Channel Prediction-Based User Selection Algorithm for Multiuser Environments

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Abstract—In this paper, we propose a channel prediction-based user selection algorithm for a single-cell wireless network with multiuser environments. The proposed algorithm focuses on mitigating the degradation of performance due to a feedback process. In particular, by using the Naive Bayes (NB) classifier, the proposed algorithm selects the user who is expected to have the biggest channel gain after feedback delay. Simulation results show that the proposed algorithm mitigates a performance decrease of achievable rates.

I. INTRODUCTION

In a downlink cellular system with a single cell, it is well-known that the base station (BS) can achieve the highest achievable rates when the BS communicates with the mobile station (MS) with the biggest channel gain. To obtain this result, the BS requires the MSs' accurate information of channel gain through a feedback process, which is not a practical assumption due to changes of the MSs' channel during feedback process.

To solve this problem, several studies on channel prediction have been conducted [1]-[3]. However, these approaches cannot fully utilize the random variation of channel; moreover, they also cannot be implemented in practical systems. Thus, BS cannot select the best user, and subsequently, suffers from performance degradation in the downlink system.

In this paper, we propose a channel prediction-based user selection algorithm. Applying the NB classifier of machine learning algorithm in [4], the proposed algorithm selects the best possible user after feedback delay based on the database (DB). Simulation results show that the proposed algorithm mitigates a performance decrease of achievable rates.

II. SYSTEM MODEL

We consider a single-cell model with multiple users. Every user has mobility at the given time and frequency in the time-varying downlink channel. BS and MSs are equipped with a single transmit antenna and a single receive antenna. Above all, our goal is to maximize the capacity of the cellular system as

\[ u^*(t) = \arg \max_{1 \leq i \leq L} \log_2(1 + \frac{|h_i(t)|^2 P_i}{N_0}), \quad (1) \]

where \( u^*(t) \) denotes an optimal user index at time \( t \), \( h_i(t) \) is a channel vector from BS to \( i \)-th MS at time \( t \), \( L \) is the number of users in the cell, \( P_i \) is a transmit power from BS to MS and \( N_0 \) is the variance of additive white Gaussian noise with the zero mean, respectively.

III. SCHEDULING BASED ON PROBABILITY ANALYSIS AND BAYSIAN RULE

Maximal rate algorithm (MRA) in [5] proposed that BS selects MS with the best channel at that time; however, MRA did not consider feedback delay. As considering feedback delay, we can formulate user selection algorithm as

\[ u^*(t + T) = \arg \max_{1 \leq i \leq L} |h_i(t + T)| = \arg \max_{1 \leq i \leq L} \alpha_i \]

\[ = \arg \max_{1 \leq i \leq L} \Pr(i = \arg \max_{1 \leq j \leq L} |h_j(t + T)| \mid C), \]

where \( C = (\text{attribute value}_{1,1}, \ldots, \text{attribute value}_{L,K}) = (d_{1,1}(t), \ldots, d_{L,K}(t)) \), \( T \) is a feedback delay, \( K \) is the number of attribute values and \( \alpha_i \) denotes a conditional probability that \( i \)-th MS has the biggest channel gain after feedback delay given the attribute values. Since BS cannot know the probability distribution of channel gain practically, MRA based on probability analysis (MRA-PA) is hard to be applied in a real system. On the contrary, it can be implemented practically, if we use the NB classifier. In addition, BS can choose same MS as the one selected by MRA-PA. It is demonstrated by

\[ u^*(t + T) = \arg \max_{1 \leq i \leq L} \alpha_i \]

\[ = \arg \max_{1 \leq i \leq L} \Pr(i = \arg \max_{1 \leq j \leq L} |h_j(t + T)| \mid C) \]

\[ = \arg \max_{1 \leq i \leq L} \prod_{1 \leq j \leq L} \Pr(d_{i,k}(t) \mid i = \arg \max_{1 \leq j \leq L} |h_j(t + T)|), \quad (3) \]

It is assumed that attribute values are independent to each other.

IV. PROPOSED USER SELECTION ALGORITHM

A. Making database

In order to use NB classifier, we need a training process such as making DB. Hence we define training data as

\[ D = \{C(t + sT), |h_i(t + (s + 1)T)|\}, \quad (4) \]

where \(-S \leq s \leq -1\). Then, we propose making DB by utilizing training data as

\[ DB(C(t), i) = \frac{-1}{s} \sum_{s=-S} f((i, \arg \max_{1 \leq j \leq L} |h_j(t + (s + 1)T)| \mid C(t + sT))), \quad (5) \]

where \( f(n,m) = 1 \), if \( n \) equals \( m \), otherwise, \( f(n,m) = 0 \), \( DB \) denotes an \( |C(t)| \times L \) matrix. After that, BS has to
\[
\alpha_i = \prod_{j \neq i} \Pr(|h_i(t + T)| > |h_j(t + T)|, \ldots, |h_L(t)|, v_1(t), \ldots, v_L(t))
\]
\[
= \prod_{j \neq i} \Pr(R_t(r \geq \sqrt{2|h_j(t)| - J_0(2\pi f_c T v_i(t)) |h_i(t)|} \bigg/ \sqrt{1 - J_0(2\pi f_c T v_i(t))^2})) = \prod_{j \neq i} \exp\left(-\frac{\sqrt{2|h_j(t)| - J_0(2\pi f_c T v_i(t)) |h_i(t)|}}{2\sqrt{1 - J_0(2\pi f_c T v_i(t))^2}}\right). \tag{9}
\]

B. Simulation results

The carrier frequency is 2.3 GHz and feedback delay is 2 ms. Fig. 1 depicts the average achievable rates vs. SNR in a single cell with 10 users environments. The proposed algorithm is compared to a modified covariance (MC) predictor, which shows the best performance on the comparative study [3]. Consequently, the proposed algorithm outperforms the MRA based on MC (MRA-MC) in all simulation environments and shows a less inferior performance gain than the MRA-PA, which is hard to be implemented in a realistic scenario.

V. CONCLUSION

In this paper, we proposed a channel prediction-based user selection algorithm for a single-cell wireless network with multiuser environments. In general, it is impossible to obtain the exact channel information in a fast fading channel due to feedback delay. For that reason, the proposed algorithm selects the best possible user using the NB classifier after feedback delay. Simulation results have shown that the proposed algorithm provides performance improvement in a delayed feedback system.

REFERENCES


