

Evaluation of Throughput using Hybrid Cooperation

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ABSTRACT

The strength of signal becomes weak as it reaches the edge of a cell. The performance degrades due to inter-cell interference. In this paper, we present the cooperation scenario which improves this performance and calculate the signal capacity using the following schemes - without cooperation, with full and hybrid cooperation

General Terms

Base station cooperation

Keywords

Cooperative transmission, Hybrid cooperation

1. INTRODUCTION

During the last few decades, wireless communication systems have been under major development. The requirements have shifted from the low data rate voice services to real time video transmissions [1]. Support for higher data rates has become more essential and the development towards more advanced wireless systems is still ongoing. Multiple antennas are currently included in many of the wireless standards to achieve the required data rates. This increases the complexity of signal processing algorithms in the receiver [2]. However, the complexity and power consumption of the wireless device should be moderate. This poses challenges in developing algorithms and architectures for the mobile receiver. To achieve higher data rates channel resources must be utilized efficiently. Using frequency reuse interference can be minimized up to some limit. But, using different frequency bands for different cell decreases the spectral efficiency [9]. A new technique to provide high spectral efficiency in downlink environment is base station cooperation [2]. In a conventional cellular network, a terminal receives signals not only from the base station of that cell, but also from other cell base stations [6]. This ability to receive signals from multiple base stations can be used to improve the spectral efficiency of the cellular network and achieve higher data rates for cell edge users. In this paper, we present the cooperation scenario including 3 cases, without cooperation, with full cooperation and hybrid cooperation. Results of all 3 schemes are compared and finally decided that hybrid scheme provides better results.

There are different sections in this paper: Section 2 signal to interference noise ratio (SINR) and user throughput for cooperation and no cooperation. Section 3 describes the cooperation selection algorithm. Section 4 presents the simulation results and Section 5 presents the conclusions

2. MODEL FOR BASE STATION COOPERATION

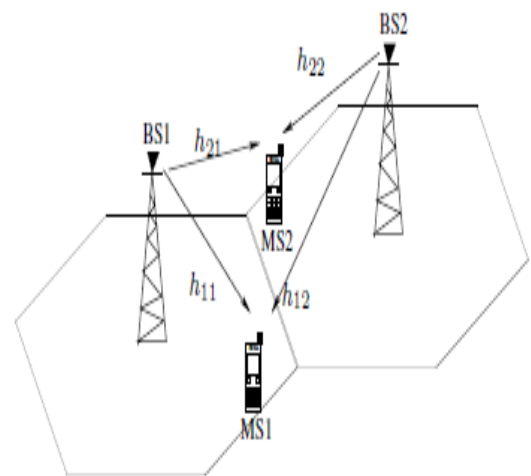


Fig. 1

The basic system model is shown in Figure 1 [7]. Base stations BS1 and BS2 are in cooperation mode, which will transmit signals to mobile terminals MS1 and MS2. For base station 1, base station 2 is one of the interfering base stations among the total 12 base stations. Here total 12 base stations are considered for simulation [3]. More than one base station can be involved in cooperation, but for simplicity we are considering only two stations to form cooperation. The signals from the serving base station and from the neighbour base station arrive at the terminal at the same time, i.e., received signal by the mobile terminal from the two base stations are frame synchronized [4]. The frame duration in which the BS1 transmits to MS1 is divided into two sub-frames, where the first sub-frame is used for signal transmission to MS1 and the second one to MS2. Similarly, BS2, which is under cooperation with BS1, transmits in the same sequence of BS1.

y_1, y_2 = received signals

h_{ij} = channel between mobile terminal i and base station j .

x_1, x_2 = transmit signal of BS1 and BS2

z_i = total interference received by MS i

n_i = additive white Gaussian noise.

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} z_1 \\ z_2 \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2 \end{bmatrix} \quad (1)$$

A. Without Cooperation

Under normal operation that is when there is no cooperative transmission, the signal to interference noise ratio (SINR) in the downlink for MS1 is given by

$$\text{SINR}_{nc} = \frac{[h_{11}]^2 E\{X_1\}^2}{\sigma_n^2 + \sum_{k=2}^L [h_{1k}]^2 E\{X_k\}^2} \quad (2)$$

where h_i represents the channel between the terminal i and base station j , $E\{X_i\}^2$ is the average transmit power of Base Station i , and σ_n^2 is noise variance.

The capacity (or throughput) for terminal MS1 in bits/sec/Hz

$$C_{nc} = \log_2(1 + b\text{SINR}_{nc}) \quad (3)$$

where, b is determined by the SNR gap between the practical coding scheme and the theoretical limit.

