International Journal on Future Revolution in Computer Science & Communication Engineering
Volume: 4 Issue: 3
ISSN: 2454-4248
162 – 166

A Review on Relay Communication, Co-operative Communication and Relay Selection Techniques

Sachin Rathee
Research Scholar, MMU Mullana
Ambala, India
Email Id: sachinrathee5@gmail.com

Dr. Kapil Gupta
ECE Department, MMEC Mullana
Ambala, India
Email Id: kapil_mbm@yahoo.com

Abstract – During the past few decades there is unpredictable growth of wireless communication systems. The growth of wireless data traffic goes far-off that it reaches to the wireless capacity. In order to overcome this situation one approach that is MIMO antenna system has been addressed to achieve the future growing demands for high data rate, more reliable transmission, quality of services etc. MIMO system requirement of multiple antennas at the transmitter and receiver which further causes the infrastructure problem. To overcome this problem relays can be employed in order to improve the system performance. Relays also improve the coverage of cellular networks without increasing the transmit power or without demanding the extra bandwidth. This paper overviews the relay communication, co-operative communication and relay selection techniques in wireless environment.

Keywords – *Resource Allocation, Relay, MIMO, Wireless Communication*

*****

I. INTRODUCTION

The demand of wireless communication is increasing rapidly in both military and civilian communication. Due to various internet applications and increasing of personal devices, billion of users around the world growing quickly. Utilization of limited radio spectrum capacity is a big challenge in world of information. Relaying is one approach which helps to achieve this goal and also reduce the requirement of infrastructure. This is the faster and economical approach to achieve the reliable communication [1]. A Relaying system is one of the reliable and advanced techniques that ensure the effective communication in wide wireless network that saves the transmission power and achieves the diversity gain. It improves the network system by including the specialized relay stations. Relay networks are wide area networks in which source and destination are connected with the help of nodes. In this network, source and destination cannot communicate directly but communicate with the help of relay nodes. Relay network is generally use where source and destination are too far away from each other. Each multi hop communication between source and destination passes through the intermediate relays. Figure 1 is showing the multi hop relay network in which the source and the destination cannot communicate directly but connected with the help of relays such as R_{11},R_{12}, R_{21},R_{22}etc.The inclusive relative stations are connected over the network in the form of tree architecture [2]. By using these paths, more than one path between source and destination can be generated and multiple copies of same data can be received at destination end. When there are multiple relays between source and destination then we have to consider the concept of interference between the relays. The relay network is also defined in a specific situation by generating the virtual cell. The number of connectivity in the cell defines the communication possibilities of a node to the relay nodes.

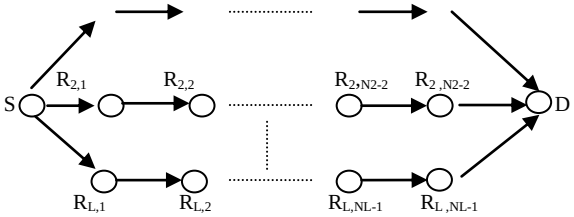

Figure 1. Multi hop Relay Network

There are various relaying protocols like estimate & forward , decode & forward, compute compress & forward which helps in reliable communication between source and destination [3-4]. The selection of particular protocol is depending upon the type of information send to the destination that is called the relay function. Information may be in form of video, text, graphic etc.

The paper is organized as follows. In section II, the idea of relay communication is defined. Section III overviewed the co-operative communication. Sections IV discuss the relay selection techniques followed by conclusion in V and references in VI.

