Performance Evaluation of Decode-and-Forward Relaying for Cellular Communication Network

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Abstract-In this paper, the performance of decode –and-forward relaying over multiple fading channels is been analyzed. Here at first overviewed traditional relaying techniques and compared it with coded cooperative relaying. BER performance the different schemes are analyzed and the results shows that coded cooperative relaying give better performance in terms of BER analysis. A new technique called network Coded cooperative relaying is introduced, analyzed the new scheme in terms of blocking probability and spectral efficiency. Diversity technique enhances link quality and increasing network capacity. Network coding achieves higher diversity order than other conventional relaying schemes. And the result shows that network coded cooperative relaying outperforms conventional relaying and non-relaying scheme. For improved performance for cell edge users also, location of relay based on distance measurement is also performed. Due to this cell center users also give better performance similar to cell edge users.

Index Terms-Cooperative relaying; coded cooperation; Network coding, relay selection..

1. INTRODUCTION

Cooperative relaying is considered as a most promising and efficient technique for improving spectral efficiency for wireless network. The goal of cooperative communication is improve the overall network performance. In communication, cooperation is of two types, implicit cooperation and explicit cooperation. Our area of interest is the cooperative relaying, which is an explicit cooperation. Explicit cooperation means there a particular frame work is being developed for supporting the cooperation by design. The main idea behind cooperative relaying is that a device is transmitting a signal to the receiver device, Another device which overhear this signal will send this overheard signal to the final destination and the destination device will combine these two received signal and will do perfect decoding. Today wireless communication has become an essential part in everyone's day to day life. Most of the users are using smartphones. This powerful mobile terminals demanding for high end services such as huge data transfer, multimedia services etc. The main challenge faced by todays cellular communication network is that the transmitting the signals from source to destination without degrading the signal. Due to fading, path loss, noises and spectrum inefficiency the current cellular system is incapable of providing higher throughput and sufficient coverage to the users.Cooperative relaying offers considerable improvement. Cooperative relaying mainly consists of two types amplify-and-forward (A&F), decode and forward(D&F). A&F relaying forwards just the amplified version of the received signal. D$F relaying decodes the received signal, re-encode it and forward

to the final destination. So here coding can also be achieved.

In terms of network capacity for the channels and thereby providing a better way to meet the increasing demand for high data transfer for downlink system. It makes use of cooperative diversity principle for enhancing reliability efficiency and reliability of transmission [4]. This cooperative diversity scheme will mitigate the fading and interference effect. In relay aided cellular network Relay station are usually helps in forwarding the received signal to the respective destination i.e., from the Base Station(BS) to the Relay station (RS) for getting much higher Signal-to-interference ratio mainly for cell edge user, for increasing the overall network throughput[2].

Network coding a novel technique is investigated, in cellular networking system [1].Network coding helps in improving the throughput and performance.This is considered to be the best technology for the future network. Relay aided network coding is of interest now-a-days [6]. Network coded cooperative relaying which helps in combing the network coding strategies with cooperative relaying scheme helps in improving the diversity order by sending a combination of the received signal to the destination[1].There is great impact of network coding in the research community because of its number of applications. It is entirely different from source and channel coding, so its implementation is still challenging. Bi-directional network coding scheme was also presented by some researchers. And it uses the decode-and-forward relaying for transmission. There are different types network coding specified by researchers, linear network

coding which send a linear combination of the received packets of data. Physical layer network coding which implies the network coding occurs naturally by the super imposition of electromagnetic waves on one another [4].
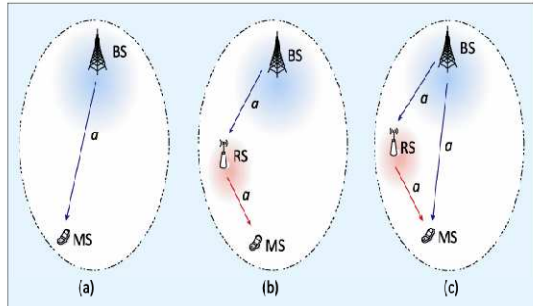

Fig.1: Conventional non relaying and relaying schemes a)traditional non-relaying scheme b) relaying scheme (diversity=1) c) cooperative relaying(diversity=2) [1]

The paper is organized as follows, first section includes the system model then follows the analysis of existing relaying techniques modeled a network coding in cooperative relaying. Finally done the simulation for the proposed scheme and the results are being analyzed and summarized.

2. SYSTEM MODEL

Our model consists of a multi node cooperative relay, in which the Source node /Base Station (BS) want to communicate with the destination/Mobile Users (MU) over a Rayleigh faded channel. Here for transmission, system under consideration consists of Relay Stations (RS) for forwarding the signal which is coming from BS to MU. Decode-and-Forward relaying having constant power is considered. The general equation for received signal over a channel H with energy E_b can be given as,

$$Y_R = \sqrt{E_b}|H|X_T + N(t) \qquad (1)$$

Where N(t) represents the additive Gaussian noise at time t.

