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Research paper

Development of a Fresh Approach to Use Cooperative Diversity for Efficient & Effective Communication in Modern Wireless Systems

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Abstract:

Cooperative communication system for wireless mobile system is the most challenging and powerful technology for implementation in the mobile and wireless communication domain. Though, various protocols have been suggested for cooperative communication, but none of them is feasible in implementation because of attenuation, noise and cost. In this paper, all the systems used are incorporated by traditional mobile system with minimum changes, so that cost can be minimized. In the proposed approach we use a multiple input multiple output technique at receiver end to improve signal strength. Random data packets have been generated which have been modulated using QPSK technique and then passed through all types of attenuations and noises. The received packets were then analyzed in terms of signal to noise ratio (SNR) and symbol error rate (SER) [1]. It has been found that more than 5dB improvement has been achieved in comparison to traditional mobile system.

Keywords: *Amplify and forward, Attenuation, Co-operative Communication, MIMO.*

1. Introduction

In the current 3G/4G mobile system the complete area is divided into small cells[2]. Every cell is served by the base station. The base stations are comprised of a bunch of highly directional antennas, designed in such a way that it can work as an omni directional pattern system. These base stations are responsible for providing radio resources to mobiles. A base station serves in a limited area named as cell with a limited band of frequency. This frequency band is reused by other cells. For smooth functioning of the system it is necessary that signals from one base station should be limited to its own cell only otherwise it may create interference. This puts limitation to maximum power that can be transmitted through base station. Normally these base stations are established at the center of cell. The signal transmitted from the base station should be limited by the attenuation within the boundary of the cell. This limitation some times creates signal problem for the mobile at the boundary of the cell due to attenuation.

We are suggesting improvement in availability of signal by Co-operative communication system [2][4][10]. In this system the radio resources can be shared between mobiles or other devices without involvement of base station. It basically involves relaying of signals if direct transmission is not possible. The devices which are used for relaying signals are also known as nodes.

Selection of relay nodes

Selection of right node is very important as every node cannot be used to support the system. Limited availability of energy [3] and instability of nodes are the prime reasons for non co-operation of nodes. The complete system of co-operative communication can be divided in two parts. (1) Searching of appropriate relay nodes (2) Transmission of signal

For searching of a node various techniques [5] has been suggested so far.

Two main techniques are being discussed below

Cost evaluation method

In this method every node broadcasts an enquiry request to all its neighbor nodes [6]. In response to the enquiry request, the available nodes will reply with their status towards the request generating node. This reply is based on following parameters

Traffic load on that node

Energy condition of that particular node(if the energy level is below critical level the node will deny to work as relay)

The response thus received on receiver node will be used to create a table. The relay node selected for data relay will be based on its location in table. This position is based on

Distance of next relay or base station

Traffic condition

Distance between transmitting and relay node

No. of relay nodes

This system has three major problems

(a) **Distance**: Since mobiles can be used as relay so they can move out of the relaying area at any time. To overcome this problem tables should be refreshed frequently.

(b) **Energy consumption**: This system will increase energy consumption at every node irrespective of its involvement in data relay.
(c) **Large memory**: For maintaing the table every node should have dedicated memory system and this memory requirement may increase with time as the no. of nodes increses in the relaying system.

A. Need based method

In this method the signal deprived node starts searching network [7].If the signal deprived node does not get signals from base station it may burst request packets in all the directions. The neighboring nodes which receive these packets may respond by sending an acknowledgement signal depending upon their own condition especially for traffic and energy condition. If signal deprived node receives the acknowledgement, then it can start sending data using relay node. If it receives packets from multiple sources then it will add up all the signals so that it can get strongest possible signal. To reduce the risk of unreliability of mobile nodes, data packets will be transmitted and received through multipath. This will reduce the burden of processing at relay nodes.

This type of routing solves two major problems
(i) Instability of nodes
(ii) Reduced processing at nodes

In this paper need based routing for relaying along with MIMO system has been used.

B. Signal transmission

Two main methods have been suggested so far (1) Amplify and Forward [4] [8] (2) Decode and Forward [4]. Other methods by some other authors have been suggested but they all need too much changes in the existing fixed infrastructure based mobile system. In this paper only amplify and forward protocol has been considered because of its simplicity in implementation with existing fixed infrastructure based mobile system.

