Performance analysis of wireless network: A review

Suryakant Pathak[1], Himanshu Katiyar[2]
[1]Research Scholar, Department of Computer Science & Engineering
BBD University Lucknow
[2]Associate Professor, Department of Electronics & Communication Engineering,
BBDNIIT, Lucknow
Email : suryakant64@rediffmail.com[1], katiyarhimanshu@gmail.com[2]

Abstract
The performance of wireless network can be analyze with mainly two parameters i.e. bit/symbol error rate & outage probability. In this we use diversity combining technique in cooperative communication. Many researchers are taking interest in this area due to vast scope & need of research. Cooperative communication provides significant performance improvement in various wireless networks. A through study of various performance measure schemes in wireless network has been discussed in this paper. We will also study the different diversity combining techniques, MIMO Technology and different Cooperative Communication scheme.

Keywords: Cooperative communication, Diversity Methods, Symbol error rate.

INTRODUCTION

The field of high data rate, spectrally efficient and reliable wireless communication is currently receiving much attention by researchers. These wireless channels suffer from smaller than expected coverage and excessive amount of shadowed area due to high operating frequencies. Cooperative relaying is attractive solution which enhances coverage as well as signal quality. By using diversity combining we will get diversity gain which improves robustness against fading for same transmitted power. It also reduces radio frequency interference to neighboring nodes [1]. Performance of cooperative relaying employing infrastructure based fixed relay having multiple antennas has been investigated in [2]. A closed from expression of outage probability has been derived when the cooperating relays and destination coherently combine the received signals. The effect of number of relay antennas and relay placement on the system performance has also been studied in [3]. An overview of various cooperation scheme and issues related to their implementation has been discussed in [4],[5]. Infrastructure multi antenna cooperative relay network has been investigated in [6]. Here closed form expression of outage probability and average error rate have been derived, when the relay and destination performs selection combining of signals. Simulation studies of multi antenna relay network have been analyzed in [7]. Outage and error performance of multi-antenna relay system have been investigated with the help of simulation studies. Here relay perform generalized selection combining and destination performs MRC of signals. Simulation studies of outage and throughput of cooperative relay network have been presented in [8], where source and relay communicate with multi-antenna destination in correlated Nakagami-m fading channel. In [9], analytical expression of average received SNR, outage, BER and channel capacity has been established for the case when source and relay are communicating with multi-antenna destination in Rayleigh fading channel.