II. RELAY COMMUNICATION

Wireless network enables the shared communication of different data forms in wide network area. For example when the transmission is real time video, there is the requirement of seamless video streaming. The real time video stream becomes more challenging for high resolution, encoded video communication. To improve the communication against real time video streaming, some specialized infrastructure called relay stations are required. The relay stations are adaptive to resolve the problem of resource allocation with relative video session formation. Such communication suffers the problem to establish the

 ISSN: 2454-4248
162 – 166

relay station and to provide adaptive resource allocation. Relays receive and retransmit the signals between users which further helps to increase the coverage area of wireless cellular networks.[3] The practical illustration of relay in wireless communication as follows:

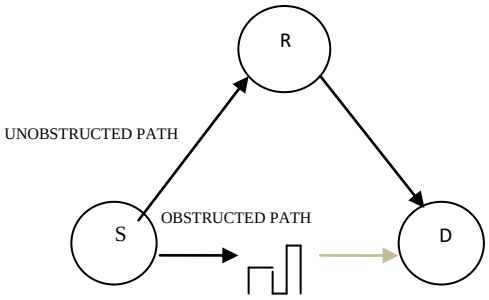

Fig 2. Relay illustration

Fig 2 shows the communication between source and destination. Here the source have two paths, one that is the direct path which is blocked by obstruction made by building or apartment and called the obstructed path and second is unobstructed path in which the communication is done with the help of relay nodes. When source transmit through direct path there is loss of communication and also there is fading of signal. But when source transmit through unobstructed path the communication become reliable and there is no loss of path. Source firstly transmits to the relay nodes then relay nodes process the signal and transmit to the destination. Along with this, relaying also have an advantage of signaling over the shorter links. Generally communication with the help of relays involves effective placement of relays, allocation of relays to user and path formation between source and destination with the help of best selected relay. During the effective placement of relay the maximum coverage connectivity, type of user, base station connectivity and service communication parameters will be considered. There are various graphical methods available with which we can perform the effective placement of relay in wireless environment. The graph processing are available for adaptive improvement to the network architecture. During the dynamic allocation of relay to the end user there is requirement of defining the constraints in terms of time, frequency and bandwidth required by a user. Various programming techniques are available to do the allocation of relay stations to the end users.

III. COOPERATIVE COMMUNICATION

Co-operative communication allows single antenna nodes antennas and generate virtual multiple antenna transmitter which helps to achieve transmit diversity. The basic idea is that in multiuser environment single antenna users share their antenna in such a way that generate virtual MIMO system [5]. Co-operative communication build diversity in new and interesting way .Sometimes it is possible for one mobile to receive data of other in such case it forward some version of overheard information along with its own data because fading paths generate by two users are statistically independent which generate spatial diversity. Along with the development of co-operative communication certain issues also emerged

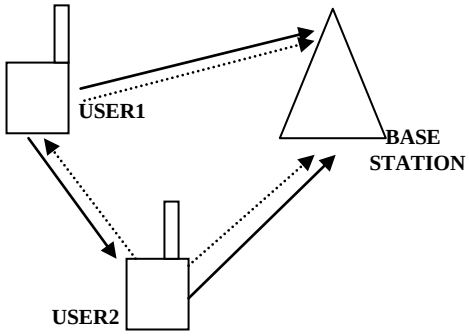

Fig 3. Cooperative Communication

which include loss of rate to cooperating mobile ,overall interference in the network, handoff, fairness of system and transmit and receive requirement of mobiles.

Mainly we are concerning wireless network of cellular and ad hoc type in co-operative wireless communication. In these network types all wireless agents are called users which increase their quality of service via co-operation. In co-operative communication each user act to transmit data and also act as co-operative agent for another user which is shown in figure 3. Cooperative communication is the approach in which each user transmit its own bits and also some information of its partner so it seems that it require more bandwidth and also loss of rate in system. With help of co-operation diversity the spectral efficiency of each user is improved and also channel code rates are increased. Whereas in non cooperative communication all users send data directly to common destination. The basic idea behind the co-operative communication is given by cover and EL Gamel.[5] He analyzed the capacity of three node network containing source, destination and a relay. He assumed that all nodes operate in same band because of that system can be decomposed into broadcast channels . Co-operative communication is different from the relay in many of respect. The purpose of relay in relay channel is to help the main channel whereas in co-operation user act both as a sources and a relays.