2.1. *Decode-and-Forward(D&F) Cooperative Relaying*

In (D&F) strategy, the relay first decodes the received signal. If decodes successfully re-encode it and forward to the destination. So along with diversity gain, coding gain is achieved here.

The received signal during the first hop from source directly to destination can be represented in the form,

$$y_{sd} = \sqrt{E_b}|H_1|x_t + n_{sd} \qquad (2)$$

$$y_{sr} = \sqrt{E_b}|H_2|x_t + n_{sr} \qquad (3)$$

where y_{sd} , y_{sr} are the received signal at the destinations and relay respectively. $H_1 \in C^{N_d *N_s}$ and $H2 \in C^{N_R *N_s}$ denote the spatially correlated Rayleigh distributed channel from the source to the destination and source to the relay respectively with AWG noise with zero mean and variance $N_0/2$.

At the second hope, the relay transmits the encoded signal to the destination and finally receiver decoupled the signal and it is denoted as,

$$y_{rd} = \sqrt{E_r}\|H_3\|^2 x_t + n_{rd} \qquad (4)$$

E_r is the transmitted energy at the relay, H3 channel matrix between relay and destination and n_{rd} is the filtered Gaussian noise.
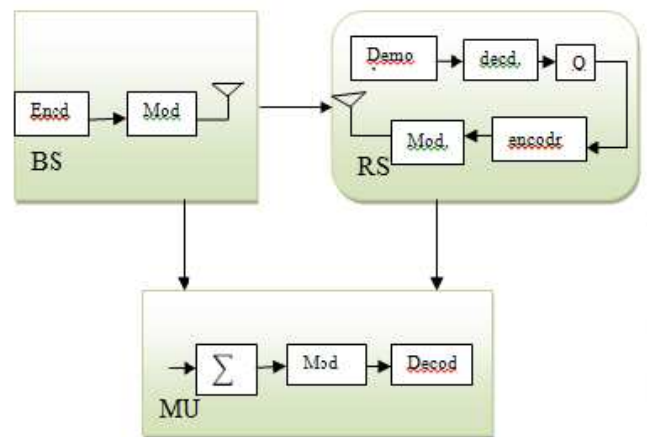

Fig 2: Block diagram representing D&F strategy

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3. PROPOSE NETWORK CODING METHOD

From the cell model of Figure 2 (a), considering hexagonal cell model and it is divided into six equidistant sub regions. If a sub region consist of two mobile users who need to communicate with a common base station and that type of mobile units (MUs) are called cooperation candidate MUs. If this condition occurs the proposed NC2R will start working. Here they can take advantage of their common Relay station which are in cooperation mode.

Suppose the first Mobile User (MU1) need a data a from the BS and the second mobile user which is cooperation with MU1 is represented as MU2 need a signal b from the same base station. And Relay Stations (RSs) which is cooperation with the two mobile stations is represented as RS1 and RS2 respectively. The operation will takes place in 3 phases.

Step 1: BS send the signal 'a' to RS1 and MS1, Also the signal 'b' to RS2 and MS2.

Step 2: RS1 and RS2 decodes the signal 'a' and 'b'. Also an intermediate node will combine the two received signals and forward the combination 'a+b' to both MS1 and MS2. And the decoded signals a and b were re-encoded and forward to MS1 and MS2 respectively.

Step 3: MS1 and MS2 extract *a* and *b* from

the three signal samples (i.e., *a* (or *b*) through direct path, a(or b) from relay *a+b*) received from BS, RS1 and RS2 respectively and then both of them do Maximal Ratio Combining (MRC) [8] to obtain the expected signals, i.e., *a* and *b*, respectively.

When there is a special situation occurs, if MS1 cannot find another CMS who wants to download data from the local BS within a certain waiting period. In this case NC2R methods will allow the Mobile User to select its local Base Relay station to download its signal of demand. And remaining steps are similar to the conventional cooperative relaying case,

Step 1: BS transmit signal to the corresponding destination and MS and its local RS.

Step 1: RS station decodes the received signal and if successfully decoded, it is being re encoded and forwards the signal to corresponding Mobile User.

