Outdated Uplink Adaptation due to Changes in the Scheduling Decisions in Interfering Cells

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***Abstract*—The major difference between a non-cellular system, i.e. a single isolated cell, and a cellular system is the *intercell interference* (ICI). In the uplink, the base station can measure the users' *signal to noise and interference ratio* (SINR) and through a feedforward channel it can inform the users which coding and modulation scheme to apply in order to perform *link adaptation* (LA). However, a user's SINR observed in the uplink by the base station when determining the link adaptation decision might no longer be the same when the link adaptation is effected by the user due to fluctuations of the intercell interference. By then, the intercell interference could have greatly changed even if the users are static, due to changes in the scheduling decisions in the interfering cells. Hence, the uplink transmission would no longer have the correct link adaptation for the current SINR, since we are to some extent blind with respect to the ICI. In this work, we quantify this degree of ICI blindness by the correlation between the *measured* ICI and the *actual experienced* ICI. Furthermore, we analyze the degradation in throughput for different degrees of ICI correlation which depends on the scheduling in the interfering cells. Additionally, we show how much benefit *correct link adaptation* provides in a cellular environment over *outdated link adaptation*. In this work, we assume that there is no intracell interference as a consequence of an orthogonal multiple access scheme.**

I. INTRODUCTION

Intercell interference (ICI) arises in cellular communication systems and is the major difference between a single-cell system and a cellular system. Uplink and downlink models for single-cell systems cannot be employed in cellular evaluations, since the ICI degrades the performance in a cellular system [1]. Thus, modeling the intercell interference and analyzing its effects is of particular interest in cellular systems [2].

In order to mitigate the ICI, several authors have proposed cooperation among several base stations for joint multi-cell processing. Downlink beamforming using several base stations has been considered to jointly transmit in the downlink to the users in the coordinated cells [3]. The same concept can be extended to the uplink [4], where several base stations cooperate in order to jointly decode the transmissions from the users. Joint multi-cell processing, in both the uplink and downlink, assumes that there is a backhaul network connecting all the sites to a remote central processor [5]. Moreover, it is assumed that the required channel knowledge is available and error-free and the latency in the backhaul network is neglected.

In a cellular network, each cell is occupied by several users and thus, the spectral efficiency can be increased by exploiting multiuser diversity. In order to benefit from multiuser diversity in the uplink, the base station must be able to track each user's SINR and be equipped with a channel-aware scheduler. Additionally, the users must be able to adapt their transmission to the instantaneous channel quality, i.e., the users must be able to perform *link adaptation* (LA) or *adaptive modulation and coding* (AMC), to benefit from the current channel conditions. Nevertheless, link adaptation can also be performed with a *round robin scheduler* (RRS) as long as the base station can measure the instantaneous channel quality (SINR) of a user and inform the user which AMC to employ in the uplink.

However, in a cellular system the user's SINR observed by the base station when determining the AMC might no longer be the same when the link adaptation is effected by the user due to fluctuations of the intercell interference. By then, the user's intercell interference experienced at the base station could have greatly changed, even if the users in the network are static, due to changes in the scheduling decisions in the interfering cells. Hence, the uplink transmission would no longer have the correct link adaptation for the current SINR and it would be outdated, since we are to some extent blind with respect to the ICI. In fact, the actual ICI could have increased and with the chosen AMC, it could be such that with the resulting SINR, the user is in *outage*. The degree of the ICI blindness depends on the correlation between the *measured* ICI and the *actual experienced* ICI. In turn, this correlation depends on the scheduling changes in the interfering cells.

In this paper, we focus on the uplink of a cellular system with single-antenna transmitting users and single-antenna receiving base stations, with no cooperation between the base stations in the network. In this work, we present a framework for modeling changes in the scheduling decisions in the interfering cells and analyze the impact of these changes on the uplink ICI of a cell of interest with link adaptation. Our contributions are the following

- For the link adaptation, we model the effect of the scheduling changes through a single probability,
- We compute the ICI correlation considering scheduling changes in the interfering cells, and
- We show how much benefit *correct link adaptation* provides in a cellular environment.

