Chorography Control In Ad Hoc Networks With Cooperative Communications

P. Kiran Kumar[#1], M. Raghavendra Rao[*2]

[#1]pursuing M.TECH (CSE) from Holy Mary Institute of Technology and Science, Keesara, Hyderabad Affiliated to JNTU, Hyderabad, Andhra Pradesh, India

[2]working as Asst Professor in Holy Mary Institute of Technology and Science, Keesara, Hyderabad Affiliated to JNTU, Hyderabad, Andhra Pradesh, India

***Abstract*— In this paper, we address the Topology control with Cooperative Communication (TCC) problem in ad hoc wireless network systems. Cooperative communication is a peculiar model introduced recently that allows combining partial messages to decode a full message. The goal of the TCC problem is to gain a strongly-connected topology with minimum total energy consumption. We show TCC problem is NP-complete and design two distributed and localized algorithms to be used by the nodes to set up their communication distance ranges. These two algorithms can be applied on any balanced, strongly-connected topology to minimize total power usage. First algorithm uses a decision distribute process at each node that makes use of only 2-hop neighbor information. The second algorithm sets up the transmission ranges of nodes recursively, over a max of six steps, using only 1-hop neighborhood information. We made a graph for the performance of our approaches through extensive simulation.**

***Keywords*— Topology control, network capacity, cooperative communications, mobile ad hoc networks**

I. INTRODUCTION

The demand for speed in wireless networks is continuously developing. Newly, cooperative wireless communication has gained outstanding interests as an untouched means for increasing the performance of information exchange operating over the ever-challenging wireless networks. Cooperative communication has appeared as a new direction of diversity to imitate the strategies designed for multiple antenna networks, Due to a wireless mobile device may not be capable of support multiple transmit antennas because of size, cost, or hardware restrictions. By exposing the broadcast behavior of the wireless channel, cooperative communication allows other single-antenna radios to share their antennas to create a virtual antenna network, and provides significant performance enhancements.

Although some previous works have been done on cooperative communications, most of the existing works are exposed on link-level physical layer issues, like interruption probability and capacity. Therefore, the impacts of cooperative communications on network-level upper layer issues, like topology control, routing and network capacity, are ignored. Certainly, most of current works on wireless networks tried to create, adapt, and manage a network on a point of point-to-point non cooperative wireless systems. Such construction can be seen as complicated networks of simple systems. However, recent advancements in cooperative communications will offer a number of advantages in flexibility over formal techniques. Cooperation mitigates certain networking problems, like collision resolution, routing, and allows for simple networks of more complicated links, instead of complicated networks of simple links. Therefore, many upper layer conditions of cooperative communications helpful further research, for example, the effects on topology control and network capacity, mainly in mobile ad hoc networks (MANETs), which can create a dynamic network without a fixed infrastructure. A node in MANETs can act like as a network router for routing packets from the other nodes and as a network host for transmitting and receiving data. MANETs are mainly useful in a reliable fixed or mobile infrastructure is not found. Quick conferences between notebook PC users, emergency operations, military applications, and other secure and sensitive operations are important applications of MANETs because of their quick and easy deployment.

The demand for new-generation wireless networks has spurred a vibrant flurry of research on cooperative communications during the last years. Still, many conditions of cooperative communications are open problems. Moreover, most of the cooperative systems proposed till now are based on ideal assumptions, like unworkable synchronization constraints between the relay nodes or the availability of perfect channel state information at the resource allocation channel. There is a need of research on constructive ways of realizing cooperative schemes based on realistic expectations. The objective of this special issue is to contribute to this twofold objective: to advance in the understanding of cooperative transmission and to explore practical limitations of realistic cooperative systems.

