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A Survey on Cooperative Routing Strategies in Mobile Ad Hoc Networks

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ABSTRACT: The process abstraction in a network is greatly affected by its architecture. For most wired networks, the link abstraction has remained robust and is directly tied to the physical propagation medium. For wireless networks, especially the increasing important class of mobile ad hoc networks (MANETs), the classical notion of a link is vaguer than in the wired case. In this context Cooperative communication has received tremendous interests in wireless networks. In this paper, an overview on cooperative communication in MANET is presented. We inscribe the benefits of cooperative transmission over traditional non – cooperative communication. Practical issues and challenges in cooperative MANET communication are discussed. We present a basic study on the advantages, applications and different routing strategies evolved for a Mobile Ad hoc Networks during the last decade.

KEYWORDS: Cooperative communication, MANET

I. INTRODUCTION

The growth in wireless devices and communication introduced new requirements and new risks into different types of wireless networks. The popularity of hand held devices and mobile applications introduced new level of communication. The infrastructure requirements to setup a network are always a limiting factor in wireless communication. The introduction of Mobile ad hoc networks (MANET) overcomes this situation by providing direct communication between the nodes without any specific relay node. The growth in MANET again introduced many hurdles in the diverse application areas. Few of them are discussed here. The management of network architecture and task in a mobile ad hoc network (MANET) is found to be getting tedious now a days [1]. The major reason behind this issue is the physical layer communication link can originate from only one transmitter. Another reason is if concurrent transmissions of multiple transmitters are used it will result in interference. It is known that in an ad-hoc network, nodes usually spend most of their energy in communication [7]. This increases the energy utilization, which is another issue faced by ad hoc networks. The demand for speed in wireless networks is continuously increasing. The improvement in performance is also another necessary situation of improvement.

A great solution for most of these issues is addressed by a cooperative MANET. A proper routing strategy can overcome the most of performance and energy issues in MANET. Recently, cooperative wireless communication has received tremendous interests as an untapped means for improving the performance of information transmission operating over the ever-challenging wireless medium. Cooperative communication has emerged as a new dimension of diversity to emulate the strategies designed for multiple antenna systems, since a wireless mobile device may not be able to support multiple transmit antennas due to size, cost, or hardware limitations. By exploiting the broadcast nature of the wireless channel, cooperative communication allows single-antenna radios to share their antennas to form a virtual antenna array, and offers significant performance enhancements.

In this paper various cooperative routing strategies in mobile ad hoc networks are addressed. A survey is conducted to exploit the technical aspects of different routing strategies in its basic abstraction. The work is mainly focused on the

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aspects of performance, interference management and energy management in MANET by the introduction of cooperative routing strategies.

The remaining sections are distributed as follows. In Section II, an overview of Cooperative Communication is given. In Section III, Cooperative routing strategies in ad hoc networks is carried out. Finally, we conclude the paper in Section IV.

II. Cooperative Communication

In cooperative wireless communication, users may increase their effective quality of service via cooperation. Each wireless user is assumed to transmit data as well as act as a cooperative agent for another user as shown in Fig. 1. It allows several nodes cooperatively transmit signals to a destination together. Cooperative communication can offer significant performance enhancements in terms of increased capacity, improved transmission reliability, spatial diversity and diversity-multiplexing tradeoff [3].

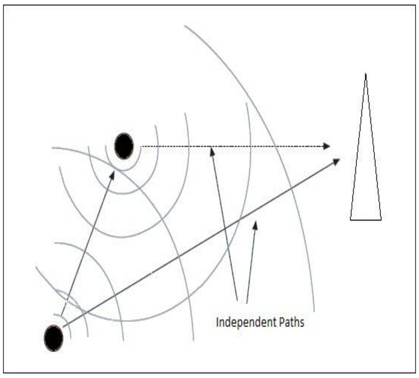

Fig. 1 Cooperative communication

These features help a lot in ad hoc mobile networks. Ad hoc wireless networks consist of wireless nodes that can communicate with each other in the absence of a fixed infrastructure. Ad hoc networks, defined in a manner in which the network nodes are organized to provide pathways for data to be routed from the user to and from the desired destination. When cooperative communication emerged in ad hoc network wireless nodes cooperate with each other in their transmissions to form a longer transmission link. This technique has attracted much attention as an effective technique to combat multi-path fading, enhance receiver reliability and achieve better energy efficiency of wireless communication systems in ad hoc network [3].