To this end, this paper is organized as follows. In Section II, the model of the cellular network and the uplink intercell interference is described. Section III discusses the outdating of the link adaptation decisions and presents a simple approach to model the scheduling decisions in the interfering cells. In Section IV, the correlation between ICI samples is computed. An evaluation of the throughput degradation due to the outdated LA is shown with simulation results in Section V. Finally, we conclude the paper in Section VI.

II. Uplink Intercell Interference Model

Consider a cellular network topology with sectorization, i.e. we have three *base stations* (BS) located at one position. Each BS serves a hexagonal cell and together the three cells form a *site*. Considering S sites, then we denote a particular BS (and cell) by the index c, where $c \in \{1, 2, \ldots, 3S\}$ The minimum distance between two sites is denoted by *inter-site distance* (ISD). With this notation, we denote the cell of interest by $c = 1$. In Fig. 1, we depict a cellular network with the previous described notation with $S = 19$ sites, i.e. with two rings of interfering sites around the cell of interest $c = 1$ depicted by the thick hexagon. Each cell is numbered with its respective cell index c. The dots represent the position of three co-located base stations and the ISD $= .500$ km in the figure. The "+" in the center of the figure, indicates the position of the BS of cell $c = 1$.

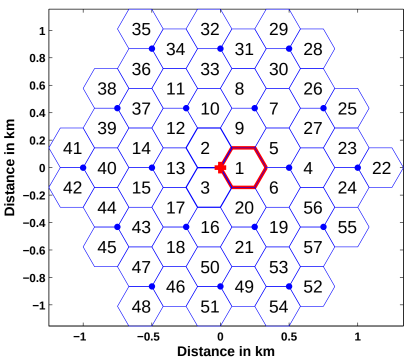

Fig. 1. Celluar Network with the Base Station of Interest in the Center.

In this work we focus on the intercell interference in the uplink of cell $c = 1$. For simplicity, we assume that each user and each base station is only equipped with one transmit antenna and one receive antenna, respectively. Furthermore, we assume that there is the same number of users K in each cell and that the users are uniformly distributed over the cell. We assume that users in their own cell are orthogonal due to the multiple access scheme, i.e., we have no intracell interference. Without loss of generality we also assume that the frequency reuse factor of the network is 1.

In the uplink, the intercell interference is produced from sources which have non-fixed positions (users) onto receivers which have fixed positions (base stations). Hence, the "+" sign in Fig. 1 represents the position of the receiver (base station) for which we will consider the uplink ICI.

Let us denote the uplink ICI experienced at the base station at time slot n on a given *frequency resource block* (FRB) as $I[n]$. This uplink ICI disturbs the transmission of a user of interest located at the cell of interest $c = 1$, whose position is irrelevant for the uplink ICI calculation [2]. With frequency reuse factor 1, in each cell of the network we assume there is a user transmitting at the same time on the same FRB as the user of interest, i.e., we have an *interfering user* in each cell. We denote the interfering user scheduled in the uplink on cell c at time slot n as $k(c,n) \in \{1, \ldots, K\}$, where K is the number of users per cell. The index of the interfering user $k(c,n)$ is given as a function of the time slot n, since the interfering user in cell c at each time slot depends on the scheduler in cell c. For instance, if at time slot $[n+1]$ the scheduler in cell c assigns a new user to the FRB under consideration, then $k(c,n) \neq k(c,n+1)$.