Due to the lack of unified control, MANETs nodes cooperate with each other to achieve a common goal. The major activities involved in self-organization are adjacent discovery, topology organization. Network topology explains the connectivity information of the complete network, as well as the nodes in the network and the connections among them. Topology control is important for the overall performance of a MANET. For eg, to keep reliable network connectivity, antennas in MANETs may work at the maximum radio power which results in high nodal degree and long link distance, but much disturbance is introduced into the network and much less throughput per node can be derived. By topology control, a node carefully selects a set of its neighbors to establish logical data links and accordingly dynamically adjust its transmit power, so as to reach high throughput in the network while keeping the energy consumption is low. In this paper, keeping in mind both upper layer network capacity and physical layer cooperative communications, we examine the topology control problems in MANETs with cooperative communications. We propose a Capacity-Optimized Cooperative (COCO) topology control scheme to improve the network capacity in MANETs by jointly optimizing transmission mode, relay node selection process, and interference control in MANETs with cooperative communications. From the simulations, we can show that physical layer cooperative communications have significant impacts on the network capacity, and the suggested topology control scheme can substantially improve the network capacity in MANETs with cooperative communications. The remainder of the article is structured as follows. We introduce cooperative communications and the topology control problems in MANET. the proposed COCO topology control scheme and Network capacity are given. We present the simulation results and discussions. Finally, we conclude this study.

II. RELATED WORK

The first four articles of this special issue focus on the first objective. They analyze and, parallel, optimize the performance of cooperative protocols. Cooperative diversity is guessed to provide significant improvement in terms of interruption probability in systems affected by slow fading and shadowing. Still, the analysis of relay-assisted systems affected by lognormal fading has not received more attention. In first article of this special aspect J. Kanellopoulos, A. Panagopoulos and V. Sakarellos analyze the effects of correlated lognormal fading in regenerative relay-assisted networks assuming maximum ratio combining (MRC) or selection combining (SC) at the destination. An exact analytical expression of the interruption probability has been provided for both orthogonal relay schemes based on time or frequency division multiple-access protocols and non orthogonal schemes supported by full-duplex relays and directive antennas at the sources. The analysis finds out the similar impact that the fading correlation has on the system performance. Moreover, the condition of the source-relay link is shown to be a critical factor in the performance of all the treated systems. Especially, the variance of the lognormal fading link source-relay has to be smaller than the variance of the source-destination link.

The second article is coauthored by J. Louveaux, L. Vanderdorpe, A. Zaidi , O. Oguz and considers a decode and-forward relay setup with OFDM modulation at the source and the relay. The article acknowledges a relaying protocol according to which the relay adaptively forwards detected data from the source. For every relayed antenna, the destination implements maximum ratio combining between the signal received from the source and the signal received from the relay. The authors examine power allocation schemes for 2 EURASIP Journal on Wireless Communications and Networking this protocol, these two under an individual and a sum-power constraint assuming perfect channel state information.