Consider an example; Suppose there are 5-node wireless ad hoc network, where S is the source and D is destination nodes, respectively. In Fig. 2 shows multihop routing, where information is transferred from one node to another until target is achieved.

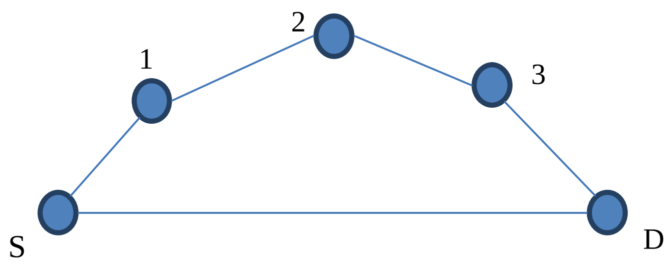

Fig. 2 Multihop Routing

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Suppose we can go through optimal multi hop path based on some routing scheme from S to D is through node 1. At the same time, node 2 and 3, which are also located within the transmission radius of S to 1, receive the information transmitted from S at no additional cost. Then in the second step, cooperation between node 1, 2 and 3 will form transmission side diversity, which will consume lower power. Here it is assumed that each node can participate in cooperative transmission after it has completely received the information as shown in Fig. 3.

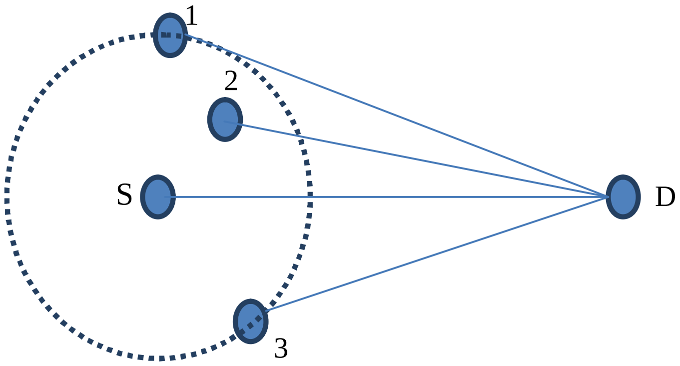

Fig. 3 Cooperative Routing

There are many advantages of cooperative ad hoc networks. They do not require infrastructure and promise greater flexibility, lower operating cost and time, higher throughput immune to interferences and better coverage. Cooperative path routing has two major benefits. First, cooperative path routing can gain higher energy saving than non-cooperative shortest path routing.Second, cooperative transmission greatly alleviates the scalability problem in wireless networks.

There are many aaplication for Cooperative MANET implementation. It explores the potential of the caching techniques. Caching techniques use to efficiently support data access in ad hoc networks. Vehicular Ad-Hoc networks (VANETs) is another major application area. It enables active safety applications such as collision warning and vehicle tracking.

III. COOPERATIVE ROUTING STRATEGIES IN AD-HOC NETWORKS

Shouhong Zhu and Kin K. Leung proposed a Distributed Cooperative Routing for ultra wide band (UWB) Ad-Hoc Networks[4]. The network scenario under investigation includes a pair of source-destination nodes and M relay nodes that constitute M parallel relay routes, all with UWB links, as shown in Fig. 4.