1. PREVIOUS WORK

To improve the performance of wireless channel we are using cooperative relaying which is an effective technique to combat multipath fading, improve system capability, and enhance the coverage. This section provides a literature survey on the various aspects of cooperative relaying. A basic fundamental to improve the BER and outage probability has been studied in [10]. Outage probability analysis of multiuser amplify-and-forward relay network with source to destination link has been carried in [11] & [12] the multiuser relay network that combines the cooperative diversity and multiuser diversity together to improve the performance even further. The multiuser diversity exploits the fact that when different users undergo independent varying channels, at any time, there must be a user who has the strongest channel gain. By allowing this user to transmit, the resources of the system can be utilized in a most efficient manner and the total throughput can be maximized. Outage Probability Analysis and Power Allocation for Two-Way Relay Networks with User Selection and Outdated Channel State Information has been carried out in [13] where author optimize the power allocation among network nodes by minimizing the asymptotic outage probability. Outage performance of decode & forward and amplify & forward relaying with direction antennas has been analyzed in [14]. The group outage performance & power allocation for cooperative multicast system has been analyzed in [15]. Outage analysis of multi hop full duplex relaying has been carried out in [16]. The exact outage probability and the symbol error rate (SER) of cognitive transmission over Rayleigh fading channels has been studied in [17]. The outage performance of decode-and-forward based cooperative multicast systems with the best relay selection (CM-RS) over Rayleigh fading channels has been analyzed in [18]. The Outage Performance of Full-Duplex Selective Decode-and-Forward Relaying has been carried out in [19] where a three terminal full-duplex relay channel that adopts a selective decode-and-forward protocol, taking relay self-interference and exploited the cooperative diversity offered by the independently fading source/relay message replicas that arrive at the destination. The outage performance of cognitive relay networks with multiple primary users in imperfect channel state information environment has been studied in [20] & [21]. The performance of optimum combining (OC) used in a decode-and-forward relay network over Nakagami-m fading channels in the presence of co-channel interference at the relay nodes and at the destination is analyzed in[22],[23]. The outage probability of a dual-hop Nth-best decode-and-forward multicast relay network in which the relay and destination undergo multiple co-channel interferences (CCIs) has been analyzed in [24].The dependence of the performance of cooperative systems with single relay selection in equally correlated environments has been studied in [25]. The outage probability analysis of multiple relay networks with an arbitrary number of supplementary non-broadcast links has been studied in [26]. Symbol error probability (SEP) of a two-way amplify-and-forward (AF) relaying system are investigated in [27]. Asymptotic symbol error rate is derived for multi branch Pre-detection equal gain combining over generalized correlated Nakagami-m fading channels has been studied in [28]. The average bit error probability of dual-hop amplify-and-forward relaying systems operating in the presence of both fast fading and shadowing is derived in [29]. The bit error probability (BEP) analysis for this cooperative system has been simulated in [30] A theoretical analysis of bit error rate (BER) expression of adaptive M-ary quadrature amplitude modulation (MQAM) for multiple-input multiple-output (MIMO) Y channels has been carried out in [31]. The average bit error probability of binary coherent signaling over flat fading channels has been derived in [32]. The bit error rate (BER) performance of the SSC system over independent and no identically distributed (i.ni.d.) Nakagami-m fading channels has been derived in [33] The bit error rate (BER) of the differential decode-and-forward (DF) free space optical (FSO) cooperative system in terms of power series has been derived in [34]. The bit error rate (BER) analysis for both orthogonal frequency-division multiple access (OFDMA) and zero-forcing (ZF) interleaved single-carrier frequency-division multiple access (SC-FDMA) systems over Nakagami-m frequency-selective fading channels with arbitrary m. has been carried out in [35]

3. DIVERSITY COMBINING TECHNIQUES

With diversity technique multiple copies of the same signal is received on different branches, which undergo independent fading. If one branch undergoes a deep fade, the another branch may have strong signal. Thus having more than one path to select the SNR at receiver may be improved by selecting appropriate combining technique. Following diversity combining methods are available.

A. Selection Combining (SC): Selection combining is based on the principle of selecting the best signal among all the signals received from different branches at the receiving end. In this method, the receiver monitors the SNR of the incoming signal using switch logic.

B. Switch and stay combining (SSC): Switch and stay combining is simplified form of selection combining. In this scheme, the receiver selects another branch only if SNR of the current branch falls below the required threshold.

C. Maximal Ratio Combining (MRC): This is the most complex scheme in which all branches are optimally combined at the receiver. MRC requires scaling and cophasing of individual branch. In this all the signals of M branches are weighted according to their individual signal voltage to noise power ratios and then summed. Thus MRC produces an output SNR, which is equal to the sum of the individual SNRs. The advantage of MRC is producing an output with an acceptable SNR even when none of the individual signals are themselves acceptable. Best statistical reduction of fading is achieved by this method.

D. Generalized Selection Combining (GSC): The maximal ratio combining is considered optimum combiner because achieved SNR is sum of the SNR's of each individual diversity branch. The conventional selection combining (CSC) selects the signal from that diversity branch with the largest instantaneous SNR. In GSC m number of large signals are chosen from L total diversity branches, and then they are coherently combined.