The uplink ICI on cell $c = 1$ results from the summation of the interfering powers from all the interfering users in the network occupying the same resources as the user of interest in cell $c = 1$ at time slot n, i.e.,

$$I[n] = \sum_{c \in \mathcal{C}} I_{k(c,n)} \tag{1}$$

where $\mathcal{C}$ is the set of indices from the interfering cells in the network, i.e., all the cells in the netwok, excluding the cell of interest $c = 1$. $I_{k(c,n)}$ is the interference produced by the interfering user in cell c at time slot n, and is given by [2]

$$I_{k(c,n)} = P_{k(c,n)} \cdot L_{k(c,n)} \cdot b_{k(c,n)} \cdot L_{\mathrm{s},k(c,n)} \cdot L_{\mathrm{f},k(c,n)}[n], \tag{2}$$

where $P_{k(c,n)}, L_{k(c,n)}, b_{k(c,n)}, L_{\mathrm{s},k(c,n)}, L_{\mathrm{f},k(c,n)}[n]$ are the transmit power, pathloss, antenna pattern, shadowing and small scale fading (squared value of the amplitude gain due to the small scale fading) from the interfering user $k(c,n)$ at cell c to the base station at the cell of interest at time slot n. For a given n, the transmit power, pathloss, antenna gain are deterministic for each given interfering user $k(c,n)$, $c \in \mathcal{C}$. However, for each $I_{k(c,n)}$ realization we assume that the shadowing $L_{\mathrm{s},k(c,n)}$ is log normal distributed and with Rayleigh fading, $L_{\mathrm{f},k(c,n)}$ is exponentially distributed, with the autocorrelation function given by the Jakes spectrum. Assuming the position of the interfering users to be random and with the other random processes involved, we have that the uplink ICI can be modelled as a random variable [2].

III. Outdated Link Adaptation

Let us now take a look at how the scheduling decisions and link adaptation decisions are made effective for the uplink transmissions. We assume that scheduling decisions can take place at each time slot, but the base stations do not need to be synchronized. We do not discuss a scheduler in particular and we assume that the base station has $Q \leq K$ frequency resources to schedule among the K users. In the following we will refer to *time slot* as TS and we assume that a user of interest x is occupying a given frequency resource block in the cell of interest. We refer to a *change in the scheduling decision* in a cell, when the scheduler in the given cell decides to schedule a new user on the resource block under consideration. Recall that we assume no coordination between the base stations in the network.

Due to processing delay, we assume that at each cell D time slots are required before a scheduling decision is made effective. For instance, assume a scenario where at the end of TS $[n]$, the base station at the cell of interest has made a new scheduling decision on the resource block under consideration: user x should stop transmitting at TS $[n{+}D]$ and user y should now transmit from TS $[n+D+1]$. As depicted in Fig. 2, the scheduling decision taken at TS $[n]$ and fed forward after TS $[n]$, from the BS to users x and y, can be made effective by the users only until TS $[n{+}D{+}1]$ due to the processing delay of D time slots. As shown in Fig. 2, user x would continue transmitting until TS $[n+D]$, until when he is aware of the new scheduling decision and from TS $[n{+}D{+}1]$, user y begins transmitting on the resource block under consideration.

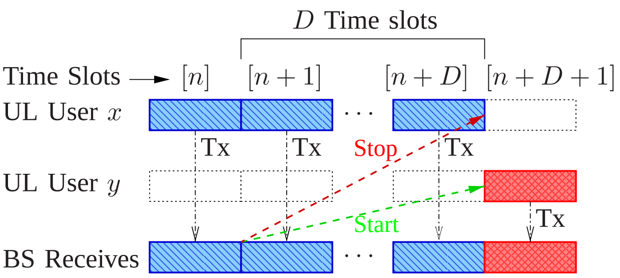

Fig. 2. Signalling of a Scheduling Decision

Assume now a second scenario, where user x occupies the resource block under consideration at TS $[n]$ and will occupy this resource block for the following time slots. For link adaptation, the BS measures the user's SINR at TS $[n]$ and with it the base station determines which AMC should user x employ. In this case there is also similarly as before, in each cell a delay for processing the link adaptation decisions, i.e., the link adaptaton decision would be available at the user after D time slots! At TS $[n+D+1]$, the link adaptation is outdated since by then the SINR could have changed due to two reasons:

1) Mobility of the users and
2) Changes in scheduling decisions in the interfering cells.