In the third article, ¨ O.Oruz and U. Ayg¨ol¨u delve into the appropriate coding schemes for a two-user cooperative communications. They explained the use of coordinate interleaved trellis codes over QPSK and 8PSK modulations exploiting both cooperative and modulation diversities over Rayleigh communication channels. Using maximum bounds on the pair-wise error changeability, the authors explained coding design criteria related to the cooperation, diversity order feasibility and coding advantage. New cooperative framework codes are obtained by exhaustive computer search. Using number evaluation, those codes are shown to outperform some reference space time codes used in cooperation with coordinate interleaving. The issue continues with a contribution by R. Vaze and R. W. Heath Jr. on the diversity-multiplexing tradeoffs for multi-antenna, multi-relay channels. The author begins by considering a multi hop relay channel and investigates an end-to-end antenna selection criterion. The idea is to look at the selection of a subset of antennas for each relay, and find the route that enlarge the mutual information among all possible routes. A confining protocol for the two-hop relay channel, along with the direct link, is treated. In both scenarios, the goal is to design protocols to touch all points of the optimal diversity multiplexing tradeoff region. Cooperative communications are reasonably well understood from the theoretical aspect. However, experimental realizations of cooperative communication systems are still quite limited. Hence, the last three articles in this special issue are devoted to implementation aspects related to cooperative communication systems. In the first one, P. Zetterberg, C. Mavrokefalidis, A. Lalos, and E. Matigak is provide an experimental evaluation of different cooperative communication protocols from the physical-layer aspect. The presented results were gained from a real-time test bed consisting of four nodes and implementation, amplify-and-forward, decode-and-forward and distributed space-time coding techniques. The writers detailed the practical evolutional requirements and constraints of the cooperative techniques under calculation, and they afford an accurate assessment of the performance loss associated with the implementation of each technique. The experimental results are going to be very useful in order to select appropriate cooperative techniques for practical realizations of cooperative communications in future wireless communication networks. In the second article, devoted to implementation aspects of cooperative communications, P. Murphy, B. Aazhang , and A. Sabharwal present the results of over-the-air experiments for an amplify-and-forward cooperative system based on orthogonal frequency division multiplexing. This system adopts a distributed implementation of an Alamouti code and discusses several interesting implementation problems. Experimental evolutions show gains in the order of 5 dB to maintain similar error rates. Remarkably, the authors show that a significant number of components used in conventional non cooperative channels need not be altered to allow implementation of cooperative OFDM.

Finally, the last article in this special issue takes an experimental approach to develop an understanding of cooperative communications at theMAC layer. In this article, T.Karakis, Z. Tao, S. R. Singh, P. Liu, and S. S. Panwar present two different implementations in order to demonstrate the practical viability of realizing cooperative communications in a real environment. Their article describes the technical challenges encountered in the implementation of these approaches, and the rationale behind the corresponding solutions that were proposed. It is explained, in experimental evolutions, that cooperative communications are very promising techniques in order to boost the performance of practical wireless network. Given the vast amount of research in cooperative wireless communications, this special concern can be no more than a sample of recent progress

III. PROPOSED METHODOLOGY

Cooperative communication typically refers to a system where users share and coordinate their resources to enhance the information transmission nature. It's a generalization of the relay transmission, in which multiple sources act as relays for every other. Previous study of relaying problems shows in the information theory community to enhance communication between the source and destination. Recently various interests in cooperative communications are due to the increased understanding of the benefits of multiple antenna systems. And also multi-input multi-output (MIMO) systems have been widely approved, it is complicated for some wireless mobile devices to support multiple antennas due to the size and cost aspects. New studies propose that cooperative communications allow single-antenna devices to work together to exploit the spatial diversity and reap the benefits of MIMO systems such as resistance to fading, low transmitted power, high throughput, and strong networks.

In a simple cooperative wireless network model with two hops, there are sources and destination, and several relay nodes. The basic idea of cooperative relaying is that some nodes, which discovered the information broadcast from the source node, deliver it to the receiver node instead of treating it as obstruction. By reason of the destination node receives multiple independently faded copies of the transmitted information from the source node and relay nodes, cooperative diversity is accomplished. Relaying could be completed using two common strategies,

i. Amplify-and-forward
ii. Decode-and-forward

In amplify-and-forward, the relay nodes simply boost the energy of the signal received from the sender and retransmit it to the receiver. In second strategy, the relay nodes will perform physical-layer decoding and then forward the decoding result to the receivers. If multiple nodes are found for cooperation, their antennas should use a space-time code in transmitting the relay signals. It is cleared that cooperation at the physical layer can achieve full levels of diversity similar to a MIMO system, and can reduce the obstruction and increase the connectivity of wireless networks. Most existing works about cooperative communications are focused on physical layer issues, like decreasing interruption probability and increasing interruption capacity, which are only link wide parameters. However, from the network's perspective, it might not be acceptable for the overall network performance, such as the whole network capacity. Hence, many upper layer network wide metrics should be carefully studied, e.g., the impacts on network structure and topology control. Cooperation offers a number of advantages in flexibility over traditional wireless networks that go beyond simply providing a more reliable physical layer. As cooperation is actually a network problem solution, the formal link abstraction used for networking design may not be valid or relevant. From the aspect of a network, cooperation can benefit not only the physical layer, but also the whole network in many different ways. With physical layer cooperative communications,