C. Amplify and forward

The amplify and forward [4] system is based on fact that every mobile or wireless device has transceivers that means they can receive a radio signal as well as they can transmit it. Normally any device which is not getting signal from the base stations start searching network form base station however it can also receive signals from other devices too but no protocols in 3G/4G system supports network sharing. According to the amplify and forward protocol if a device (D1) is deprive of signals then it can search signals, transmitted by any other device (Relay1) and thus with the help of relay. Device D1 can forward data packets first to the relay and relay/s will further transmit towards base station.

D. Decode and forward

In decode and forward [4][13] protocol all the system of searching a network is same as amplify and forward protocol wherein the only difference is in transmission. It has been proposed that every packet received by a relay will not be transmitted as it is. But every data received will be first decoded and checked for error. If the data found correct only then it is amplified and forwarded. This protocol is very useful for saving transmission power of relays but increases power loss due to increased signal processing at every relay. Bigger problem is security, because decryption algorithms have to be shared with every relay. This makes whole system most vulnerable for data access by any unauthorized person. One more problem is that every operator has its own encryption algorithm so either every relay node must check the data by every algorithm or problem of discarding good data at relay end may be arises because of their disability to decode the data because of non matching decoding algorithm.

2. Analysis of Amplify and Forward Protocol With Mimo System

As shown in Figure No 1, a mobile or wireless device situated outside of the boundary of the cell, may receive signal from two sources one directly from base station and through relay nodes. But signal reaching through base station is very much attenuated, while moving relays are not reliable. So using MIMO system [2] [11] [12], the signal received from both the relay and base station are added at destination.
Because of problems stated above only amplify and forward protocol has been considered.[14]

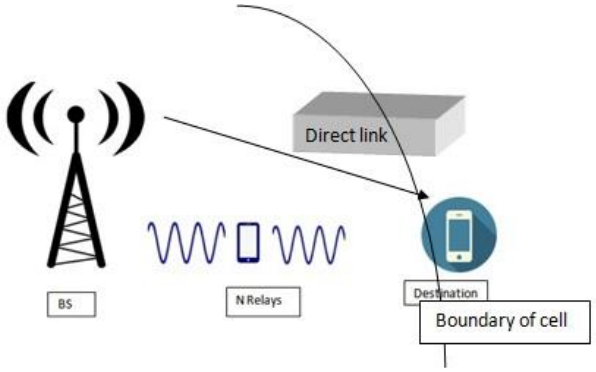

Figure 1: Illustration of a co-operative system.

In this paper we have calculated attenuation and doppler spread for the moving relays [9].
Total signal received at destination

$$P_D = P_B + P_R \quad (1)$$

Where P_D= Total Power Received by destination
P_B= Power received from base station directly
P_R= Power received from relay

Power received by relay [1] 1=$P_{R1} = \sqrt{P_B}\, C + N_{BR}$ (2)

Where C= Channel coefficient and N_{BR}= Noise between Base station and relay

Total Power at relay 2= $P_{R2} = \sqrt{P_{R1}}\, C + N_{R1R2}$ (3)

Where G_{R2} is the ant enna gain for relay 2.
Total power received at node = sum of power received from relay two+ sum of power received from base station
Algorithm of amplify and forward protocol

Channel coefficient between source and relay

$$C = \frac{1}{\sqrt{2}} * P_B \quad (4)$$

Average channel gain

$$G_{BR1} = \frac{\sum C_{BR1}}{N} \quad (5)$$

$$N_T = \frac{1}{\sqrt{2}}(N_P + JN_P) \quad (6)$$

Where N_P= Random noise power

$$R_F = \frac{1}{\sqrt{2}}(N + JN)) \quad (7)$$

Where G_{BS1RS1}= Channel gain

C_{BS1RS1}= Channel between base station and relay

B_S= Power transmitted by base station

N= No of channel between source and relay

N_T= Total noise power between source and relay1 or relay1 to relay2 or relay2 to destination

