} \quad o_{i,j,k^*,u} \neq 0, 1 \end{cases} \tag{8}$$

The transmissions to the other users are not visible for the code word of interest, so $o_{i,j,k,u} = 0$ for $k \neq k^*$.

3) Random OFDMA

Consider an OFDMA system, where K users share N_T tones, such that each user is allocated $\frac{N_T}{K}$ tones which are randomly distributed across the N_T tones. Within a codeword the random distribution is independently repeated N_H times (tone hopping). Each hop covers N_S OFDM symbols, i.e. a user codeword covers $N_H \cdot N_S$ OFDM symbols. Such an access scheme is applied for instance in IEEE802.16 or in Flash-OFDM, and we refer to it as Random-OFDMA (R-OFDMA). Similar to the TDMA case, we assume BS synchronization. Deriving the suppression factor for such an OFDMA system becomes a combinatorial problem of tone collisions and $o_{i,j,k,u}$ is random again.

Let us now collect in a matrix the K^2 suppression factors $o_{i,j,k,u}$ from all the interfering users $k = 1, \dots, K$ at cell (i, j) for all the users $u = 1, \dots, K$ at the cell of interest:

$$\mathbf{X} = \begin{pmatrix} o_{\text{i,j,1,1}} & \cdots & o_{\text{i,j,1,K}} \\ \vdots & \ddots & \vdots \\ o_{\text{i,j,K,1}} & \cdots & o_{\text{i,j,K,K}} \end{pmatrix} \in \mathbb{R}_+^{K \times K}. \tag{9}$$

Let us now assume that all of the available bandwidth for a cell is used by all of the users in each cell. Thus, each of the columns and rows of the matrix given in (9), must sum up to one. That means that the suppression factors for the users at the cell of interest are coupled and the suppression factors cannot be generated independently.

For instance, if FDMA is used as multiple access scheme with full load and BS synchronization, then only one transmission from each interfering cell interferes with one user at the cell of interest. Then we could have that $\mathbf{X}_{\text{FDMA}} = \mathbf{1}_K$, where $\mathbf{1}_K$ is the $K \times K$ identity matrix. Notice that the ones in $\mathbf{X}_{\text{FDMA}}$ have been placed on the diagonal, but we could have another assignment, as long as there is only one 1 per column and row. In the following we assume that we have a fully loaded system.

For R-OFDMA, the elements of the matrix must be distributed according to the marginal distribution of the suppression factors for R-OFDMA given in [3]. However, at same time the columns and rows of the matrix in (9) should sum up to one. To this end, we present a procedure in order to generate this random matrix for R-OFDMA without simulating the exact allocation of frequency resources in each cell in the network. The procedure is as follows:

1. For a given BS (i, j), generate K^2 independent $o_{i,j,k,u}$'s drawn from their marginal distribution given in [3] to construct a matrix $\mathbf{X}$ as in (9) with independent suppression factors.

2. **Normalization:** apply a weight factor $w_{\text{k,u}}$ to each element (k, u) for $k = 1, \dots, K$ and $u = 1, \dots, K$ of the matrix $\mathbf{X}$ to construct the following matrix:

   $$\mathbf{Y} = \begin{pmatrix} w_{1,1} \cdot o_{\text{i,j,1,1}} & w_{1,2} \cdot o_{\text{i,j,1,2}} & \cdots & w_{1,\text{K}} \cdot o_{\text{i,j,1,K}} \\ w_{2,1} \cdot o_{\text{i,j,2,1}} & w_{2,2} \cdot o_{\text{i,j,2,2}} & \cdots & w_{2,\text{K}} \cdot o_{\text{i,j,2,K}} \\ \vdots & \vdots & \ddots & \vdots \\ w_{\text{K},1} \cdot o_{\text{i,j,K,1}} & w_{\text{K},2} \cdot o_{\text{i,j,K,2}} & \cdots & w_{\text{K,K}} \cdot o_{\text{i,j,K,K}} \end{pmatrix},$$

   where $\mathbf{Y}$ has the same dimensions as $\mathbf{X}$. The weights are chosen such that

   - For fixed k: $\sum_{u=1}^{K} w_{\text{k,u}} \cdot o_{\text{i,j,u,k}} = 1$ (Sum over rows).
   - For fixed u: $\sum_{k=1}^{K} w_{\text{k,u}} \cdot o_{\text{i,j,u,k}} = 1$ (Sum over columns).
   - $\sum_{u,k} (w_{u,k} - 1)^2$ is minimized.

