Throughput Improvement for Cell-Edge Users Using Selective Cooperation

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Abstract: *In this paper, we introduce the technique mainly to improve the performance of the mobile phone users who are at the edge of the cell. In cellular radio system a land area to be supplied with radio waves is divided into regular hexagonal shape assigned with multiple frequencies ($f_1 - f_6$) which have corresponding base stations. In such an environment inter cell interference do exist and also responsible for degradation of performance. Here in this technique, we use co-operative transmission to improve the spectral efficiency. Here downlink capacity of cell edge users is evaluated. Co-operative scheme of base stations is responsible for to improve the spectral efficiency. Throughput and Signal to interference noise ratio (SINR) of cell edge users is co-ordinated by the base stations and transmission is controlled through base stations. Selective co-operation is being introduced here where the selection criteria is based on throughput.*

Keywords: Signal to interference noise ratio (SINR), Spectral efficiency, Cell edge user

1. Introduction

The numbers of cellular users are increasing more or less exponentially. The expected economic impact of mobile and wireless communications providing improved productivity in business processes and access to information anytime and anywhere is driving the further improvement of communication systems. Traffic over mobile and wireless systems is expected to increase significantly especially for data applications. Data traffic is strongly increasing mainly due to Internet traffic. Ever increasing demand to Support higher data rates for broadband services like triple play, online gaming etc., over wireless networks, requires a large capacity. A major issue in beyond 4G systems is to make the high bit rates available in a larger portion of the cell, especially cell edge user. For high (QoS) many techniques have been proposed in order to improve coverage enhance signal quality and increase system capacity. Cell edge users, as they are far away from the Base Station; suffer from low Throughput due to low Signal to Interference Noise Ration (SINR). In a multi-cell environment, inter-cell interference(ICI) degrades the performance of wireless systems[6]. It is essential to improve the quality of service because the cost paid by all the users in a network is same and to maintain the cell edge user's throughput to a specified level is one of the constraints to be followed by a service provider.

One of the reasons to get low SINR at the cell edge is severe fading of radio channel. The mobile wireless channel suffers from fading, meaning that the signal attenuation can vary significantly over the course of a given transmission. Transmitting independent copies of the signal generates diversity and can effectively combat the deleterious effects of fading. The spatial diversity is generated by transmitting signals from different locations, thus allowing independently faded versions of the signal at the receiver. Recently base Station Cooperatiion has been proposed to mitigate the cell edge effect [4]. In multicell environment cell edge throughput can be improve by coordinating Scheduling and signal transmission [6]. In networked MIMO system cooperative encoding and scheduling is discussed [1].To

achieve maximum downlink capacity other cell interference is being suppress [1] using cooperation in multicell environment the overall interference can be reduced [5]. In this paper cooperation scenario is being discussed where interference is present .Transmission rate to each user is calculated depending on signal to interference plus noise ratio (SINR). Co-MIMO is an extension of conventional single-BS based MIMO techniques. It allows multiple BSs to serve one or multiple MSs simultaneously over the same radio resource through coordination among BSs .Selective cooperation method is being proposed based on users throughput that provides the better capacity than full cooperation. The downlink environment under consideration will not have any interference from users in the same cell. They are properly separated in time, frequency or code such that orthogonally exists.
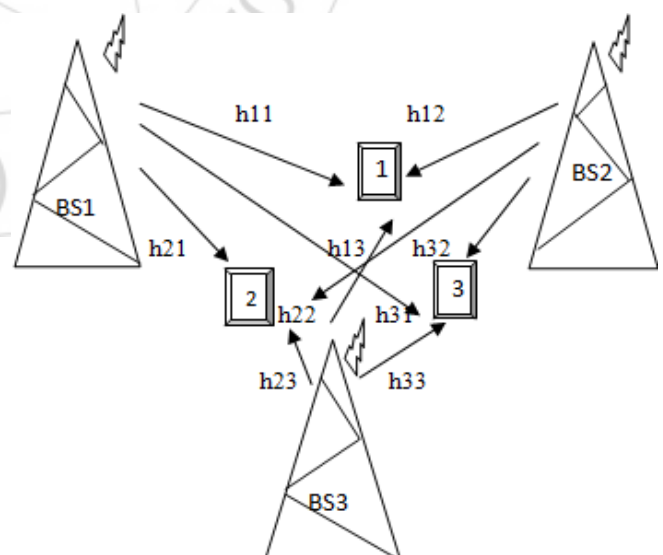