If the users are static, the link adaptation will not be outdated due to the mobility of the users. For the following we assume that the users are static or experience a slow mobility scenario, such that the link adaptation is just outdated due to the second reason. Hence, we have that the intercell interference $I\,[\,n\;+\;D\;+\;1\,]$, and in turn the SINR at time slot $[\,n+D+1\,]$ could have greatly changed in comparison to the intercell interference $I[n]$ at TS $[n]$ due to scheduling changes in the interfering cells. Between TS $[n]$ and TS $[\,n+D+1\,]$, the cells could have made changes in their scheduling decision, i.e., the set of interfering users at TS $[\,n\;+\;D\;+\;1\,]$ can be different from the set of interfering users at TS $[n]$.

If no changes in the scheduling decisions are effected in the interfering cells, the interfering set of users remains the same at TS $[\,n+D+1\,]$, so $I\,[\,n+D+1\,]\;=\;I\,[\,n\,]$. Hence, the *measured* ICI $I[n]$, used for determining the link adaptation, is the *same* as the *actual experienced* ICI $I\,[\,n+D+1\,]$, when the link adaptation is made effective. Thus, the link adaptation would still be correct and not outdated. Let us recall that this assumption holds as long as the users are static.

However, if there is a change in the scheduling decision at each interfering cell, the measured ICI $I[n]$ is totally *different* than the actual experienced ICI $I[n{+}D{+}1]$. This would be the worst case for the link adaptation, since the actual experienced ICI is totally *uncorrelated* with the measured ICI, i.e., the chosen AMC is not at all adapted for the ICI $I\,[\,n+D+1\,]$! In this case the link adaptation is completely outdated or blind with respect to the ICI. The user could be in outage if the interference is larger or the user could not be taking advantage of a smaller interference with a better AMC if the interference has decreased. How wrong the link adaptation decision at TS $[n+D+1]$ is, depends on how often the other cells change their scheduling decisions. The more stable and *persistent* the schedulers in the other cells are, the *less outdated* the link adaptation would be for user x at TS $[\,n\;+\;D\;+1\,]$.

A. Probability of Changes in the Scheduling Decisions

For our analysis we are just concerned with how often the interfering cells change their scheduling decisions. To this end, let us simply model the scheduling process by a first order Markov model characterized by a transition probability p_{s}. With probability p_{s} there has been a change in the scheduling decision in an interfering cell c, i.e., that a new user will occupy the frequency resource block under consideration at time slot $[n+D+1]$ at cell c, which means that $k(c, n+D+1) \neq k(c,n)$. It is out of the scope of this work to explain how we can obtain a given changing probability p_{s}. We assume that depending on the scheduler and *quality of service* (QoS) contraints we have a given p_{s}. For instance, in the case of the RRS we would have that $p_{\mathrm{s}} = 1$, since the scheduling decisions are changed at each time slot and without coordination between cells, the base station of interest is not aware of this change. Meanwhile, if we have some sort of *greedy scheduler*, which serves just the best user and sticks with the decision ignoring fairness and quality of service issues, then $p_{\mathrm{s}} \to 0$. The changing probability p_{s} could be also computed analytically for other schedulers.

IV. Correlation of the Intercell Interference

Let us now consider the effect of changes in the scheduling decisions on the ICI by computing the correlation between the *measured* ICI $I[n]$, when the AMC is selected, and the *actual experienced* ICI $I\,[\,n\;+\;D\;+1\,]$, when the selected AMC is applied. For this, we assume that at each interfering cell in the network we have the same probability p_{s}. Our analysis can be extended to assume different p_{s}'s for each cell, but for simplicity and limitations of space we avoid that here. The correlation between $I[n]$ and $I\,[\,n\;+\;D\;+\;1\,]$ is given by

$$\rho \;=\; \frac{\mathrm{Cov}(I[n], I[n+D+1])}{\sqrt{\mathrm{Var}(I[n]) \cdot \mathrm{Var}(I[n+D+1])}}, \qquad (3)$$

where Cov(a, b) is the covariance between the random variables a and b and Var(a) is the variance of a. Since the intercell interference is stationary, (3) simplifies to

