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An Algorithm for Efficient Power Control Using Network Coding in MANETs

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ABSTRACT*: MANET is a network which is constructed by using a number of mobile devices, through temporary connection. The information should reach all nodes in the network through broadcasting. When broadcasting the message, broadcasting storm problem will occur. In order to get efficient communication the lifetime of the node should be increased. Lifetime of the node will be depend upon the power consumption of the node. The power consumption of every node should be reduced by using multipoint relay selection(MPRs) method. In this method a relay node will be affected by power consumption problem. To make energy efficient, network coding procedure has been introduced. In this paper we propose an algorithm Co-operative Analog Network Coding Algorithm (CANCA) to reduce power consumption of the secondary users. The power consumption of the node should be decreased by using this algorithm. Thus power can be saved upto 80%. The algorithm will be simulated and the result will be compared with the previous methods.*

Keywords*: network coding, energy efficient, MANET, relay node, multipoint relay (MPR), broadcasting, storm problem*

I. INTRODUCTION

MANET is a wireless network having mobile nodes with no fixed infrastructure and has a dynamically changing topology. These kinds of networks are heavily used in areas such as environmental monitoring in emergency situations where no infrastructure is available, for example battle fields, disaster mitigation etc.

1.1 Challenges in Mobile Ad-hoc Networks

Ad- hoc networks have to suffer many challenges at the time of routing. Dynamically changing topology and no centralized infrastructure are the biggest challenges in the designing of an ad-hoc network. The position of the nodes in an ad-hoc network varies continuously so we can't fix the protocol because topology also varies frequently.

Another challenge in MANET is limited bandwidth. If we compare it to the wired network then wireless network has less and more varying bandwidth. Node position will be changed means control messages will be transferred to all other nodes in the network. If number of control message will be increased bandwidth wastage will be more. If we are sending control message continuously the lifetime i.e. power consumption of the node gets increased hence network lifetime is reduced. Network lifetime is the one more challenge in MANET.

1.2 Routing

It is the process of establishing path and forwarding packets from source node to destination node. It consists of two steps, route selection and forwarding of data packets to the destination. This paper is focused on finding the shortest path with minimum power consumption.

1.3 Energy Efficient Routing

A key consideration for any energy-efficient protocol is the energy consumption at a wireless node. With respect to network activities (i.e. ignoring energy consumed in lighting up a display, power a hard drive etc), each node's radio can be in one of the following three states:

Transmitting: the node is transmitting messages with transmission power P_t.

Receiving: the node is receiving messages with reception power P_r.

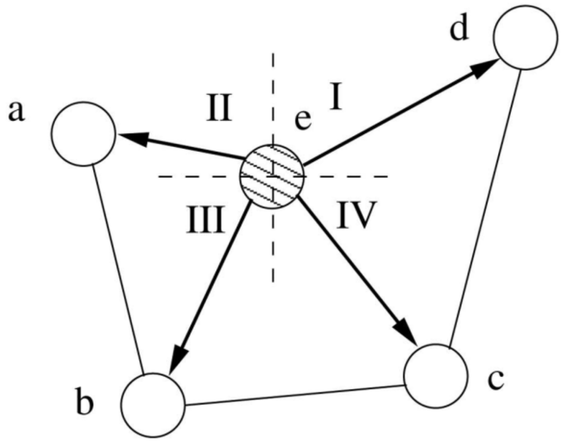
Idle: When no message is being transmitted, the node stays idle and keeps listening to the medium, consuming energy at a rate that corresponds to a power level P_{idle}.

$P_{idle} < P_r < P_t$

II. RELATED WORK

2.1 Network Coding

Network coding [10] is defined as allowing intermediate nodes to process the incoming information flows. When a forwarding node, chosen by a certain approach, needs to forward several messages to all of its neighbors, while some neighbors already have some of the messages, this node can combine some of the messages to reduce the number of forwardings, and each neighbor can still get every message via decoding. For instance, node c gets two messages from nodes a and b, respectively. In order to let a and b have each other's message, c needs to forward both the messages as a traditional forwarding node. With network coding, c only needs to forward one coded message containing both original messages through the XOR operation. Nodes a and b can decode the message with the help of their own messages through the XOR operation. Note that the network coding works only when there are multiple messages broadcast at the same time in the network.



(a)

	A	B	C	D
a	1	1	0	0
b	1	1	1	0
c	0	1	1	1
d	0	0	1	1
e	1	1	1	1

(b)

	P_1	P_2
I	1	1
II	1	1
III	0	1
IV	1	0

(c)

Fig. 2.1. (a) A sample network, (b) neighbor reception table of node e, and(c) transmission table of node e

2.2 Power Consumption

Resource limitation, mobility of hosts and changing of wireless link make it difficult for MANET to manage for all quality of services. For efficient operations of network with the changing topology with the node mobility generates higher control message overhead. Methods to reduce energy consumption include:

Considering residual battery energy while selecting the route.

Reducing the communication overhead of control messages.

Efficient route reconfiguration mechanisms (effect of topology changes)

Total energy consumption is divided into two parts: $E_{path\text{-}discovery}$, $E_{packet\text{-}transmission}$. $E_{path\text{-}discovery}$ is directly proportional to number of control packet. The principal sources of energy waste in MAC assume collision, message overhearing and control packets overhead and idle listening.