(A) Various co-operative methods:

- Detect and Forward: In detect and forward method each co-operative agent detect the partner information and retransmit the detected information (Fig.4). In this method we consider two users which are partnering with each other but in reality each user is having partner

 ISSN: 2454-4248
162 – 166

which provide second data path .An example of decode and forward method is found in the work of sendonaries et al.[6] which present the analysis of code division multiple access. In this scheme two users co-operate to each other. [7]In CDMA each user has its own spreading code but it also have a disadvantage of near far problem. In this each user have its own data bits which is denoted by $b_i^{(n)}$ where i =1,2,3….n and n denotes the time index of information bits. Here $a_{i,j}$ denotes the amplitude of signal. In this each signal period consist of three bit intervals Signal of user 1and user 2 is denoted as:

$$X_1(t)=[\, a_{11}\, b_1^{(1)} c_1(t),\ a_{12}\, b_1^{(2)}\, c_1(t),\ a_{13} b_1^{(2)}\, c_1\,(t)+a_{12}\, b_2^{(2)} c_2\,(t)] \qquad (1)$$

$$X_2(t)=[\, a_{21} b_2^{(1)}\, c_2(t),\ a_{22}\ \ b_2^{(2)}\, c_2(t),\ a_{23}\, b_1^{(2)} c_1\,(t) + a_{24} b_2^{(2)} c_2\,(t)\,] \qquad (2)$$

In first and second interval each user send its own bits and also each user detect the other user second bit. In third interval user send the combination of its own bits and its partner bits and each multiplied by the spreading code. Sometimes it is possible that detection by partner is unsuccessful in such cases cooperation can be unfavorable to the eventual detection of bits at base station.

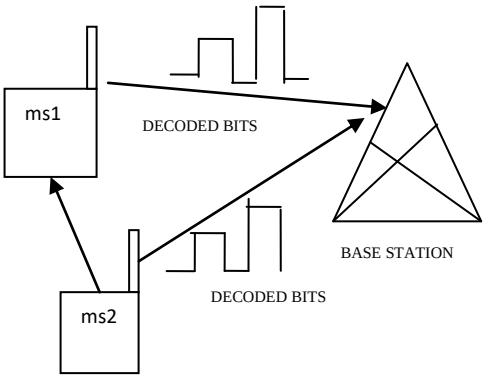

Fig 4 Detect and Forward Cooperative method

- Amplify and forward method: This is another cooperative signaling method in which user 2 receives the noisy signal from partner. This noisy signal is amplify it and send to the base station by user 2 as shown in Fig.6. After that base station combine the partner signal and user signal and make the final decision on transmitted signal [7-10]. In this scheme receiver i.e base station receives two versions of signal and makes decision on better detection of signal. Although this is the simple method of cooperative communication but in this also there is a challenge of sampling, amplifying and retransmitting analog values etc It is assumed that base station knows inter-user channel coefficients for performing the optimal decoding.
- Coded Co-operation**:** Coded cooperation is generalization of decode and amplify forward protocol. This is the co- operation communication method in which different portions of each user codeword is transmitted via two independent fading paths. In this each user transmit incremental redundancy to its partner .The key point is that coded cooperation is managed by code design and no feedback between the users.