Step 3: MU will do maximal Ratio combining to extract the original signal from the two copies of the signal.
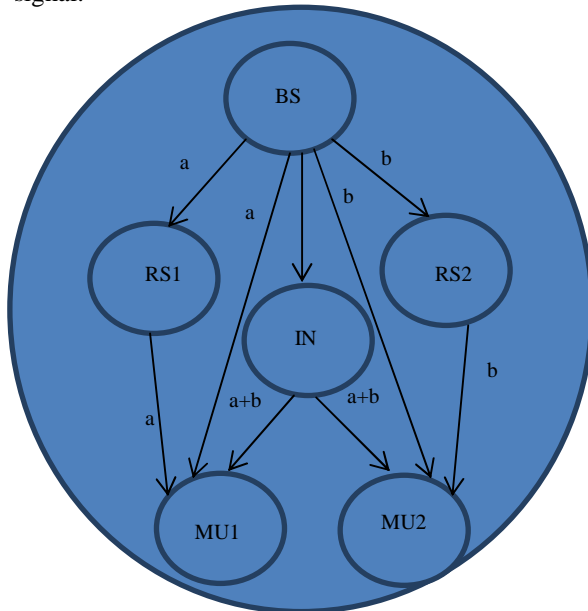

Fig. 3: Network Coding in Cooperative Relaying

From fig.3 NC[2]R it is clear that the end user receives 3 copies of the transmitted message thereby achieving a siversity order of 3 and from the figure 1a) and 1b) shows that occures only one copy of the message and the diversity order will be 1 and the in figure 1c) the diversity order will be two. Diversity, is a main part of broadcasting of wirelesss channels, is

used to combat fading effects by increasing the signal-to-noise ratio (SNR) of the received signals. SO NC2R have high SNR due its higher diversity order than other 3 scenerios.Consequently the diversity oreder can be calculated using the general form,

$$\lim_{SNR\to\propto} \left| \frac{log\, p_e}{\log SNR} \right| = -d$$

Where p_e is the probability of error.

4. SINR ANALYSIS

As interference limited network, CDMA network is been preferred for transmission, CDMA network is interference limited multiple access system, where each channel is disguised by using unique spreading codes. Each user has its own unique spreading codes. CDMA transmits signals in the same frequency band. Due to channel fading and noise MAI cannot be removed completely. And the system is got interfered by the transmitted power of the neighbouring RSs and BSs. denoted as inter channel interference. For convenience here are considering only 6 local BSs and 42 RSs, which includes 6 local RSs and 36 neighbouring RSs in the same cell.

In order for clarity for characterising interference effects, assumed the below given notation for received and transmitted power,

P_B: BSs transmitted power

P_R: Transmitted power of relay station

d_{BM}: distance between target local BS and MS

d_{MBi}: distance between target MU and i^{th} BS

P_M: received power of the target MU

P_{lBN1}: Received power of the total signal transmitted from BS to all the users in N1 of current cell at the target MU.

P_{lBN2}: Received power of the total signal transmitted from BS to all the users in N2 of current cell at the target MU.

P_{nBN}: Received power transmitted by the six neighbouring BSs to all their users at the target MU.

P_{RN}: Received power transmitted by the local RSs and neighbouring RSs located in the six nearest neighbouring cells to their users at the target MU

Therefore the total interference at the target MU can be given as,

$$I_{tot} = P_{lBN1} + P_{lBN2} + P_{nBN} + P_{RN} - P_{MU}$$
------------ (5)

The above equation indicates that all received power induces interference to the desired signal except the part of the desired signal.

Once the total interference is determined it is easy to calculate Signal-to-Interference ration (SINR) for the proposed NC[2]R by using the general formula[1],

$$SINR = \frac{G P_{MU}}{\eta I_{tot} + N_0} \qquad (6)$$

Where, $G = W/R$, W bandwidth of the CDMA network and R is the transmission rate. For

convenience set η=0, so the codes are perfectly orthogonal if η=1, the codes are totally non-orthogonal. If it is non-orthogonal interferences will get maximized.

5. SIMULATION RESULTS

Simulations are performed to evaluate the performance of the proposed algorithm and it is based on spectrum efficiency and blocking probability. Still it is difficult to identify the best relay out of the many.

A) Simulation Parameters

Here considering a hexagonal model with 7 cell reuse and number active users assumed to 101.This active users are uniformly distributed in cell. Location of the relay station is characterised on the basis of the distance between RS and BS and it is within the range[0,1].

From first result it is shown that proposed method will give better performance to cell edge user. bUt cell-centre users suffer from interference, because base station transmits the edge signal twice and this will increase the amount of interference in the cell centre user. To improve the performance here also considering distance measurement it is an important factor which determines the performance. And it is observed that relatively law blocking probability can be achieved for cell-centre users when distance<0.6 and also high spectral efficiency can be achieved in the range 0.4<d<0.6. From the plot it is clear that NC^2R achieves lower blocking probability and higher spectral efficiency for both cell-centre and cell-edge user if the distance come under the range 0.4<d<0.6.