Figure 1: System Model

2. System Model

BS1 Base station 1 and BS2 Base station 2 are in cooperation, they transmit signals to the mobile phones MS1, MS2 and MS3. There may be more base stations but

Paper ID: SUB152900

530

we consider only two base stations for simplification purpose. All the signals from BS1 and BS2 are being transmitted simultaneously and being received by the mobile stations at the same time. The signal to be transmitted by Base station and received by mobile station are frame synchronized that is they are divided in to three sub frames .The first sub frame is used for MS1 ,second sub frame to MS2 and third sub frame for MS3.BS2 also repeat the same signal transmission ,which is in cooperation with BS1.

$$\begin{bmatrix} y1 \\ y2 \\ y3 \end{bmatrix} = \begin{bmatrix} h11 & h12 & h13 \\ h21 & h22 & h23 \\ h31 & h32 & h33 \end{bmatrix} \begin{bmatrix} x1 \\ x2 \\ x3 \end{bmatrix} + \begin{bmatrix} z1 \\ z2 \\ z3 \end{bmatrix} + \begin{bmatrix} n1 \\ n2 \\ n3 \end{bmatrix} \qquad (1)$$

Where signals at MS1,MS2 and MS3 are y1,y2 and y3 respectively.h_{ij} is the channel between MS(i) and BS(j).x1,x2 and x3 are the signal to be transmitted by BS1 ,BS2 and BS3.Zi is the total interference(except cooperation by all Base stations) and ni is the additive white Gaussian noise.

A. No Cooperation

When there is no cooperation, the SINR Signal to interference noise ratio for MS1 for downlink is

$$SINRnc = \frac{|h11|^2 E\{X1^2\}}{\sigma n^2 + \sum_2^{12} |h1k|^2 E\{Xi^2\}} \qquad (2)$$

h_{ij} is the channel between the terminal i and base station j, $E\{X1^2\}$ is the average transmit power of base station i,and σn^2 is noise variance

The throughput of MS1 (bits/sec/Hz) is derived by Shannon capacity is

$$Cnc = \log 2\ (1+bSINRnc) \qquad (3)$$

b is determined by SINR gap between the practical coding scheme and theoretical limit (≈1)

B. Cooperation

When MS1 is in cooperation with BS1,BS2 and BS3 then the SINRcoop ,SINR in downlink channel depends on type of cooperation

$$Ccoop = \alpha \log 2\ (1+bSINRcoop) \qquad (4)$$

Considering resources fairness the value of $\alpha = \frac{1}{3}$

3. Cooperation Modes

Different modes of cooperation are considered

1) Cooperative MIMO

In this mode base stations BS1, BS2 and BS3 transmit information signal to MS1
The SINR expression *is*

$$SINRcoop = \frac{(|h_{11}|^2 + |h_{12}|^2 + |h_{13}|^2)E\{x_1^2\}}{\sigma_n^2 + \sum_{k=3}^{12} |h_{1k}|^2 E\{x_1^2\}} \qquad (5)$$

2) Simple Cooperation

The signals transmitted by base stations BS1, BS2 and BS3 are added using simple vector addition. The SINR will be

$$SINRcoop = \frac{(|h_{11} + h_{12} + h_{13}|^2)E\{x_1^2\}}{\sigma_n^2 + \sum_{k=3}^{12} |h_{1k}|^2 E\{x_1^2\}} \qquad (6)$$

3) Cooperation with 1 –bit Phase feedback

The addition of three signals is done with proper co phasing the information signal from the second and third Base station on the 1 bit feedback of the phase information. The SINR expression
SINRcoop=

$$\frac{(|h_{11}|^2 + |h_{12}|^2 + |h_{13}|^2) + 2R(|h_{11}\ h_{12}\ h_{13}|))E\{x_1^2\}}{\sigma_n^2 + \sum_{k=3}^{12} |h_{1k}|^2 E\{x_1^2\}} \qquad (7)$$