$$\rho = \frac{\text{Cov}(I[n], I[n+D+1])}{\text{Var}(I[n])}. \quad (4)$$

The summands $I_{k(c,n)}$ in the intercell interference summation of (1) are independent, so the numerator in (4) can be expressed as shown in (5) at the bottom of the page. By definition (5) can be expressed as (6), where E$[a]$ is the expected value of a. (7) follows by simply separating the sums when $d \neq c$ and $d = c$, and from the fact that the $I_{k(c,n)}$ and $I_{k(d,n+D+1)}$ are uncorrelated for $d \neq c$, since the $I_{k(c,n)}$'s at the same or different time slots produced by different interfering users in different intefering cells are independent, i.e. $\forall\ \Delta n, \forall\ c \neq d$:

$$\text{E}\left[I_{k(c,n)} I_{k(d,n+\Delta n)}\right] = \text{E}\left[I_{k(c,n)}\right] \text{E}\left[I_{k(d,n+\Delta n)}\right] \quad (12)$$

For the following, denote the random variable $h = 0$ when there is no change in a scheduling decision in a cell and $h = 1$ when there is a change. Continuing with the derivation from (7) to (8), we have clearly that the first term of (7), involving the sum over $c \in \mathcal{C}$ and the sum when $d \in \{\mathcal{C}\backslash c\}$, i.e., when $d \neq c$, is zero. In the first term of the single sum over $c \in \mathcal{C}$ of (7), the expectation can be separated into two cases: when the scheduling decision in cell c does not change ($h = 0$) which occurs with probability $(1-p_\text{s})$ and when there is a scheduling change in cell c ($h = 1$) which occurs with probability p_s. Hence, (7) can be expressed as (8). Now, note that if there is a change in the scheduling decision in cell c, a new user becomes the interfering user from cell c, i.e., $k(c, n+D+1) \neq k(c, n)$. In this case, under the assumption of independent channels between the users from the same cell, we have that $I_{k(c,n)}$ and $I_{k(c,n+D+1)}$ are independent

$$\text{E}\left[I_{k(c,n)} I_{k(c,n+D+1)} | h = 1\right] = \text{E}\left[I_{k(c,n)}\right] \text{E}\left[I_{k(c,n+D+1)}\right]. \quad (13)$$

Therefore, (9) follows from (8) by using (13). (10) follows from (9) since the $I_{k(c,n)}$'s are stationary and by using the definition of $I_{k(c,n)}$ given in (2) and by the fact that $k(c, n) = k(c, n + D + 1)$. Substituting the following constants in (10),

$$L = \sum_{c\in\mathcal{C}} \text{E}\left[P^2_{k(c,n)} \cdot L^2_{k(c,n)} \cdot b^2_{k(c,n)} \cdot L^2_{\text{s},k(c,n)}\right]$$

$$H_1 = \text{E}\left[L_{\text{f},k(c,n)}[n] \cdot L_{\text{f},k(c,n)}[n + D + 1]\right]$$

$$M = \sum_{c\in\mathcal{C}} \left(\text{E}\left[I_{k(c,n)}\right]\right)^2.$$

we can express the covariance (6) finally as (11).

Since the ICI per cell $I_{k(c,n)}$'s are independent over the cells in the network, the expression in the denominator of (4) is simplified to

$$\text{Var}(I[n]) = \sum_{c\in\mathcal{C}} \text{Var}(I_c[n]) \quad (14)$$

$$= \sum_{c\in\mathcal{C}} \text{E}\left[I^2_{k(c,n)}\right] - \left(\text{E}\left[I_{k(c,n)}\right]\right)^2 \quad (15)$$

$$= L \cdot H_0 - M, \quad (16)$$

where H_0 is a constant given by

$$H_0 = \text{E}\left[L^2_{\text{f},k(c,n)}[n]\right]. \quad (17)$$

Using (11) and (16), the correlation between the measured ICI and the actual experienced ICI expressed in (4) is

$$\rho = \frac{(1 - p_\text{s}) \cdot (L \cdot H_1 - M)}{L \cdot H_0 - M}. \quad (18)$$