E. Equal-Gain Combining (EGC): *M*RC requires knowledge of the time-varying SNR on each branch, which can be very difficult to measure. A simpler technique is equal-gain combining, which co-phases the signals on each branch and then combines them with equal weighting,

4. MIMO

More recently multiple input/multiple output (or MIMO) techniques have been applied that place multiple antennas at the transmitter and receiver to improve wireless system capacity and performance. The basic idea behind MIMO is to exploit the space resource of the propagation channel and combine it with sophisticated signal processing to achieve significant gains in spectral efficiency. A MIMO demonstration by Lucent Technologies with 8 transmit and 12 receive antennas achieved a 1.2-Mb/s data rate in 30 kHz of bandwidth. A conventional radio link is single input/single output (SISO) and is subject to fading. A single input/multiple output (SIMO) channel offers diversity options at the receiver, such as space diversity, with multiple antennas. A multiple input/single output (MISO) channel offers diversity options at the transmitter, such as pattern or angle diversity. For example, a transmit phased array antenna can steer the main beam toward a particular receiver. Also beamforming techniques can be employed at the transmitter to generate multiple beams. Finally, for improved data rates a MIMO channel allows multiple data streams to be transmitted and recombined at multiple receive antennas. The system capacity improvement for a MIMO system is linearly proportional to the number of antennas. However, in a MIMO system, many handheld receivers do not have multiple antennas. In such cases, maximum gain is achieved through transmit diversity by transmitting the same signal on multiple antennas. The premise is that one of the propagation channels to the receiver will likely have less fading (or none at all) compared to the other channels. When the receiver does have multiple antennas (true MIMO), maximum capacity is achieved through parallel transmission of different data streams. A good analogy for true MIMO is parallel computing where different portions of a large numerical simulation are sent to different processors, achieving much higher compute performance than a single processor. A current area of research in wireless communications is multiple-user MIMO (MU-MIMO) where the basic MIMO concept is extended to multiple receivers, each with multiple antennas.

5. COOPERATIVE COMMUNICATION

A. COOPERATIVE RELAYING

The use of multiple antennas to achieve diversity in cellular communication is difficult due to size constraints at mobile station. It is because; antenna spacing of half the carrier wavelength is required to ensure uncorrelated signals. Although multi-antenna system improves diversity gain of wireless network, but is not suitable for small wireless nodes due to limited hardware and signal processing capability. The need of high-data-rate, spectrally efficient and reliable wireless communication can be met by cooperative communication. The diversity can be achieved through user cooperation, when mobile users share their physical resources to create a virtual array, which eliminates the necessity of multiple-antenna on wireless terminal.

In cooperative communication fig.1, the signal is transmitted as broadcast through relaying by intermediate relay terminals in between source and destination.

1. **Amplify and forward**: If the relay receives the signal, amplifies it and then transmits in next phase, it is called *amplify and forward* (AF) mode of relaying. AF requires very less processing by the relays which makes them fast in terms of delay, hence suitable for delay sensitive signal such as voice or live video. Noise amplification also occurs along with signal, which is a serious issue in AF operation.

2. Decode and forward (DF): is a digital and regenerative scheme, where relay receives the signal, decode it and after encoding retransmit it in the next time slot. Noise does not propagate, processing time in higher causing delay; hence DF is not suitable for delay sensitive signals.

3. Decoded and re-encode (DR) : In this scheme where code used at relay for encoding the message is different than that used at source. Thus destination receives two copies of the same message encoded with different codes.

The adaptive cooperation relay system improves performance by eliminating noise/error propagation. This system adapts their transmission format according to channel condition between source and relay. The relay nodes process the signal received from the source if received SNR at relay is more than threshold; else the relay remains the silent. When relay remains silent, the source may retransmit the signal to destination or can choose more powerful code to mitigate fading. In recent past *coded cooperative communication* has become a fertile area to research among researchers because of its efficiency and robustness. Several signal can be simultaneously received in the same time-slot, thus improving the spectrum efficiency of the system.