4. Cooperation Selection

The user in the serving cell and neighbouring cell who wish to do cooperation shares the available resources (time, frequency or code) equally. Considering b=1 in the capacity expression (3) and (4) .the expression for capacity (or user throughput for cooperative scheme with resource constraints to improve the normal transmission i.e. Coop> Cnc

$\frac{1}{3}$log (1+bSINRcoop) >log (1+bSINR nc)

$1+bSINRcoop > (1 + bSINR)^2$

$1 + bSINRcoop > 1+b^2\ SINR_{nc}^2 +2bSINR_{nc}$

$SINR_{coop} > bSINR_{nc}^2 +2SINR_{nc}$ \qquad (8)

For low SINR case as log (1+x) ≈x, for the user capacity in "cooperation mode" should be at least equal to the capacity of same user under "No cooperation". For High SINR the relationship between two SINR is exponential. The SINR under cooperation (SINRcoop) is superior to SINRnc.

**Flow Chart:**

Paper ID: SUB152900

531
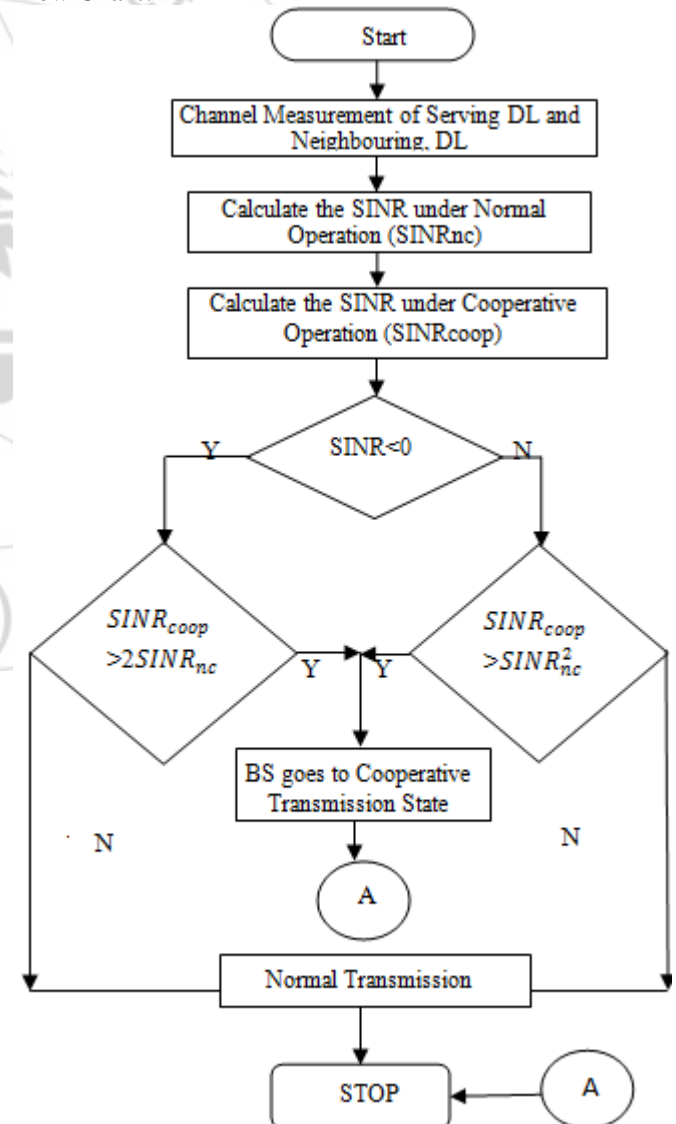
5. Observations

Our observation from simulation revealed that for some of the time. The user throughput without cooperation (3) is better than expression (4) for $\alpha = \frac{1}{3}$ .Maximum Throughput and SINR for cell edge user for different cooperative scheme is shown in table 1.1 and 1.2.