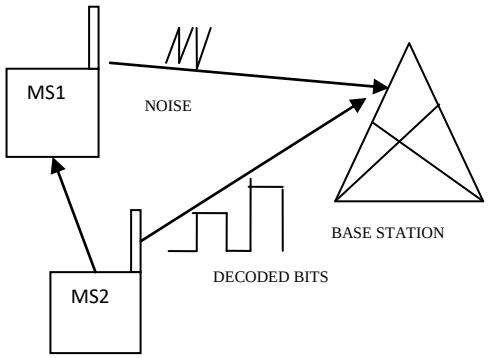

Fig 5 Amplify And Forward Cooperative Method

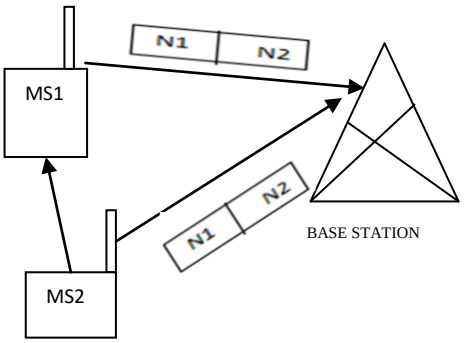

Fig 6 Coded cooperation

In this scheme source data are divided into blocks with cyclic redundancy check(CRC) code. Here user data is encoded into codeword which is portioned into two segments N_1 bits and N_2 bits respectively [11] The original codeword contain the(N_1+N_2) bits. In coded cooperation the period of transmission is divided into two time segments of bit internal N_1 and N_2 respectively and these time intervals are called frames. Each user transmit the codeword containing the N_1 bit code partition for first frame and also decode the transmission of its partner. While in second frame the user calculates and transmits the second code partition of its partner which consist N_2 code bits. So each user transmit total of N=N_1+N_2 bits over two frames. Various channel coding methods are used within coded cooperation.

 ISSN: 2454-4248
162 – 166

IV. RELAY SELECTION TECHNIQUES

Selection of relay in wireless communication is always the challenging task. Overall performance of the network can be improved by proper selection of relay. The performance can be improved in terms of higher data rate, throughput, lower power consumption and better bit error rate . The relay communication is mainly depends on the performance index like Channel State Information (CSI), Signal to Noise Ratio (SNR), Packet Error Rate (PER) etc. The relay is not to be selected by only considering the source to destination performance but it must be done by keeping the overall system performance in view. Initially the concept of relaying has been started in unidirectional and one way relay network but now a day it gained much more interest in two way relay network. The two way relay network allows the source and destination to exchange the information with the help of single or multiple relays [12]. It allows source and destination to exchange information simultaneously which further improve the bandwidth efficiency. The relay selection can be classified as follows.

(A) Relay selection criteria:

The relay selection criteria for one way relay network is simple. Here end to end SNR is maximize to obtain the optimal performance and at same time transmission rate is maximize and error rate is minimize[12]. While for two way relay network two task of communication is performed each have its own end to end SNR and BER. Relay selection criteria depend upon the overall quality of service required by network. The general relay selection problem is:

$$R= \arg \max_{R\in\{1,2,..R\}} \min \{ \Upsilon_{U1},R,\Upsilon_{U2},R\} \quad (3)$$

where $\Upsilon_{U1},\Upsilon_{U2}$ is the signal received by the end user.

(B) Single Relay Selection:

In single relay selection only one relay out of total available relays in network is chosen for the communication between two users. Relay selection helps us to improve the communication and also reduce noise. Single relay selection maximizes the system secrecy capacity. One of the advantage of single relay selection is that the adjustment of phase at selected relay is not necessary and only amplitude of channel is required at the relay. For relay selection consider two way wireless relay network as shown in Fig 8 have two end users having names u_1,u_2 and also consist of R relays[13].

Here each relay have the single antenna which can be used for both transmission and reception .The f_1,f_2,f_J,f_r are the coefficients which form the channel from user1 to relay whereas g_1,g_2,g_j,g_r are the coefficients which from the channel from relay to user 2.

RELAYS

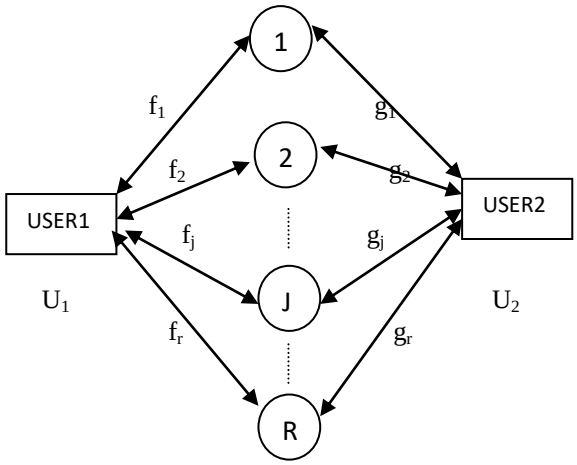

Fig 7 Two way relay network

For each user power budget is P and the information transmitted by user1 and user2 is denoted by s_1 and s_2 respectively. For two users to exchange information there is requirement of two phase protocol. In first phase user1 and user2 transmit s_1 and s_2 respectively to all relays then relay which is selected suppose here relay j is chosen receive the superposition of two signal given as:

$$y_j=\sqrt{P}\, f_j\, s_1+\sqrt{P}\, g_j\, s_2+v_j \quad (4)$$

where v_j is the noise, P is power budget, S_1,S_2=information transmitted by user1 and user 2, f_i,g_j=channels.
Then in second phase chosen relay amplify the received signal which is received during phase 1 and transmit to both the uses.Here relay knows only his channels whereas two end users knows all the channels. The signal received by user1 and user2 is given as:

$$y_{u1}= \sqrt{P}\, \alpha_j\, f_j\, g_j\, s_2 +\alpha_j\, f_j\, v_j+w_1 \quad (5)$$
$$y_{u2}= \sqrt{P}\, \alpha_j\, f_j\, g_j\, s_1 +\alpha_j\, f_j\, v_j+w_2 \quad (6)$$

where v_j is the noise at the relay,P=power budget,S_1,S_2=information transmitted by user1 and user 2,f_i,g_j=channels,w_1,w_2 =noise at both the users.

Single relay selection problem is defined as:

$$y_j = \arg \max_j \min \{ \Upsilon_{u1},\{j\},R,\Upsilon_{u2},\{j\}\} \quad (7)$$

This problem help us to find the relay and result in maximum worse SNR. At either of end user relay selection cab be performed which knows all channels. Here user find the index of relay that is" j" along with the highest worse SNR and transmit the index information to all relays.

(C) Multiple relay selection: As the name suggest in multiple relay selection more than one relay is selected to participate in communication.MRC scheme have certain advantages over the SRC such that more power efficient, faster increase in sum rate with respect to increase in relays

 ISSN: 2454-4248
162 – 166

in network etc. The MRC scheme is proposed for two way relay network with the help of relay ordering which is described in [14-17]. However it is not straight forward for two way relay network because here are two communication task with its own symbol error and end to end SNR. MRC for one way relay network have better performance than single relay selection for one way relay network. But MRC also have the disadvantage that when more than one relay is allowed to cooperate than at two end users relay signals are to be added coherently so cooperative relays adjust the phase of their transmission which require the carrier level synchronization. As shown in figure 9 there are R relays and each relay have two choices.MRC scheme consist of following steps as follows[14]:

STEP1: Calculate Y_J ={ Υ_{u1}, {j},R,$\Upsilon_{u2,}${j}}for all j= 1……R

STEP 2: Sort the Y_J in descending order to get relay ordering ($i_{1.....}i_r$)

STEP 3: for K =1:R do

STEP 4: Calculate ($Y_{u1,}\{i_{1.....}i_k\}$and $Y_{u2,}\{i_{1.....}i_k\}$

STEP 5:Find

$$k=\arg\max_{k} \min(Y_{u1,}\{i_{1.....}i_k\}\&Y_{u2,}\{i_{1.....}i_k\}$$

STEP 6: transmit a number which is between

$$\min (Y_{u1,}\{i_k\}Y_{u2,}\{.i_k\}\&\min Y_{u1,}\{i_{k+1}\}Y_{u2,}\{.i_{k+1}\}$$

These steps can be performed at any end user. After receiving the value (From step 6) each relay whose knows its own Y_J compare with the value and decide whether to co operate or not. If Y_j is greater than value than it cooperates otherwise it does not cooperate.

V. Conclusion

In this paper we discussed about Relay communication which provide the information regarding reliable transmission of data between source to destination This paper also helpful to know about the Co-operative communication which generate the virtual MIMO system. This paper also overviewed the relay selection techniques which improve the overall performance of system by better selection of relay.

VI. REFERENCES

[1] Yingbo Hua, Daniel W.Bliss, Saeed, Gazor, Yue Rong, Youngchul Sung," Theories & methods of advanced wireless relay," in IEEE Journal, vol. 30,no.8,pp 1297-1303,2012.