There are three transmission types in MANETs:

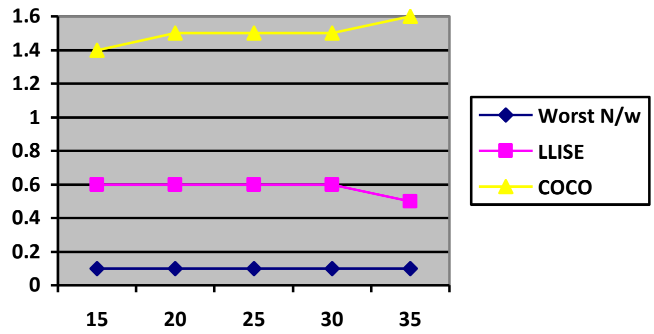
A. Direct transmissions,
B. Multi hop transmissions
C. Co-operative transmissions.

Direct transmissions and multi-hop transmissions can be regarded as special types of cooperative transmissions. A direct communication uses no relays while a multi-hop transmission does not combine signals at the receiver. The cooperative channel is a virtual multiple-input single-output (MISO) channel, where spatially allocated nodes are integrated to form a virtual antenna to emulate multi-antenna transceivers.

As a key indicator for the information delivery capacity, network capacity has gained tremendous interests since the landmark paper by Gupta & Kumar. There are various definitions for network capacity. Two types of them are introduced; first is transport capacity, which is related to the total one-hop capacity in the network. It considers the distance and is based on the sum of bit-meter products. One bit-meter means, one bit has been transported to a distance of one meter toward its destination. Second capacity is throughput capacity; it is depended on the information capacity of a channel. Certainly, it is the total amount of the data successfully transmitted in a unit time. It has been given that the capacity in wireless ad hoc networks is limited. In traditional MANETs without cooperative communications, the capacity will decreased as the number of nodes in the network increases. Similarly, the per-node throughput declines to zero when the number of nodes approaches to infinity [9]. In this study, we adopt the second type of definition. The expected network capacity is determined by various factors: wireless channel data rate in the physical layer, space reuse arrange and interference in the link layer, topology control presented earlier, traffic balance in routing, traffic arrangements, etc. In the physical layer, channel data rate is one of the main aspects. Theoretical perspective, channel capacity is derived using Shannon's capacity formula. In practical, data rate of wireless channel is jointly determined by the modulation, transmission fading, channel coding, power, etc. Additionally, outage capacity is usually used in practice to represent the link capacity, which is supported by a small outage probability. In the link layer, the spatial reuse is the major ingredient that affects network capacity. A link conflict, which refers to the affected nodes during the transmission, also has a important effect on network capacity. A High conflict may reduce simultaneous transmissions in the network, thus reduce the network capacity, and inversely. The MAC function should avoid collision with existing transmission. MAC uses a temporal and spatial scheduling so that simultaneous transmissions do not interfere with each other. Nodes within the transmission range of the sender must keep silent to avoid destroying ongoing transmissions. And additionally, there are some factors that prevent the channel capacity from being fully utilized, such as hidden and exposed terminals, which need to be solved using handshake protocols or a dedicated control channel in wireless networks.