Since we have assumed Rayleigh fading with a Jakes spectrum, we have that $H_1 \leq H_0$ which then means that $(L \cdot H_1 - M)/(L \cdot H_0 - M) \leq 1$. Hence, the correlation is upper bounded by

$$\rho \leq (1 - p_\text{s}).$$

Assuming low mobility, i.e. $H_1 \approx H_0$, then $\rho \approx (1 - p_\text{s})$. With no mobility or static users ($H_1 = H_0$), we have

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$$\text{Cov}(I[n], I[n + D + 1]) = \sum_{c\in\mathcal{C}}\sum_{d\in\mathcal{C}} \text{Cov}(I_{k(c,n)}, I_{k(d,n+D+1)}) \quad (5)$$

$$= \sum_{c\in\mathcal{C}}\sum_{d\in\mathcal{C}} \left(\text{E}\left[I_{k(c,n)} \cdot I_{k(d,n+D+1)}\right] - \text{E}\left[I_{k(c,n)}\right] \cdot \text{E}\left[I_{k(d,n+D+1)}\right]\right) \quad (6)$$

$$= \sum_{c\in\mathcal{C}}\sum_{d\in\{\mathcal{C}\backslash c\}} \left(\text{E}\left[I_{k(c,n)}\right] \text{E}\left[I_{k(d,n+D+1)}\right] - \text{E}\left[I_{k(c,n)}\right] \text{E}\left[I_{k(d,n+D+1)}\right]\right) + \sum_{c\in\mathcal{C}} \left(\text{E}\left[I_{k(c,n)} I_{k(c,n+D+1)}\right] - \text{E}\left[I_{k(c,n)}\right] \text{E}\left[I_{k(c,n+D+1)}\right]\right) \quad (7)$$

$$= 0 + \sum_{c\in\mathcal{C}} \text{E}\left[I_{k(c,n)} I_{k(c,n+D+1)} | h = 0\right] \cdot (1 - p_\text{s}) + \sum_{c\in\mathcal{C}} \left(\text{E}\left[I_{k(c,n)} I_{k(c,n+D+1)} | h = 1\right] \cdot p_\text{s} - \text{E}\left[I_{k(c,n)}\right] \text{E}\left[I_{k(c,n+D+1)}\right]\right) \quad (8)$$

$$= (1 - p_\text{s}) \cdot \sum_{c\in\mathcal{C}} \text{E}\left[I_{k(c,n)} I_{k(c,n+D+1)} | h = 0\right] - (1 - p_\text{s}) \cdot \sum_{c\in\mathcal{C}} \text{E}\left[I_{k(c,n)}\right] \text{E}\left[I_{k(c,n+D+1)}\right] \quad (9)$$

$$= (1 - p_\text{s}) \sum_{c\in\mathcal{C}} \text{E}\left[P^2_{k(c,n)} L^2_{k(c,n)} b^2_{k(c,n)} L^2_{\text{s},k(c,n)}\right] \text{E}\left[L_{\text{f},k(c,n)}[n] \cdot L_{\text{f},k(c,n)}[n + D + 1]\right] - (1 - p_\text{s}) \cdot \sum_{c\in\mathcal{C}} \left(\text{E}\left[I_{k(c,n)}\right]\right)^2 \quad (10)$$

$$= (1 - p_\text{s}) \cdot (L \cdot H_1 - M). \quad (11)$$

$$\rho \quad = \quad (1 - p_{\rm s}). \tag{19}$$

The correlation decreases linearly with the probability that the scheduler in the interfering cells changes its decision. The less persistent the schedulers in the interfering cells are, the less correlated the measured ICI and the actual experienced ICI would be.