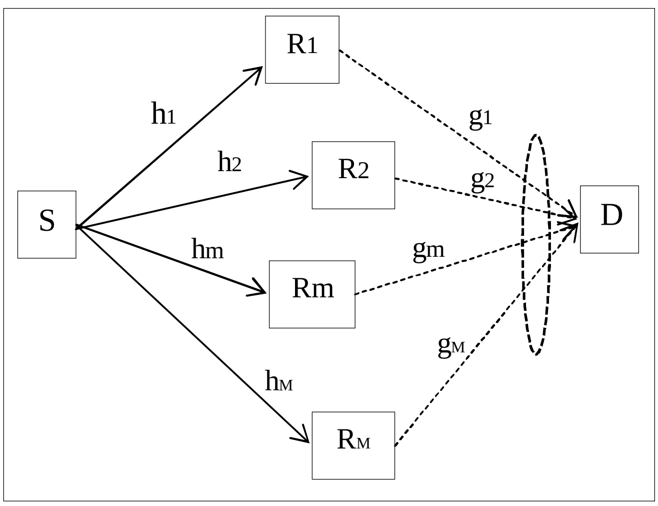

Fig. 4. Network scenario: a UWB parallel two-hop relay network

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The scenario represents a snapshot of wireless ad-hoc networks and the role of source; destination and relay nodes can change over time. The source node, labeled as S, broadcasts data to all relay nodes, labeled as from R1 to RM. The direct transmission between the source and destination nodes is not guaranteed because of the obstacles or distance between them. To take advantage of diversity of various radio routes, one of the relay nodes with the best instantaneous route quality is selected to forward the received data to the destination node, labeled as D, meanwhile all other relay nodes prohibit their data forwarding by the MAC protocol.

In the proposed scheme, each relay node uses the carrier sensing with deterministically mapped back-off period as the MAC protocol. Immediately after receiving the last data symbol from the source node, each relay node senses the channel and determines the quality of its source-relay-destination route in terms of bit error rate (BER). The back-off period for each relay is chosen such that the higher the quality for its source relay- destination route, the shorter the back-off time. Each relay continues monitoring the channel activity and starts its data forwarding at the end of the back-off period, if no other relay node has started its data forwarding. On the other hand, the relay node will refrain from forwarding if another node has started already. As a result, the selection of back-off periods at various relay nodes ensures that the relay with the best route quality will be the one responsible for forwarding the data to the destination node. From the simulations it is seen that the BER, rather than the received SNR, is a more appropriate measure for communication quality. This method combines the PHY and MAC layer mechanisms to select the best route in a cooperative and distributed way. The method is unbiased and its estimation errors are significantly lower than the reported algorithms in literature.

Fang, Hui, Ping,and Ning proposed a simple cooperative Diversity Model in selection of routing strategies[5]. The mechanism first search the 'optimal' path based on multihop routing nodes selection schemes, say power consumption based or physical distance based, and then performs cooperative diversity based on the 'optimal' path. The routing problem can be viewed as a multi-stage decision problem; where at each stage the decision is to pick the set of nodes S participating in relaying the information and the set of nodes D receiving the information. The routing strategy is as follows. Search for the optimal route firstly; say S, 1, 2, 3…, D. Fig. 5 is a simple flow chart of cooperative routing process.

