

A Review on Cooperative Communication Protocols and Relay Selection TechniquesGreeshma Gopi¹, Snigdhamol M S²¹PG Scholar, ²Assistant Professor

Dept of ECE, Thejus Engineering College, Thrissur, Kerala

Email: ¹greeshmapulikkal@gmail.com**Abstract**

The field of high data rate is developing rapidly for the next wireless generations. Cooperative communication mechanism helps to obtain higher throughput and reliability. Cooperative communication can effectively combats the effects of path loss, shadowing and fading with the help of relays. So the selection of best relay among the multiple number of relays plays an important role in cooperative communication. The properly selected relay can achieve full diversity with low complexity and overhead. This paper provides a review on cooperative communication protocols and relay selection techniques.

Keywords: cooperative communication, relay , relay selection, MIMO, cooperative protocol, diversity, data rate, amplify and forward, decode and forward ,compress and forward

1. Introduction

The growth of multimedia services increases in future so that wireless communication field requires high data rate and reliable transmission link. Multiple input multiple output technology provides significant capacity gains over single input single output technology. The wireless communication's broadcast nature describes that a source signal transmitted towards the destination can be "overheard" at nearest nodes. The managing and retransmission of this overheard data at the nearest nodes is known as Cooperative communication.

Higher throughput and reliability can be obtained by this mechanism. With the help of relays cooperative communication effectively reduces the severity of shadowing and fading. The technique behind the cooperative communication is basically a simple three terminal relay model introduced by Van Der Meulen. Without using multiple antennas or using costly RF chains the diversity gain can be achieved through wireless communication.

The most important cooperative schemes used by relays are (1) amplify and forward (AF), (2) decode and forward (DF), (3) compress and forward (CF). In AF, the user amplifies the data received from the transmitter and forwarded to the destination. In DF, the user decodes the data received from the transmitter and re-encodes then forwarded to the destination. In CF, the user decodes the data received from the transmitter and the compressed version of the received data is forwarded to the destination. In a network topology with large number of relays, relay selection is an important technique to implementing an effective cooperative communication. The main contribution of this paper is to

- (i) Basic idea behind the cooperative communication
- (ii) Overview of different relay selection techniques

2. Cooperative Communication

The direct transmission between the source and destination in wireless communication needs high transmit power. This requires high cost which reduces the battery life. So the interference increases due to fast draining of battery. The signal received at the destination differs from the original transmitted signal due to fading that occurs in the signal when the signal is transmitted through the channel. Data throughput and link range of multiple input multiple output systems (MIMO) significantly increases with the help of diversity technique without any additional bandwidth or transmit power. In diversity techniques, the data or information transmitted over multiple paths reduces the fading. The multiple copies of the transmitted signal is combined at the receiver using any of the diversity techniques like maximal ratio combining or equal gain combining etc. But for this multiple transmitter and receiver antennas are required which increases the complexity of the system. MIMO is an important part of wireless communication due to its valuable advantages. The transmit diversity is an important feature of MIMO but it may not be applicable for all practical scenarios.

A new concept cooperative communication is introduced which is alternative to MIMO. In cooperative communication the concept is more than one user get copies of the transmitted signal and retransmit the copies to the destination. These users are known as relay nodes. Relay nodes have wide separation and it may be virtual antenna elements.

In cooperative transmission that means relayed transmission, the data or message from the source terminal follows its own transmission path. And the data from all the relays are combined at the destination. By this way the performance degradation due to signal fading is reduced. For combating fading diversity techniques are used.

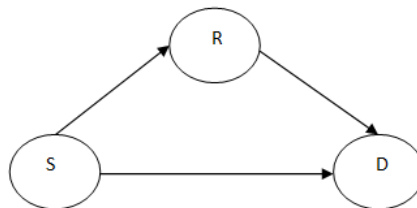


Figure 1: Cooperative communication [7]

3. Steps To Implement Cooperation

In this paper, cooperation is implemented with an assumption that each node in the wireless network has a different identification number. Then the cooperation is implemented with the following steps. They are:

- i) Neighbor Maintenance Step
- ii) Information Exchange Step
- iii) Local Distribution Step

Neighbor Maintenance Step

The total transmitting time is split into different intervals. In each interval the each node in the wireless network broadcasts a cooperative request (COR). This request is broadcasted over a control channel and will be received by all the

nearest nodes (NN) which are located in the transmitting range. Once the COR is transmitted there are two chances. One chance is that the COR received node will cooperate and other chance is that the node is also loaded with traffic and energy constraint will not cooperate. The node is ready to cooperate with requested node it will send agree on cooperation (AOC) along with its identification number. By continuing this technique all the requested nodes will get cooperative nodes. The requested nodes will store identification number of the cooperative nodes. In this way the requested nodes will maintain the neighbor set.