[2] G. Pan, E. Ekici and Q. Feng, "Performance Analysis of Multi-Branch Multi-Hop Wireless Relay Systems over Log-Normal Channels," in *IEEE Transactions on Wireless Communications*, vol. 13, no. 1, pp. 223-233, January 2014

[3] C. I. Ionita, J. Lilleberg and B. Aazhang, "Detectors for Estimate-and-Forward Wireless Relay Networks," in *IEEE Transactions on Wireless Communications*, vol. 13, no. 11, pp. 6342-6355, Nov. 2014

[4] Dohler, M. and Li, Y. (2010). *Cooperative Communications: Hardware, Channel & PHY*. Wiley Publishing, West Sussex, UK

[5] T.M Coverand A.A.E Gamel,"capacity theorem for relaychannel, "IEEE Trans. info. theory, vol.25, no.5, p.p 572-84, Sept 1979.

[6] Aria Nosratinia,"cooperative communication in wireless environment,"IEEE Communication magzine,October 2004.

[7] Sendonaries ,Y. Sun, X. Wang, H. Yu, W. Tang and Y. Zhang, "Ergodic capacity and SER performance analysis of amplify-and-forward cognitive relay networks with partial relay selection," *Personal, Indoor, and Mobile Radio Communications (PIMRC), 2015 IEEE 26th Annual International Symposium on*, Hong Kong, 2015, pp. 1775-1780

[8] M. W. Baidas, A. B. MacKenzie and R. M. Buehrer, "Network-Coded Bi-Directional Relaying for Amplify-and-Forward Cooperative Networks: A Comparative Study," in *IEEE Transactions on Wireless Communications*, vol. 12, no. 7, pp. 3238-3252, July 2013

[9] A. Kuhestani and A. Mohammadi, "Destination-based cooperative jamming in untrusted amplify-and-forward relay networks: resource allocation and performance study," in *IET Communications*, vol. 10, no. 1, pp. 17-23, 2016

[10] Juhi Garg, Priyanka Mehta and Kapil Gupta, "A Review on Cooperative Communication Protocols in Wireless World", in International Journal of Wireless & Mobile Networks, vol. 5, no. 2,pp.107-126, June 2013.

[11] C. Wang, Y. Fan, J. S. Thompson and H. V. Poor, "A comprehensive study of repetition-coded protocols in multi-user multi-relay networks," in *IEEE Transactions on Wireless Communications*, vol. 8, no. 8, pp. 4329-4339, August 2009

[12] Yindi Jing and Hmid Jafarkhani,"single and multiple relay selection schemes and their diversity orders" IEEE Transactions ,vol-8,no-3,march 2009

[13] Saman Atapattu and yindi jing and Hai Jiang and Chintha Tellambura,"relay selection schemes and perfromance analysis approximations for two way relay network" IEEE Transactions,vol.61,no3,march 2013

[14] Priyanka Mehta, Suman Rathore and Kapil Gupta, "Performance Analysis of Cooperative Communication Network with Relay Selection over Rayleigh Fading Channel", in *International Journal of Computer Applications*, Vol. 68, No.25, pp. 48-51, April 2013.

[15] J. Lee and N. Al-Dhahir, "Exploiting Sparsity for Multiple Relay Selection with Relay Gain Control in Large AF Relay Networks," in *IEEE Wireless Communications Letters*, vol. 2, no. 3, pp. 347-350, June 2013

[16] V. Pourahmadi, S. Fashandi, A. Saleh and A. K. Khandani, "Relay Placement in Wireless Networks: A Study of the Underlying Tradeoffs," in *IEEE Transactions on Wireless Communications*, vol. 10, no. 5, pp. 1383-1388, May 2011.

[17] Juhi Garg, Kapil Gupta and P. K. Ghosh, "Performance Analysis of MIMO Wireless Communications over Fading Channels - A Review", in *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, Vol. 2, Issue 4, pp. 1272-1302, April 2013.