V. Throughput Degradation due to ICI blindness

Let us now consider the throughput degradation due to the blindness or outdating, with respect to the ICI, of link adaptation as a result of the changes in the scheduling decisions in the interfering cells. We consider the uplink of a user of interest at the cell of interest $c = 1$, with two rings of interfering sites as shown in Fig. 1 with an ISD $= 0.500$ km. We assume that the user of interest experiences Rayleigh fading, considering a round robin scheduler at the cell of interest. For the shadowing we consider a variance of 8 dB. The ICI samples are generated using the procedure described in [2], where we assume that each user in the network is received with the same average receive power at his own base station. The AMC's used to map the SINR to throughput are given by [6]. The users' maximum transmit power is 24 dBm and the frequency resource block assigned to a user is 900 kHz. The users in the interfering cells are located uniformly in their respective cell and the outdating of the link adaptation is only due to the changes in the scheduling decisions in the interfering cells, i.e., the users are static and $H_1 = H_0$. We assume that the schedulers employed at each interfering cell have the same probability $p_{\rm s}$ of changing the scheduling decisions.

In Fig. 3, the mean user throughput is depicted as a function of the probability $p_{\rm s}$ for the cases of (1) *correct link adaptation*: the actual experienced ICI is the same as the measured ICI; (2) *incorrect link adaptation*: the actual experienced ICI and the measured ICI are completely uncorrelated; and for the case of (3) *outdated link adaptation*: the actual ICI is partially correlated with the measured ICI as expressed by the correlation (19). The case of correct link adaptation is an upper bound, since this is what one can achieve if the ICI that the user will actually experience is known beforehand. On the other hand, the case of incorrect link adaptation is the lower bound, since this corresponds to the case when the link adaptation is completely blind or outdated with respect to the ICI. It can be seen how the mean user throughput degrades as the probability $p_{\rm s}$ of changes in the scheduling decisions increases. Recall that as $p_{\rm s}$ increases, the ICI correlation p from (19) decreases. In order to observe better this degradation, in Fig. 4, the percentage loss of the outdated link adaptation with respect to the correct link adaptation is shown. Notice that in the worst case, i.e., when the measured ICI and the actual experienced ICI is totally uncorrelated, there is a loss of more than 40%. The worst case occurs when the actual interfering set of users is totally different than the interfering set of users at the time the ICI is measured.

VI. Conclusion

In this work we have analyzed the adverse effect of outdated or blind link adaptation decisions with respect to the intercell

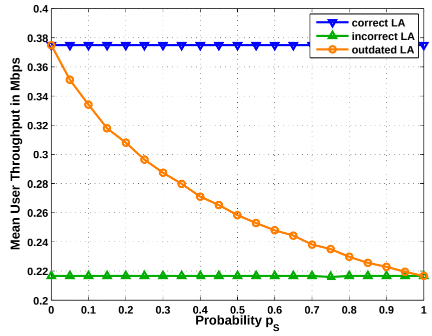

Fig. 3. Mean User Throughput Degradation as a function of $p_{\rm s}$.

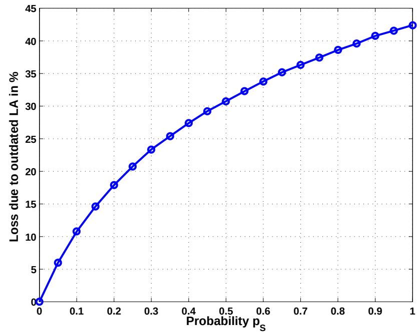

Fig. 4. Percentage Loss as a function of $p_{\rm s}$.

interference. The degree of blindness depends on the correlation between the measured ICI and the actual experienced ICI. In turn, this correlation depends on the persistency of the scheduling decisions in the interfering cells. As expected, the more outdated the link adaptation is, the larger the throughput degradation. However, the more persistent the schedulers in the interfering cells, the more correlated the measured ICI and the actual experienced ICI are and hence, the more correct the link adaptation is. Nevertheless, one cannot control the persistency in the interfering cells and methods for making the ICI predictable in order to have correct LA are of interest for future work, since the throughput can be strongly degraded due the outdated link adaptation.

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