3. **Re-Normalization:** The previous step changes the marginal distribution of the suppression factors. Therefore, a re-normalization step is then performed to adjust the statistics of the suppression factors:

$$\mathbf{Z} = \sqrt{\frac{\mathrm{var}[x]}{\mathrm{var}[y]}} \cdot (\mathbf{Y} - \mathrm{E}[y] \cdot \mathbf{I}_K) \; + \; \mathrm{E}[x] \cdot \mathbf{I}_K, \qquad (10)$$

   where $\mathrm{var}[x]$, $\mathrm{E}[x]$, $\mathrm{var}[y]$ and $\mathrm{E}[y]$ represent the variance and mean of the elements in the matrix $\mathbf{X}$ and the variance and mean of the elements in the matrix $\mathbf{Y}$, respectively. Additionally, $\mathbf{I}_K$ represents a matrix where all elements are equal to 1, of dimension $K \times K$. Restoring the mean and variance restores most of the statistical properties of the suppression factors since the marginal distribution of the suppression factors is similar to a Gaussian distribution [3].

4. Finally, we take the (k, u) elements for $k = 1, \ldots, K$ from the matrix $\mathbf{Z}$ as the suppression factors $o_{i,j,k,u}$'s to compute the intercell interference given by (2) for each user $u = 1, \ldots, K$ at the cell of interest.

F Further considerations

In the model presented, we have considered a frequency reuse factor of 1. However, other frequency reuse factors can be employed. To this end, one has to consider in the summation given in (3) the set of cells which have the same frequency band as the cell of interest.

Also, we have considered that each site consists of three base stations. However, we can have a site consisting of only one base station, i.e. no sectorization, where the BS is placed in the center of the cell. In this case the BS antenna pattern $B(\theta_{i,j,u})$ corresponds to that of an omnidirectional antenna, i.e. constant antenna gain for $-\pi \leq \theta_{i,j,u} \leq \pi$.

For the generation of the suppression factors for R-OFDMA, we have assumed a fully loaded system. However, the described model can be extended to consider a less loaded system, such that the sum per column and row is no longer 1 but becomes random variable, which has to be less than 1.

III SEMI-ANALYTIC EVALUATION

Attempting to compute a closed form for the probability density function (pdf) of the intercell interference based on the distribution of the random variables is a difficult task due to the dependencies among the random variables and since the intercell interference consists of a summation of products of random variables. Therefore, we follow a semi-analytical approach based on Monte-Carlo simulations, similar to the one presented for the uplink in [3]. Samples of the random variables as described in Section II are computed in order to generate independent samples of the intercell interference, which still capture the important effects. At the same time such an approach is significantly faster compared with a system level simulation, because the components are modeled as random variables. With sufficient samples, we generate numerically a histogram which should converge towards the pdf of the intercell interference.

Taking a look at (3), one can see that the intercell interference on a user of interest u, is a weighted sum of $S_{i,j,u}$'s. The weight for each $S_{i,j,u}$ is $L^{\mathrm{P}}(r_{i,j,u}) \cdot B(\theta_{i,j,u})$, which is deterministic, given the position of the user u. Before summarizing the procedure to generate the intercell interference, we discuss the $S_{i,j,u}$-term in (3).

A $S_{i,j,u}$-term

As stated before, given the position of the user of interest u, $S_{i,j,u}$ is the term containing all the random components of the intercell interference given in (2). $S_{i,j,u}$ is given by (4) and is independent of the position of the user u. The $S_{i,j,u}$ for $u = 1, \ldots, K$ for the users at the cell of interest are coupled due to the inherent coupling in the transmit power in the downlink and the coupling of the suppression factors as described in Section 3). Stacking all these terms for the users $u = 1, \ldots, K$ at the cell of interest in a vector such that $\mathbf{S}_{i,j} = [S_{i,j,1}, S_{i,j,2}, \ldots, S_{i,j,K}]^{\mathrm{T}} \in \mathbb{R}_{+}^{K}$, we then have that $\mathbf{S}_{i,j}$ is independent and identically distributed for all the cells (i, j) in the network. Let us denote the random vector $\mathbf{S}$ which has the same distribution as $\mathbf{S}_{i,j}$. It is clear, that the multiple access scheme ($o_{i,j,k,u}$) and the transmit power allocation ($\epsilon_{i,j,k}$) directly affect the distribution of $\mathbf{S}$. Therefore, analyzing the joint impact of different multiple access schemes and power allocations on the intercell interference, reduces to analyzing the effect of these issues on $\mathbf{S}$.