R_F= Fading of signal

Average channel gain between relay destinations

$$G_{RS1MS1} = \frac{\sum C_{RS1MS1}}{N} \quad (8)$$

Noise between relay and destination

$$C_{RS1DS} = \frac{1}{\sqrt{2}}(N_P + JN_P) \quad (9)$$

By putting all these values in equations (2) to (9) in equation (1) we can get the value of received signal

$$P_D = P_B + P_{R2} \quad (10)$$

$$P_D = P_B + \sqrt{P_{R2}}\, C + N_{R1R2} \quad (11)$$

$$P_D = P_B + \sqrt{\sqrt{P_{R1}}\, C + N_{R1R2}}\, C + N_{R1R2} \quad (12)$$

$$P_D = P_B + \sqrt{\sqrt{\sqrt{P_B} * \frac{1}{\sqrt{2}} * P_B + N_{BR}} * \frac{1}{\sqrt{2}} * P_B + N_{R1R2}} * \frac{1}{\sqrt{2}} * P_B + N_{R1R2} \quad (13)$$

If we consider total noise between source to destination as N_T

$$P_D = P_B + \sqrt{\sqrt{\sqrt{P_B} * \frac{1}{\sqrt{2}} * P_B} * \frac{1}{\sqrt{2}} * P_B * \frac{1}{\sqrt{2}} * P_B + N_T} \quad (14)$$

If Pt is total transmitted power then

$$P_B = \frac{P_t}{\pi r^2} - R_F \quad (15)$$

From equation (14) it can be very clearly seen that the total power received at destination is greater than direct power received from base station. But this power is dependent upon the distance from base station and attenuation

If we receive packets from N relay nodes then by use of MIMO [15]

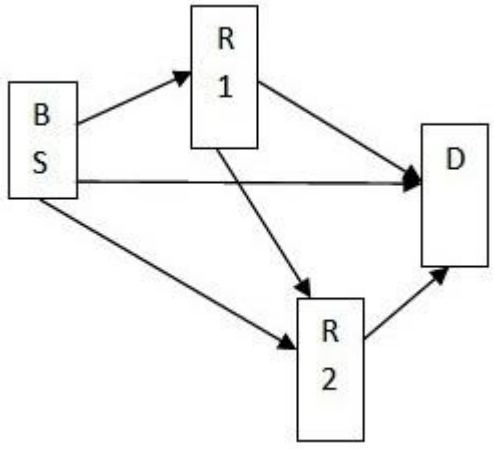

Figure 2: Possibility of multiple paths from source to destination

In the fig 2 it is clearly shown that signal can travel from source to destination using several paths. By the use of MIMO we can add these signals.

If BS is base station, R1 is relay node 1, R2 is relay node 2, and D is destination then possible paths can be

BS⟶ D Signal power received S1

BS ⟶ R1 ⟶ D Signal power received S2

BS ⟶ R1 ⟶R2 ⟶D Signal power received S3

BS ⟶ R2 ⟶D Signal power received S4

Total Signal power received at destination

P_{DTM}= H1S1 + H2S2 +H3S3 + H4S4

Where H1 H2 H3 H4 are paths between nodes.

If we combine all the signal powers from N nodes and N different paths then total power can be represented as below

$$[P_{DTM}] = [H][S]$$

Where P_{DTM} is power received after use of MIMO.

H is channel characteristics and S is signal sent.

3. Results And Analysis

In this paper the total power radiated by a mobile base station is 33dBm as per global standard and cell size 2km. We have used COST207 modelling MATLAB for simulation of for attenuation. This simulation is provided by MATLAB for all terrains and all type of attenuations. Random data sequence has been generated, modulated by QPSK method and then transmitted. The received data is checked at edge of the cell. The signal is further relayed towards destination. The received data has been decoded and checked for error. The whole process is repeated again but without relaying and compared the results .We checked various parameters in this paper but main parameters are Signal to Noise Ratio and Symbol Error Rate. From the fig 3 it can be clearly seen that the value of SER and SNR is improved

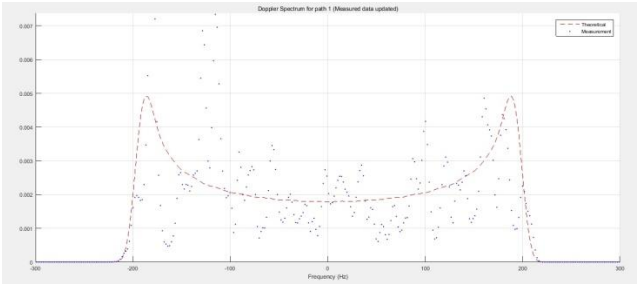

Figure 3: Doppler Spectrum.