IV. Experimental Evolutions

In this section, the performance of the proposed scheme is illustrated using computer simulations. We consider a MANET with 30 nodes randomly deployed in a 800 × 800 m2 area. The numbers of nodes will changes in the parallel. The channels follow a Raleigh circulation. We also verified the performance of the proposed scheme with that of an existing well-known topology control scheme [10], called LLISE, which only considers traditional multi-hop transmissions without cooperative communications and preserves the minimum interference path for each neighbor link locally. We also evaluated the worst network capacity among all the topology configurations for comparison. Links exist whenever the associated two end nodes are within transmission range of one another. It is shown that this topology lacks any physical layer cooperative communications. Figure shows the resulting topology using the proposed COCO topology control scheme. In Fig, the solid lines denote traditional direct transmissions and multi-hop data transmissions, and the dashed line indicates links involved in cooperative communications. As we can see to maximize the network capacity of the MANET, most of links in the network are included in cooperative communications. For example, two-phase cooperative communications is shown in the top left corner of the figure. Figure 4 shows the network capacity per node in different topology control schemes with different numbers of nodes in the MANET. As we see from the graph, the proposed COCO scheme has the highest network capacity regardless of the number of nodes in the network. Similar to COCO, LLISE is executed in each node distributed. It preserves all the edges on the minimum interference path for each link in the resulting topology, hence minimizes the conflicts to increase network capacity. Nevertheless, COCO can achieve a much higher network capacity than LLISE, since LLISE only considers multichip transmissions. The performance increase of the suggested scheme comes from the joint design of transmission selection mode, node relay selection, and interference minimization in MANETs with cooperative communications.



Conclusions

In this article, we have introduced physical layer cooperative communications, topology control, and network capacity in MANETs. To increase the network capacity of MANETs with cooperative communications, we have proposed a Capacity Optimized Cooperative (COCO) topology control scheme that considers both upper layer network capacity and physical layer relay selection in cooperative communications. Simulation experimental results have displayed that physical layer cooperative communications techniques have significant impacts on the network capacity, and the suggested topology control procedure can substantially improve the network capacity in MANETs with cooperative communications. Future work is under processing to consider dynamic traffic patterns in the proposed scheme to further improve the performance of MANETs with cooperative communications.

REFFERENCES

- J. Laneman, D. Tse, and G. Wornell, "Cooperative Diversity in Wireless Networks: Efficient protocols and Outage Behavior," *IEEE Trans. Info. Theory*, vol. 50, no. 12, 2004, pp. 3062–80.
- P. H. J. Chong *et al.*, "Technologies in Multihop Cellular Network," *IEEE Commun. Mag.*, vol. 45, Sept. 2007, pp. 64–65.
- K. Woradit *et al.*, "Outage Behavior of Selective Relaying Schemes," *IEEE Trans. Wireless Commun.*, vol. 8, no. 8, 2009, pp. 3890–95.
- Y. Wei, F. R. Yu, and M. Song, "Distributed Optimal Relay Selection in Wireless Cooperative Networks with Finite-State Markov Channels," *IEEE Trans. Vehic. Tech.*, vol. 59, June 2010, pp. 2149–58.
- Q. Guan *et al.*, "Capacity-Optimized Topology Control for MANETs with Cooperative Communications," *IEEE Trans. Wireless Commun.*, vol. 10, July 2011, pp. 2162–70.
- P. Santi, "Topology Control in Wireless Ad Hoc and Sensor Networks," *ACM Computing Surveys*, vol. 37, no. 2, 2005, pp. 164–94.
- T. Cover and A. E. Gamal, "Capacity Theorems for the Relay Channel," *IEEE Trans. Info. Theory*, vol. 25, Sept. 1979, pp. 572–84.

Q. Guan *et al.*, "Impact of Topology Control on Capacity of Wireless Ad Hoc Networks," *Proc. IEEE ICCS*, Guangzhou, P. R. China, Nov. 2008.

AUTHERS PROFILE

P. Kiran Kumar Pursuing M.TECH(CSE) from Holy Mary Institute of Technology and Science, Keesara, Hyderabad Affiliated to JNTU, Hyderabad, Andhra Pradesh, India

Mr. M. Raghavendra Rao, working as an Asst. Professor in Computer science Engineering in Holy Mary Institute of Technology and Science, Keesara, Hyderabad Affiliated to JNTU Hyderabad, Andhra Pradesh, India.