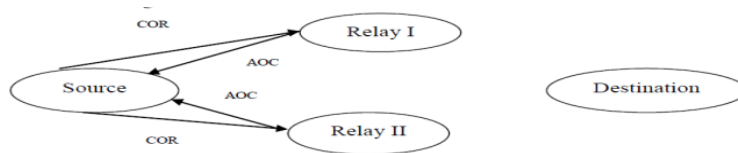


Figure 2: Neighbor Maintenance Step [1]

Information Exchange Step

The time in which the requesting nodes get an AOC then it plans to transmit the data. In cooperative network the destination may be free or deliberately engaged with its own assignment. The requesting node will send transmission request (TR) whether it is ready to receive information. If the node is ready to receive information send necessary information like CSI.

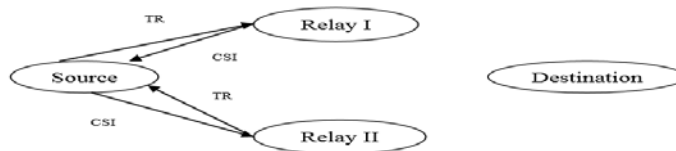


Figure 3: Information Exchange Step [1]

Local Distribution Step

After applying the above steps the node selection and data or power allocation is done. Finally the data is transmitted to each of the selected and assigned nodes. In this way the cooperation is established and achieved.

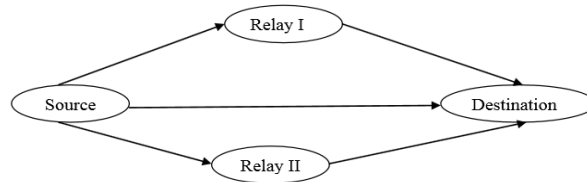


Figure 4: Local Distribution Step [1]

4. Cooperative Relaying Protocols

Avoid the interference between the two phases either in TDMA or FDMA, the cooperation technique is modeled as two orthogonal phases.

In phase I, source transmits the information to its destination at the same time information is received by the relay due to the broadcast nature of the source. This process is shown in fig below.

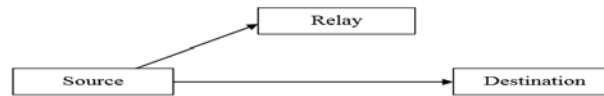


Figure 5: Phase I [8]

In phase II the relay forwards the information to the destination as shown in fig.

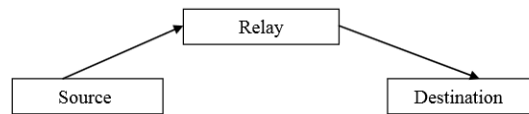


Figure 6: Phase II [8]

In cooperative communications, each user helps other users in the network. The users not only broadcast their own message but also relay the information. The scheme for relaying information to the destination is known as protocol.

Amplify and Forward

Amplify and forward protocol is the simplest protocol. The technique used in this protocol is the information received from the original transmitter is amplified and then forwarded to the destination. Lane man et al formally introduced the amplify and forward protocol based on the principle of amplifying repeaters.

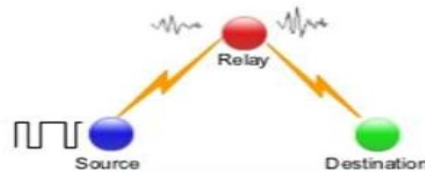


Figure 7: Amplify and Forward [5]

The source- relay (S-R) channel quality is poor; DF will introduce serious error propagation so AF is superior to DF in this condition. The cooperative AF relay can be deployed in larger area with lower secrecy rate.

Decode and Forward Protocol

In this protocol the relay decodes the message received from the original transmitter and then re-encodes and finally this message is forwarded to the destination. The signal have to be decoded at the relay before being forwarded to the destination. Therefore more processing is required in DF than AF. But the signal is correctly decoded at the relay that means there is no error the performance is more than that of AF. DF relaying is very efficient. It very much relies on the capacity of the link between source and relay.

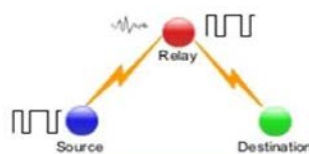


Figure 8: Decode and forward [5]

Compress and Forward Protocol

This protocol decodes the message from the transmitter and the compressed version is forwarded to the destination.