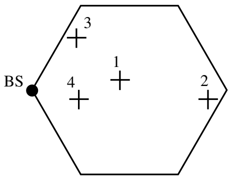
B Downlink Intercell Interference Generation

1. **Offline**: Generate samples of the vector $\mathbf{S}$ according to the multiple access scheme and transmit power. Note that here we have to draw realizations for the shadowing and for the small scale fading as given in (4).
2. **Initialization**: Generate the positions of the interfering BS considering the reuse strategy in the network.
3. Generate randomly the position of the users at the interfering cells and the position of the users at the cell of interest, drawn from a discrete uniform distribution.
4. For each user at the cell of interest, compute $d_{i,j,u}$ and $\theta_{i,j,u}$ as given in Fig. 1. With these compute the pathloss and the antenna beam pattern required in (2).
5. Calculate a sample of the intercell interference for each user u at the cell of interest according to (2).
6. Repeat the procedure with independent realizations of users' positions and store the intercell interference samples per user position. Recall that the positions are discrete.

Afterwards, a pdf of the intercell interference can be generated for each discrete position.

IV EXAMPLE: SIMULATION RESULTS

In the following we present an example where the downlink intercell interference has been evaluated with the proposed semi-analytical model for different multiple access schemes and different discrete positions of users. A network employing sectorization with full load, reuse factor 1 and transmit power balancing is considered. The interference of the first three tiers of BS's is considered. The rest of the parameters and the position of the users considered are shown in Fig. 2.



Parameters	
Pathloss law	$A = 128.1$,$B = 37.6$
Reference	$d_0 = 1$ km
Shadowing	$\sigma_S^2 = 6$ dB
Transmit Power	$P_T = 23$ dBm
ISD	1.732 km
Number Users	$K = 4$
WCDMA	$SF = 4$
TDMA	$\eta = 1$
R-OFDMA	$N_T = 112$,$N_H = 1$

Figure 2: List of Parameters and Position of Users

In Fig 3, the pdf of the downlink intercell interference is depicted. Notice the dependency of the intercell interference on the position of the user. Users close to the base station experience a high and broad interference. The user in the middle of the cell experiences less interference due to being located farther away from the two interfering BS's at its own site but still far from the other interfering BS's. Meanwhile cell edge users experience higher interference. The tail at the right edge of the pdf for the cell edge users and users close to the BS indicates there is always a non-zero probability for having a very high interference value. Regarding the access schemes, we can observe that WCDMA and R-OFDMA perform exactly the same since under our assumptions of full load and transmit power balancing, their $\mathrm{S}_{i,j}$ have the same distribution and therefore are equivalent. For TDMA, higher interference is present due to the fact that the users are served with the full transmit power and reuse factor 1. However, the intercell interference does not tell the whole story. Users close to the BS experience good SINR because they have low pathloss, while the SINR for cell edge users is low as they suffer from high interference and high pathloss.

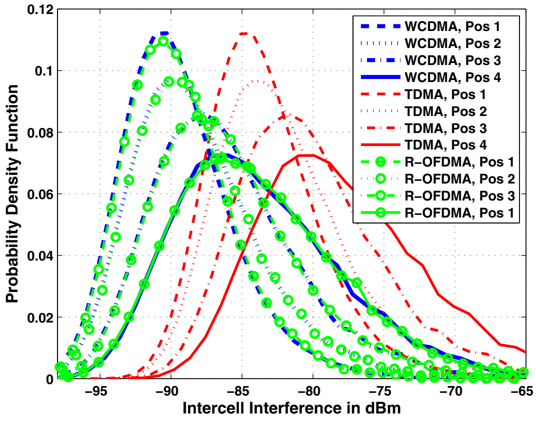


Figure 3: Downlink Intercell Interference for different Multiple Access Schemes and User Positions

V CONCLUSIONS AND OUTLOOK

In this paper, a semi-analytical model for evaluating the downlink intercell interference for different multiple access schemes has been presented. This stochastic model captures the significant effects of the intercell interference by appropriately modeling the components of the intercell interference as random variables, including dependencies among them. The proposed model enables quick and reliable evaluations without computationally exhaustive system level simulations. The focus of this work is on the methodology rather than on the results.

Our analysis presented the intercell interference as a weighted sum of identically and independently distributed S-terms, which capture the joint effect of the multiple access scheme and the transmit power allocation. These terms represent the random component of the intercell interference and for instance, the variance of the intercell interference depends on the variance of this term. Thus, by focusing on this random component one can gain insight into the comprehension of the intercell interference.

Contrary to the uplink, the intercell interference in the downlink depends on the position of the receiving user in the cell, as it was shown in the example. However, the intercell interference does not tell the whole story. A more appropriate figure of merit for evaluating the performance in the cell is the throughput. Nevertheless, our model can be extended to generate SINR samples following the same approach in order to evaluate the throughput. We have done this and work on further extensions is ongoing and will be presented later on. For instance, the effects of adaptive modulation and scheduling can be incorporated. Additionally, the impact of different traffic models can also be considered. Other issues such as intercell interference mitigation can also be treated with our semi-analytical approach, which allows a quick, early and reliable assessment of different strategies for future communication systems.

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