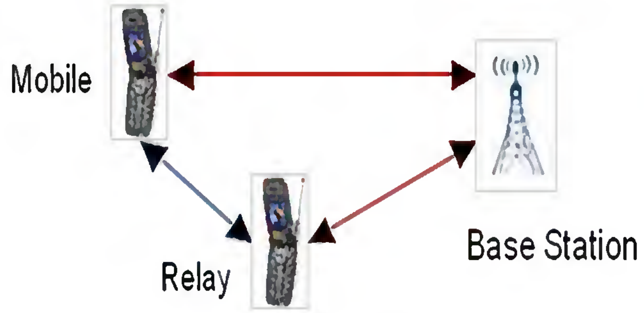

Fig.1. Cooperative Communication

B. RELAY TRANSMISSION TOPOLOGY:

I. **Serial relay transmission**: In serial relay signal propagates from one relay to another relay hence may face multi-path fading.

II. **Parallel relay transmission.** In Parallel relay transmission overcomes the problem by propagating the signal through multiple relay paths in same hop and destination combines the signal by the combining technique.

APPLICATIONS

This section highlights some of the area where we can improve the network performance using cooperative relaying.

1. Cooperative sensing for cognitive radio: In cognitive radio system, unlicensed users can use the resources which are licensed for primary users. When primary users want to use their licensed resources, secondary users have to vacant these resources. Hence secondary users have to constantly sense the channel for detecting the presence of primary user. It is very challenging to sense the activity of spatially distributed primary users in wireless channel. Spatially distributed nodes can improve the channel sensing reliability by sharing the information and reduce the probability of false alarming.
2. Virtual antenna array: The field of high data rate, spectrally efficient and reliable wireless communication is currently receiving much attention. The use of MIMO antenna improves the diversity gain of wireless system. However multi antenna technique is not attractive for tiny wireless nodes due to limited hardware and signal processing capability. Diversity can be

achieved through user cooperation, whereby mobile users share their physical resources to create virtual array, which removes the burden of multiple antennas on wireless terminals.

3. Wireless sensor network: Cooperative relaying can be used to reduce the energy consumption in sensor nodes. Hence lifetime of sensor network can be increased. Due to nature of wireless medium, communication through weaker channels requires huge energy as compared to relatively stronger channels. Careful incorporation of relay nodes which corporate with each other into routing process can select better communication links and precious battery power can be saved.

TRACKS FOR FUTURE WORK

This paper has investigated the performance of wireless network using diversity combining techniques in cooperative environments. For practical implementation of such schemes in a network environment, it is necessary to investigate several other issues, some of which briefly outlined below.

- System modeling taking inference into consideration: In network scenario, cooperative relay system can suffer from co-channel and adjacent channel interference. Hence, the effect of interference needs to be addressed in future.
- Power optimization based on linked condition: wireless nodes generally have limited battery power. If relay based systems have some feedback mechanism, then power can be allocated based on link condition. Such dynamic allocation of power may save battery power or boost the data transfer rate and hence an important area to be investigated.
- Full duplex operation of relays: Relay operation in half-duplex mode creates system bandwidth expansion. Full –duplex relay operating in single frequency can solve this problem. Hence further investigation is necessary for full duplex relay operation.
- Multi-hop communication: The research community has increased its attention towards wireless multi-hop communication due to its envisioned application of Ad-Hoc networks, sensor network, and range –extension of cellular networks.
- Complexity performance trade-off: Relays can process the signal in no-regenerative or regenerative mode depending on there functionality. Non-regenerative type simply amplifies and forwards the signal, while in regenerative, the relay decodes, encodes, and forwards the received signal. Despite of noise propagation, amplify and forward (AF) mode of operation puts lets processing burden on the relay and hence is often preferred when complexity and /or latency issues are important. Adaptive protocol with DF scheme have a drawback that relay remains silent if received SNR at relay is poor; hence, relay remains silent and diversity order of system reduces. Relay operates in DF mode if received SNR at relay is above the particular threshold and switched to AF mode if it is below the particular value may solve the problem; so, extension in this way may be interesting.

CONCLUSION

As stated above, the field of high-data-rate, spectral efficient and reliable wireless communication, is currently receiving much attention. Cooperative transmission is emerging as an effective technique for combating the effect of path loss shadowing and multi-path fading. Cooperative relaying provides diversity gain, reduces outage, and improves BER performance. Various types of relays, mode of operations, applications, and tracks for future work have been discussed here. This paper will be helpful for incorporating the relay based system in real scenario.