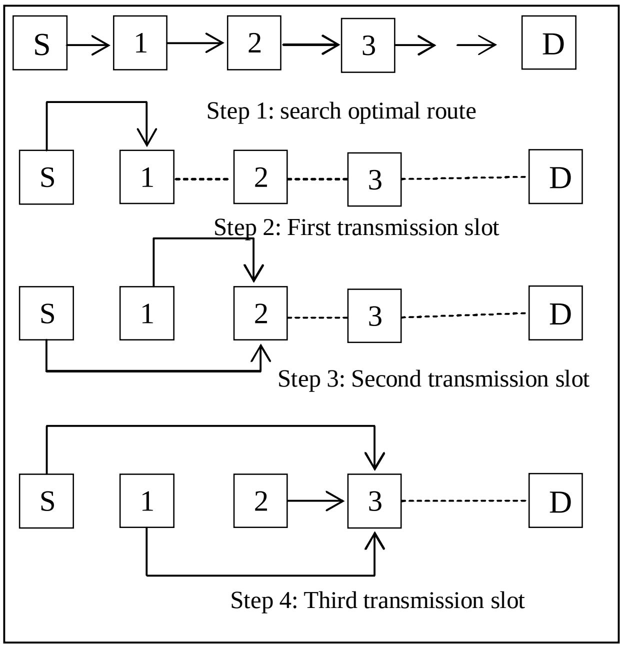

Fig. 5 cooperative routing process

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Secondly, at each transmission slot, all nodes that have received the information cooperate to send the information to the next node along the optimal route. That is, in first transmission slot, the source node S transmits information to the first hop, node 1, and then in the second transmission slot, node S and 1 cooperate to transmit information to the second hop, node 2, and then in the third transmission slot, node S, 1 and 2 cooperate to transmit information to the third hop, node 3, and so on, until the destination node D is found. With the simulation results the authors concluded that with cooperative diversity incorporated in the routing selection schemes, both power- based and physical distance-based strategies could save power compared with multi-hop cases and the more nodes participate in cooperation, the more energy could be saved.

Now we considered another strategy of topology control for network capacity improvement in MANETs with cooperative communications. Guan, Jiang, Yu, and Leung proposed a Capacity-Optimized Cooperative (COCO) topology control scheme for MANETs with cooperative communications [6]. They have clearly described the capacity of MANET in terms of transport, and throughput and the proposed their scheme. They set the network capacity as the objective function in the topology control problem. For this it is necessary to obtain the link capacity and inference model when a specific transmission manner (i.e., direct transmission, multi-hop transmission, or cooperative transmission) is used.

Here a best relay needs to be selected proactively before transmission. The COCO topology control mechanism adopts the decode-and-forward relaying scheme. The source broadcasts its messages to the relay and destination in the first slot. The relay node decodes and re-encodes the signal from the source, and then forwards it to the destination in the second slot. The two signals of the source and the relay are decoded by maximal rate combining at the destination. The maximum instantaneous end-to-end mutual information, outage probability, and outage capacity can be derived. For the interference model, in the broadcast period, both the covered neighbours of the source and the covered neighbours of the relay and the destination have to be silent to ensure successful receptions. In the second slot, both the covered neighbours of the selected relay and the destination have to be silent to ensure successful receptions.

After obtaining the link capacity and inference models, the network capacity can be derived as the objective function in the topology control problem. By considering direct transmission, multi-hop transmission, cooperative transmission, and interference, the proposed COCO topology control scheme extends physical layer cooperative communications from the link-level perspective to the network-level perspective in MANETs. The proposed scheme can determine the best type of transmission and the best relay to optimize network capacity.

They also identified two constraint conditions in the COCO topology control scheme. One is network connectivity, which is the basic requirement in topology control. The end-to-end network connectivity is guaranteed via a hop-by-hop manner in the objective function. Every node is in charge of the connections to all its neighbours. If all the neighbour connections are guaranteed, the end to end connectivity in the whole network can be preserved. The other aspect that determines network capacity is the path length. An end-to-end transmission that traverses more hops will import more data packets into the network. Although path length is mainly determined by routing, COCO limits dividing a long link into too many hops locally. The limitation is two hops due to the fact that only two-hop relaying are adopted here.

IV. CONCLUSION

The study was to understand the basic routing strategies using cooperative communication in Mobile Ad Hoc Networks. It provides an insight regarding improvements that can be introduced into MANET in terms of performance, time, energy efficiency and QoS. By analysing the various aspects in the studies it is found that a cooperative communication can introduce sensible improvements in the management of architecture and network task in various network setups especially in Mobile Ad hoc Networks. Three general techniques which are evolved during the last decade came into picture. The mode and the effect of cooperation are highlighted using this survey. The findings show that this can be a baseline to proceed towards the more realistic and modern protocols to introduce cooperative

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communication into MANET and improve the technical aspects in terms of performance, energy efficiency and speed of transmission in a great extent.

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BIOGRAPHY

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