**Table 1.1:** Maximum Throughput for cell edge user (bit/sec/Hz) for different cooperation schemes

Types of Cooperation	Cooperative MIMO	Simple Cooperation	Cooperation with 1 bit phase feedback
Without Cooperation	1.56	1.56	1.56
With Cooperation	7.92	8.22	8.22

Table 1.2: SINR for different cooperative schemes

Type of scheme	Cooperative MIMO	Simple Cooperation	Co1operation with 1bit phase feedback
Without Cooperation	1.28	1.28	1.28
With Cooperation	1.42	1.47	1.47
Selective cooperation	2.14	2.88	2.20
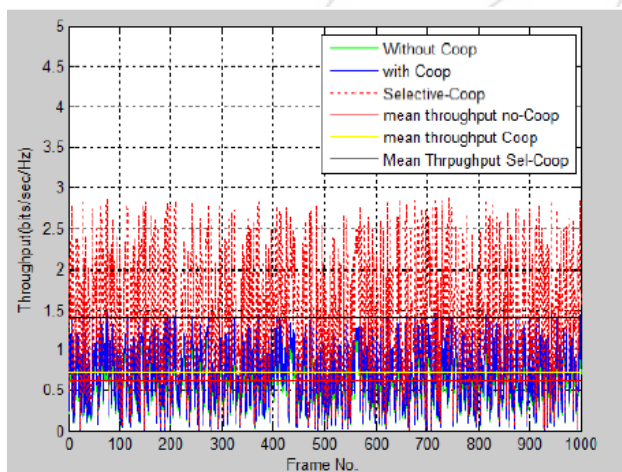
Figure 1: User throughput comparison for various operations in simple cooperation
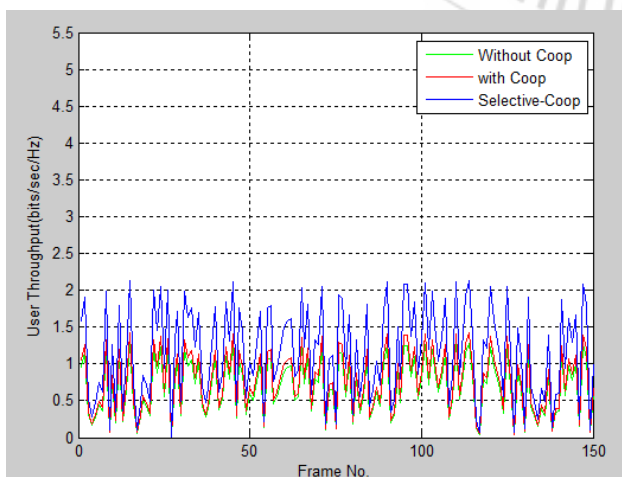
Figure 2: User throughput comparison for various operations in Cooperative MIMO for First 150 frames
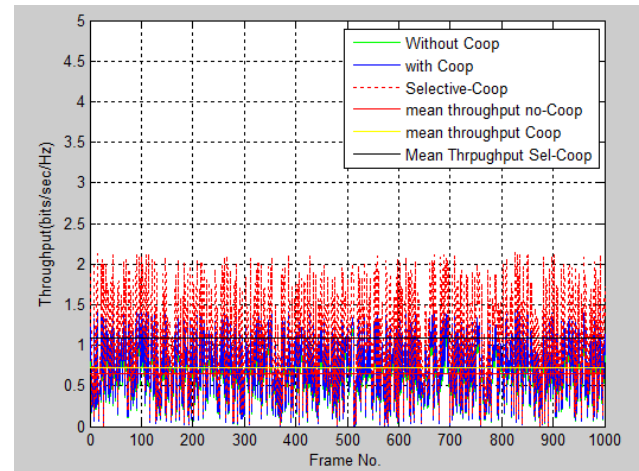
Figure 3: User throughput comparison for various operations in Cooperative MIMO

6. Conclusion

In cooperative communication, throughput is improved but in resource fairness cooperation, the user capacity of a cell edge user is not always better than normal transmission .By doing selective cooperation throughput is improved. The throughput improvement is achieved from full cooperation to selective cooperation for same SINR.

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Paper ID: SUB152900

533