REFERENCES

1. H.Katiyar, and R. Bhattacharjee. Power allocation strategies for non-regenerative relay network in Nakagami-m fading channels. IETE Journal of Research, 55(5), 205-211, 2009.
2. H.Katiyar, and R. Bhattacharjee. Performance of two-hop regenerative relay network under correlated Nakagami-m fading at multi-antenna relay" IEEE Communication Letters, 13(11), 820-22, 2009.
3. H.Katiyar, and R. Bhattacharjee. Outage performance of multi-antenna relay cooperation in the absence of direct link. IEEE Communication Letters. 15(4), 398-400, 2011.

4. H. Katiyar, B.S. Paul and R. Bhattacharjee. User Cooperation in TDMA wireless System. IETE Technical Review Journal, 25(5): 270-276, 2008.
5. H. Katiyar, A Rastogi and R. Agrawal. Cooperative communication: A review. IETE Technical Review Journal. 28(5):409-417, 2011.
6. H. Katiyar, and R. Bhattacharjee. Performance of two-hop infrastructure based multi-antenna regenerative relaying in Rayleigh fading channel. Physical Communication (Elsevier), 4(3):190-195, 2011.
7. H. Katiyar, R. Bhattacharjee, and Sandarshi. Outage performance of switch and stay combining scheme for multi-antenna relay network. In Proc, of UKIWCWS 2010, IIT Delhi, India.
8. H. Katiyar and R. Bhattacharjee. Performance of regenerative relaying at uplink of multi-antenna access point in Nakagami-m fading. In Proc, of NCC 2009. IIT Guwahati, 165-169, 16-18, 2009.
9. H. Katiyar and R. Bhattacharjee. On the Performance of decode-and-forward relaying with multi-antenna destination. AEU (Elsevier)- International Journal of Electronics and Communications, 66:1-6, 2012.
10. Rappaport T.S., Wireless Communications, 2nd ed., Prentice Hall, 2002.
11. Xiaoyi Liu, Xin Zhang, and Dacheng Yang, Outage Probability Analysis of Multiuser Amplify-and-Forward Relay Network with the Source-to-Destination Links. IEEE Communication Letters, 15(2), 2011.
12. H. Ding, J. Ge, D.B. da Costa, Y. Guo, Outage Analysis for Multiuser Two-Way Relaying in Mixed Rayleigh and Rician Fading". IEEE Communication Letters, 15(4), 2011.
13. L. Fan, X. Lei, P. Fan, R.Q. Hu, Outage probability analysis and power allocation for two-way relay networks with user selection and outdated channel state information. IEEE Commun. Lett. 16(5), 2012.
14. Zhiwei Lin, Xiaoming Peng, Francois Chin, and Wenquan Feng, Outage Performance of Relaying with Directional Antennas in the Presence of Co-Channel Interferences at Relays". IEEE Wireless Communications Letters, 1(4), 2012.
15. Dong Li, Outage Probability and Power Allocation for Cooperative Multicast Systems, IEEE Communication Letters, 16(7), 2012.
16. Tarun Kr. Baranwal, Diomidis S. Michalopoulos, and Robert Schober, "Outage Analysis of Multihop Full Duplex Relaying. IEEE Communication Letters, 17(1), 2013.
17. Huogen Yu, Wanbin Tang, and Shaoqian Li, Outage Probability and SER of Amplify-and-Forward Cognitive Relay Networks. IEEE Wireless Communications Letters, 2(2), 2013.
18. In-Ho Lee, Howon Lee and Hyun-Ho Choi, Exact Outage Probability of Relay Selection in Decode-and-Forward Based Cooperative Multicast Systems, IEEE Communication Letters, 17(3), 2013.
19. Mohammad Khafagy, Amr Ismail, Mohamed-Slim Alouini, and Sonia A¨ıssa, On the Outage Performance of Full-Duplex Selective Decode-and-Forward Relaying". IEEE Communication Letters, 17(6), 2013.
20. Qihui Wu, Zongsheng Zhang, and Jinlong Wang, Outage Analysis of Cognitive Relay Networks with Relay Selection under Imperfect CSI Environment. IEEE Communication Letters, 17(7), 2013.
21. Xinrong Guan, Weiwei Yang, and Yueming Cai, Outage Performance of Statistical CSI Assisted Cognitive Relay with Interference from Primary User. IEEE Communication Letters, 17(7), 2013.
22. Navod Suraweera, and Norman C. Beaulieu, Outage Probability of Decode-and-Forward Relaying with Optimum Combining in the Presence of Co-Channel Interference and Nakagami Fading. IEEE Wireless Communications Letters, 2(5), 2013.
23. HaiYan Huang, Zan Li, JiangBo Si, and Rui Gao, Outage Analysis of Underlay Cognitive Multiple Relays Networks with a Direct Link". IEEE Communication Letters, 17(8), 2013.