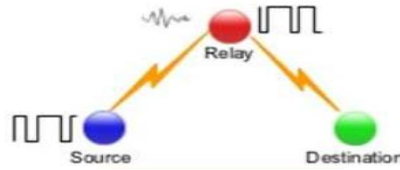


Figure 9: Compress and Forward [5]

5. Relay Selection Techniques

Selection of a relay in a cooperative communication is a challenging task. If selection of the relay is proper it can improve the performance of the network in terms of data rate, lower power consumption and higher data rate etc. The relay selection is done by not only considering the source relay performance but also considering the overall system performance. There are many types of relay selection techniques. Mainly it is classified in to:

Group Selection: Relay selection occurs before transmission. This method helps to achieve certain pre-defined performance level.

Proactive Selection: The relay selection is performed by the source, the destination, or the relay itself during the transmission time.

On-demand Selection: If the direct channel conditions decreases below a pre-defined level the relay selection is done. In this method, the relay selection is done when needed.

Cooperative Relay Selection: In this method the selection procedure require the exchange of information among the evolved nodes. It is mainly two types. They are table based relay selection and contention based relay selection. In table based relay selection method the relay is selected based on the information kept by the source node. Contention based relay selection method leads to the selection of a set of variable number of relays.

Opportunistic Relay Selection: The selection is based on the local measurements. It is classified in to measurement based relay selection, performance based relay selection and threshold based relay selection. Measurement based relay selection is based only on the local measurement of the channel conditions, no topology is required. Performance based relay selection is selecting a relay based on some criteria like energy efficiency, delay etc. Threshold based relay selection is used to reduce the overhead of the channel estimation by defining a certain threshold level.

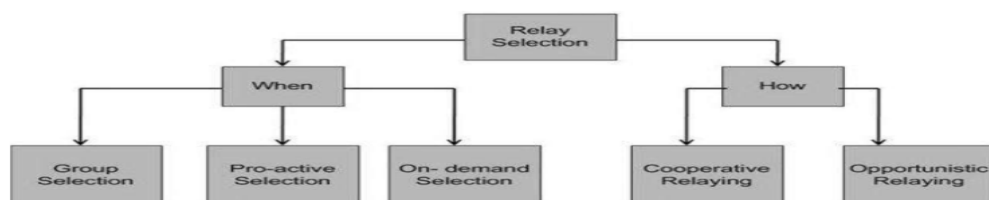


Fig 10: Classification of Relay Selection [7]

The protocols in the cooperative communication are mainly operated in three phases. They are relaying candidate selection, relay assignment and cooperative transmission.

Phase I: Relaying Candidate Selection

This phase, determines the relaying candidate in the communication link between the source and destination among the number of nodes.

i) Pre-assigned Selection Scheme

It is the simplest method for relaying candidate selection in terms of design complexity. In this method the relaying candidates are selected before the data flow connection with the help of cooperative multi-hop mesh structure construction. But this scheme cannot deal with node mobility, wireless channel variation and other network dynamics. This method is constructed fully independent from the data flow but it suffers significant communication overhead.

ii) Adaptive Selection Scheme

Communication overhead is reduced with the help of adaptive selection scheme. And this method deals with networks dynamics more than the pre-assigned selection scheme. Request to send (RTS) and clear to send (CTS) are the two signaling messages in the MAC layer. If a node act as relaying node it overhears the RTS signal from source and CTS signal from the destination. This node is a common neighboring node for both source and destination.

The relaying candidate selection scheme is integrated with the route-finding mechanism, that is, Ad Hoc On-Demand Distance Vector Routing Protocol. In the route discovery procedure, for two adjacent routers (one-hop sender and receiver), a node determines that it is a relaying candidate for the routers if it has heard both the route request signal transmitted by the sender and the route reply replied by the receiver and has not been selected by the sender as the next hop router[8].

Phase II: Relay Assignment

One of the relaying candidate is chosen from the set of selected relaying candidate based on some criteria to establish a communication link between the source and destination. The frequently used criteria for relay assignment are

i) Pre-defined and Random Relay Assignment

The simplest method for relay assignment is assigning the relay in advance or choosing relay randomly during run time. The design complexity and network overhead reduces with the help of these methods. But these schemes cannot give optimal performance in dynamic environments.

ii) Distance Based Relay Assignment

The direct method for optimal relay assignment is using distance, towards the source or the destination. In this method the optimal relay is a node that is a closest one to the destination. At the beginning of the relay selection competing procedure a back-off timer is set with its value proportional to the value of the candidate's distance to the source. Thus the node closest to the source known as candidate node will first expires its back-off timer and wins the competition. A M-CTS signal will be send by the node that wins the competition procedure to inform the source that it is ready to send and notify the other candidates to cancel their own competing procedure.