Figure 4 represents the case in which there is no distance consideration made. So from the graph it is clear that the cell-edge users shows lower spectral efficiency and higher blocking probability blocking probability. But the sacrifice of performace for cell-centre users are considerably very small when comparing with the performance improvement achieved by cell-edge users Parameter considered here are α=4,ŋ=0.5,R=1000.

If the distance from Base Station to Relay Station in between 0.4 to o.6 it is possible to improve the spectral efficiency and reduce the blocking probability of cell-center users.
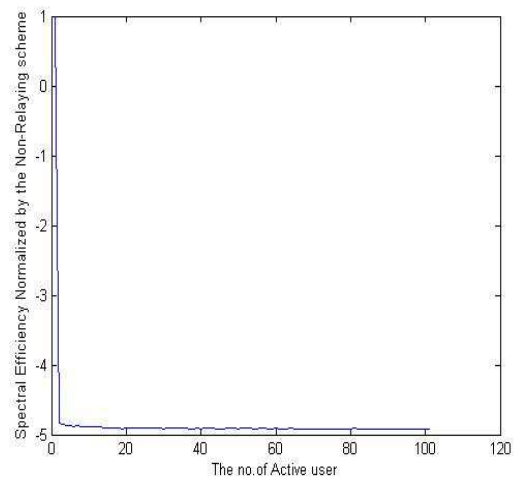

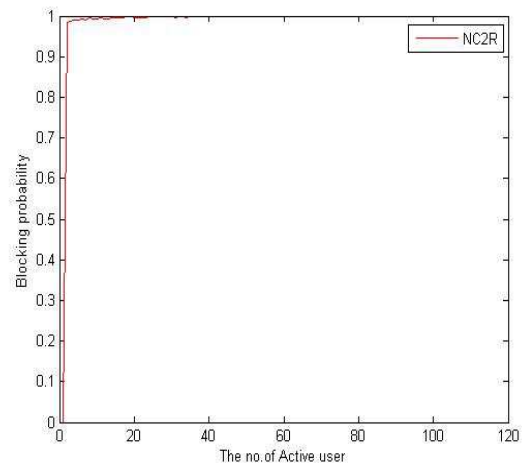Fig 4. (a) Spectral efficiency of cell-centre users

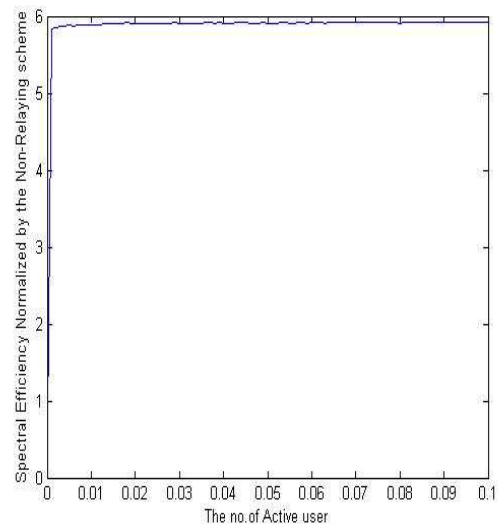Fig 4 (b) Blocking probability of cell-centre users

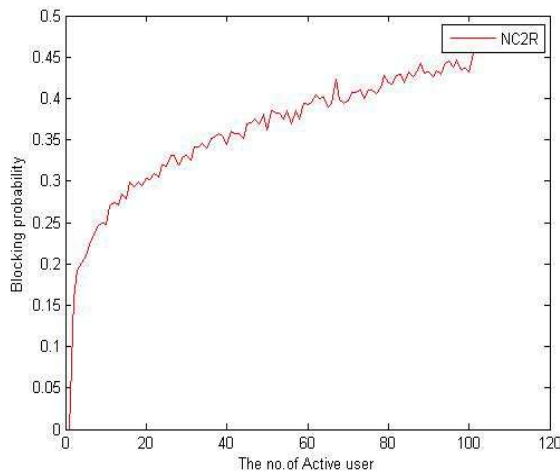Fig 4. (c) Spectral efficiency of cell-edge users

Fig 4 (d) Blocking probability of cell-edge users

CONCLUSION & FUTURE WORK

This study analysed different types of decode-and-forward relaying schemes. Proposed a new technique called network coding in cooperative relaying. This technique achieves a diversity order of 3 for downlink cell-edge users. However here also analysed the SINR for Network Coding scheme with consideration of channel fading, ICI and MAI. Simulation result shows that network coding when combined with cooperative relaying will achieve low blocking probability and higher spectral efficiency for total cell users and especially cell-edge users. This highly improves the network performance.

There are some issues which still kept unsolved. One among that is no error correction codes are specified here this lead to error propagation in the system. Channel coding when implemented into the current network coded system will result in more error free transmission.

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