24. Ping Yang, Qi Zhang, and Jiayin Qin, Exact Outage Probability of Nth-Best Multicast Relay Networks with Co-Channel Interference" IEEE Wireless Communications Letters, 2(6), 2013.
25. Binh V. Nguyen, Richard O. Afolabi, and Kiseon Kim, Dependence of Outage Probability of Cooperative Systems with Single Relay Selection on Channel Correlation. IEEE Communication Letters, 17(11), 2013.
26. Daryl Reynolds, Wentian Zhou, and Ricky Hussman," Outage Probability for Multiple Relay Networks with Supplementary Non-Broadcast Links". IEEE Communication Letters, 17(11), 2013.
27. Hui Guo, Jiantua Ge and Haiyang Ding. Symbol Error Probability of Two-Way Amplify and Forward Relaying" IEEE Communication Letters, 15(1), 2011.
28. Dharmendra Dixit and P.R. Sahu, Symbol Error Rate of Rectangular QAM with Best-Relay Selection in Cooperative Systems over Rayleigh Fading Channels. IEEE Communication Letters, 16(4), 2012.
29. Kostas P. Peppas, "A New Formula for the Average Bit Error Probability of Dual-Hop Amplify-and-Forward Relaying Systems over Generalized Shadowed Fading Channels". IEEE Wireless Communication Letters, 1(2), 2012.
30. Tao Lu, Jianhua Ge, Ye Yang, and Yang Gao, BEP Analysis for DF Cooperative Systems Combined with Signal Space Diversity". IEEE Communication Letters, 16(4), 2012.
31. Keov Kolyan Teav, Zhendong Zhou, and Branka Vucetic, On the Asymptotic Bit Error Probability of M-QAM for MIMO Y Channels. IEEE Communication Letters, 16(5), 2012.
32. Hamza Soury, Ferkan Yilmaz, and Mohamed-Slim Alouini, Average Bit Error Probability of Binary Coherent Signaling over Generalized Fading Channels Subject to Additive Generalized Gaussian Noise. IEEE Communication Letters, 16(6), 2012.
33. Tao Lu, Jianhua Ge, Ye Yang, and Yang Gao, "On Bit Error Performance of Full-Rate Signal Space Cooperative Communication over Nakagami-*m* Fading Channels, IEEE Communication Letters, 16(8), 2012.
34. Manav R. Bhatnagar, "Average BER Analysis of Differential Modulation in DF Cooperative Communication System over Gamma-Gamma Fading FSO Links". IEEE Communication Letters, 16(8), 2012.
35. Miaowen Wen, Xiang Cheng, Xuefeng Yin, Liuqing Yang, and Bingli Jiao, "A General Framework for BER Analysis of OFDMA and Zero-Forcing Interleaved SC-FDMA over Nakagami-m Fading Channels with Arbitrary m". IEEE Wireless Communications Letters, 2(4), 20.