Phase III: Cooperative Transmission

In this phase the assigned relays can cooperate with the communication link between the source and destination for any

packet transmission by retransmitting the overheard signals. For the design of cooperative protocol, the overheard message from the source is retransmitted to the destination with the help of two selected relays. That means, the destination receive three copies of the signals transmitted from the source. Thereby reduce the network overhead and increase the spatial efficiency by triggering the cooperative communication if it is necessary.

A new automatic repeat request (ARQ) mechanism is introduced in the cooperative communication protocol. Signal transmitted by the source in the direct phase is successfully decoded at the destination. Then it sends back an acknowledgment (ACK) and the relay keeps idle. Otherwise it sends back a negative acknowledgment (NACK). In the latter case, a cooperative transmission will be invoked, that is the relay forwards the signal to the destination.

6. Conclusion

Field of high data rate, spectrally efficient and reliable wireless communication is known as cooperative communication. And it effectively combats the effect of shadowing, multipath fading and path loss. The relay selection plays an important role in maximizing the diversity gain achieved in wireless cooperative communication. Variety of relay selection schemes from the literature is studied.

7. References

- [1] Xuedong Liang, Min Chen, Ilanko Balasingham and Victor C.M. Leung, "Cooperative Communications with Relay Selection for Wireless Networks: Design Issues and Applications", *Wirel. Commun. Mob. Comput.* 2013; 13:745–759.
- [2] Vishal K.Shah and Anuradha P.Gharge "A Review on Relay Selection Techniques in Cooperative Communication" *"International Journal of Engineering and Innovative Technology"*, vol.2, no.5, November 2012.
- [3] P.K.Kharat and J.D.Gavade "Cooperative Communication: New Trends in Wireless Communication", *International Journal of Future Generation Communication and Networking*, vol.6, no.5, pp.157-166.
- [4] Ibrahim AS, Sadek AK, Su W, Liu KJR. "Cooperative communications with relay - selection: when to cooperate and whom to cooperate with?" *IEEE Transactions on Wireless Communications* 2008; 7(7):2814–2817.
- [5] Laneman JN, Tse DNC, Wornell GW. "Cooperative diversity in wireless networks: efficient protocols and outage behavior". *IEEE Transactions on Information Theory* 2004; 50: 3062–3080.
- [6] Xuehua Zhang, Mazen Hasna and Ali Ghayeb, "Performance Analysis of Relay Assignment Schemes for Cooperative Networks with Multiple Source Destination Pairs," in *Proc. IEEE* 2012.
- [7] Sudheer Shukla, Jaya Dipti Lal, S. V Charhate "A Review on Relay Selection Techniques in Cooperative Communication" *International Journal of Digital Application & Contemporary Research* Volume 4, Issue 9, April 2016.
- [8] Juhi Garg, Priyanka Mehta and Kapil Gupta, "A Review on Cooperative Communication Protocols in Wireless World", *International Journal of Wireless & Mobile Networks(IJWMN)* Vol.5, No.2, April 2013.
- [9] Manisha Upadhyay, D.K.Kothari "Review of Relay Selection Techniques for Cooperative Communication Systems" *"International Journal of Electronics and Communication Engineering & Technology* Volume 5, Issue 1, January (2014), pp. 16-25.
- [10] A. Sendonaris, E. Erkip, and B. Aazhang, "User cooperation diversity—part I: system description," *IEEE Trans. Commun.*, vol. 51, no. 11, pp. 1927–1938, Nov. 2003.

- [11] A. Sendonaris, E. Erkip, and B. Aazhang, "User cooperation diversity–part II: implementation aspects and performance analysis," IEEE Trans. Commun., vol. 51, no. 11, pp. 1939–1948, Nov. 2003.
- [12] R. Madan, N. B. Mehta, A. F. Molisch, J. Zhang, "Energy-Efficient Cooperative Relaying over Fading Channels with Simple Relay Selection", in Proc. IEEE Global telecommunication Conference GLOBECOM 2006.
- [13] A. Nosratinia and T. E. Hunter, "Grouping and partner selection in cooperative wireless networks," IEEE J. Sel. Areas Commun., vol. 25, no. 2, pp. 369–378, Feb. 2007.
- [14] Zhi-Yong Liu, Weihai, "Single and Multiple Relay Selection for Cooperative Communication under Frequency Selective Channels", IEEE Region 10 Conference, TENCON, pp. 1-4, October 2013.