B. With Cooperation

When terminal MS1 is in cooperation with BS1 and BS2, SINR_{coop} , SINR of the downlink is given by

$$\text{SINR}_{coop} = \frac{(|h_{11}|^2 + |h_{12}|^2) E\{X_1\}^2}{\sigma_n^2 + \sum_{k=3}^L [h_{1k}]^2 E\{X_k\}^2} \quad (4)$$

The capacity (or throughput) for terminal MS1 under cooperation in bits/sec/Hz will be

$$C_{oop} = \beta \log_2(1 + b\text{SINR}_{coop}) \quad (5)$$

β defines the proportion of resource sharing among the terminals under cooperation. In our simulation, the value for β is $\frac{1}{2}$.

3. HYBRID COOPERATION

User capacity under cooperation increases but not all the time. The overall (mean) capacity is increased compare to normal scheme but the individual user capacity is not increased all the time [5]. Sometimes it is worst than normal operation. To go under cooperation, it requires large backhaul signaling and extra cost in terms of complexity is also getting added [8]. Hence the question arises whether it is worth doing cooperation all the time. Therefore hybrid cooperation is introduced which provides following algorithm. This algorithm decides whether to do cooperation or simple operation.

Algorithm 1 Hybrid selection

1. Get the channel information of the serving DL and nearest DL.
2. Calculate SINR for without Cooperation scheme (SINR_{nc}).
3. Calculate SINR for full Cooperation scheme (SINR_{coop}).
4. Case: Low SINR regime
5. For $\text{SINR}_{nc} \leq 0$ Do
6. If $\text{SINR}_{coop} > 2 * \text{SINR}_{nc}$ then
7. Base station selects Cooperation mode.
8. Else
9. Base station selects normal operation mode.
10. End if
11. End for
12. Case: High SINR regime
13. For $\text{SINR}_{nc} \geq 0$ do
14. If $\text{SINR}_{coop} > \text{SINR}_{nc}^2$ then
15. Base station selects Cooperation mode.
16. Else
17. Base station selects normal operation mode.
18. End if
19. End for

4. SIMULATION AND RESULTS

Table 1

Scheme	Mean Capacity (bits/Sec/Hz)
Full Cooperation	0.3508
Hybrid Cooperation Low region	0.5532
High region	0.4583

In hybrid cooperation, full cooperation is selected only when $SINR_{nc}$ is smaller than $SINR_{coop}$ as given in algorithm. In this simulation we have considered 12 base stations with one user per cell edge. The average power transmitted by serving base station as 10dB, noise variance as 5dB and average interfering power of base stations is 6dB, according to path loss model COST 231 is considered [6]. The mean throughput or capacity and mean SINR for cell edge user's under No cooperation, Full cooperation and hybrid cooperation scheme is shown in Table 1. Throughput captured from first 1000 frames is shown in Fig. 2, Which describes Hybrid cooperation with red colour gives better result as compared to other 2 schemes.

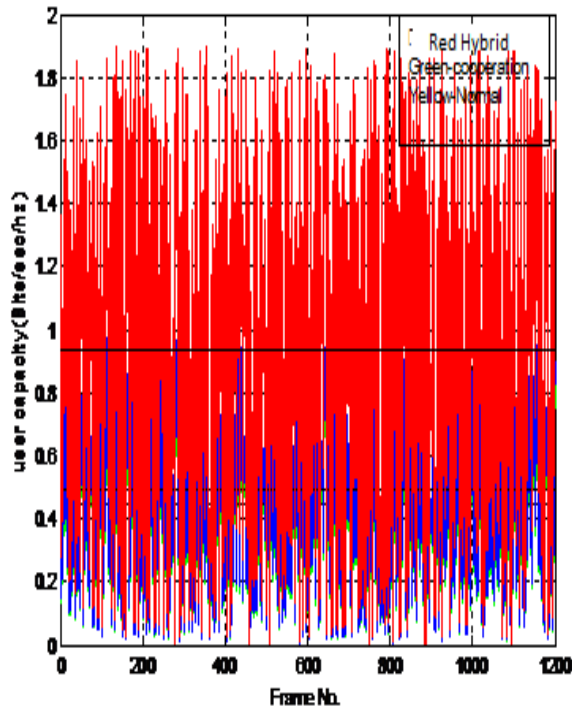


Fig. 2 Comparison of all 3 schemes

5. CONCLUSIONS

In this paper, simulation analysis of hybrid cooperation in a cellular network was presented. The simulation results show that under normal operation the cell edge user SINR and Capacity is quite poor due to interference. In full cooperation although the interference is removed, the user capacity of a cell-edge is not always better than normal transmission due to bad channel condition. By using hybrid method, both capacity and SINR is improved. The improvement is about 61.70% from full cooperation, which was 33% in previous research. According to the result, the proposed hybrid scheme provides a better result compared to full-time cooperation.

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