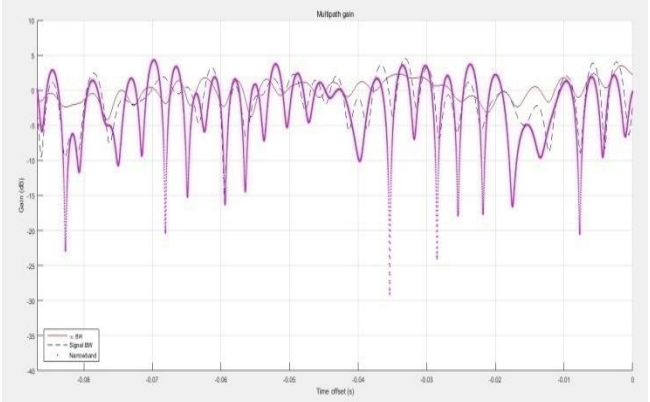

Figure 4: Multipath Gain.

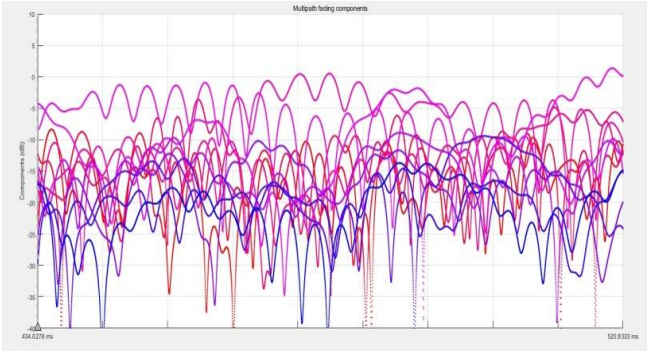

Figure 5: Multipath Fading.

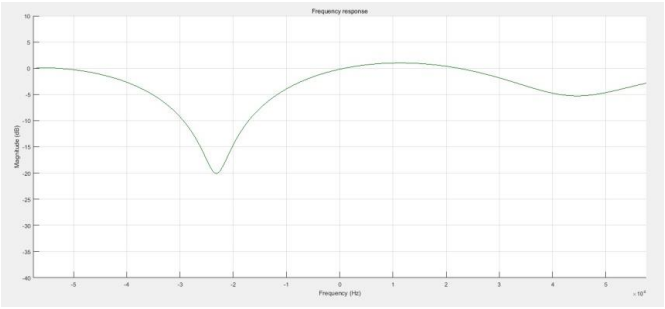

Figure 6: Frequency response of channel.

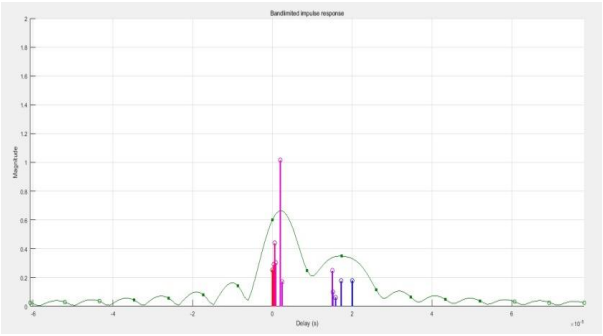

Figure 7:. Impulse response of channel.

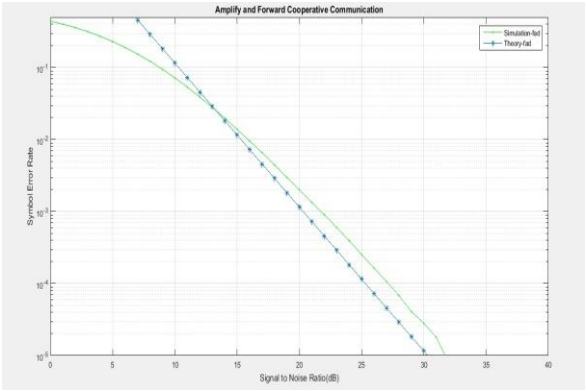

Figure 8: Graph between SER and SNR of received signal

4. Conclusion

We have plotted various graphs not only for calculation of attenuation fading and multipath effect but also for the characteristics of the channel. These characteristics have been compared with standard channel condition. We found that the use of MIMO increased the probability of reception of correct signal. However a lot of work is still pending for making cooperative communication implementable. We have to create a common protocol which can be used for both the systems ie. for the infrastructure[10] as well as cooperative system.

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