$E_{total} = E_{path\text{-}discovery} + E_{packet\text{-}transmission}$

$E_{path\text{-}discovery} \propto \text{control-packets}$

$E_{packet\text{-}transmission} = E_{idle} + E_{active} + E_{sleep} + E_{transient}$

$E_{active} = E_{transmit} + E_{receive}$

$E_{sleep} = 0$

To increase node and network life time the route is established by taking the lightly loaded nodes with sufficient power resources. For longer network life and minimize energy consumption the following approaches are suggested.

1. Power management Approach 2. Power Control Approach 3. Topology Control Approach

Energy conservation is achieved not by taking any solutions alone; it is possible by taking the combination of two or three techniques simultaneously. Some of the techniques are as follows.

III. TOPOLOGY CONTROL

Mobility of wireless nodes makes the topology of network changes temporary. It is affected by many uncontrollable factors like node mobility, weather conditions, environmental interference and obstacles and some controllable factors like transmission power, antenna direction and duty cycle scheduling. Topology of network is considered as graph with its nodes as vertices and communication links between node pairs as edges. The edge set is large possible one if communication is established by node's maximum transmission power. In dense network too many links leads to high energy consumption. The primary target of topology control is to replace long distance communication with small energy efficient hops. Dense network ensures tight connectivity and high interference. In sparse network connectivity between nodes is being a question. So there is a tradeoff between network connectivity and sparseness [9].

Network topology can enhance network throughput because of two benefits. First the interference is reduced if transmission radii of nodes are reduced to near one. Second more data transmission is carried out simultaneously in the neighborhood of a node. A bad network topology has many adverse effects such as low capacity, high end-to-end delay and weak robustness to node failure. Where as a good network topology minimize energy consumption and end to end delay without much affecting the throughput [10].

IV. PROPOSED APPROACH

Cooperative communication refers to a system where the user share and coordinate their resource to enhance the information transmission quality. It allow single-antenna devices to work together to exploit the spatial diversity and resistance to fading, high throughput, low transmitted power, and resilient networks. Simple cooperative wireless network model with two hops there are a source, a destination, and several relay nodes. The basic idea of cooperative relaying is that some nodes which overheard the information transmitted from the source node relay it to the destination node instead of treating it as interference. Since the destination node receives multiple independently faded copies of the transmitted information from the source node and relay nodes, cooperative diversity is achieved. If multiple nodes are available for cooperation, their antennas can employ a space time code in transmitting the relay signals. Most existing works about cooperative communications are focused on physical layer issues, such as decreasing outage probability and increasing outage capacity, which are only link-wide metrics.

The goal of topology control is to set up interference-free connections to minimize the maximum transmission power and the number of required channels. It is also desirable to construct a reliable network topology since it will result in some benefits for the network performance. Topology control focuses on network connectivity with the link information provided by MAC and physical layers. There are two aspects in a network topology: network nodes and the connection links among them. Classical MANET parameterized by some controllable parameters which determine the existence of wireless links directly. In MANET topology control is an important approach to conserving energy, which aims at determining a set of wireless links among nodes so as to achieve certain energy-efficient properties. Our work proposes the energy efficient routing for MANET, which utilizes cooperative communication with topology control. The traditional method proposed in [1] has improved the network capacity using topology control with cooperative communications. Anyhow network capacity has been improved; energy consumption has not been taken into account. So that, providing minimum energy consumption for MANET nodes is considered in this work. Our approach works on physical layer with cooperative communication and proposes two routing algorithms: 1) Non Cooperative Routing Algorithm and 2) Cooperative Routing Algorithm. To prove the efficiency of our proposed method, these two algorithms are to be compared. As in cooperative communication, relay is essential to transmit a packet from source to destination, electing the relay node is crucial. Initially, r-neighboring region of source node is evaluated in our proposed scheme and then election of relay node is presented based on higher energy and Link expiration time. Once relay node is elected, cooperative communication method is adopted and also it will be compared with non-cooperative communication with the same relay node.

4.1 Optimal Energy- Efficient RS and PA (EE-RS-PA)

A relay is defined to be selected if it is allocated with transmit power. Hence, the joint optimization of RS and PA can be modeled as an optimal power allocation problem. The objective is to find the optimal power allocation$\{p_{s,1}, p_{s,2}, p_i\}$ that minimizes the total transmit power subject to satisfying the required end-to-end rates $c_1$and c_2.The problem is formulated as,

$$\begin{aligned} &\text{minimize} \quad p_{s,1} + p_{s,2} + \sum_{i=1}^{k} p_i \\ &\text{subject to} \quad r_{1,2} \geq c_1, r_{2,1} \geq c_2 \\ &\qquad\qquad\quad p_{s,1} \geq 0, p_{s,2} \geq 0 \\ &\qquad\qquad\quad p_i \geq 0,\ i = 1, \cdots, k \end{aligned}$$

To facilitate the study, we assume that the noise variance $\sigma_i^2, \sigma_{s1}^2$ and σ_{s2}^2 are chosen as 1. The Karush-Kuhn-Tucker (KKT) conditions are necessary for a solution in nonlinear programming to be optimal. By substituting and applying KKT conditions, the transmit power of $S_1$and S_2 can be expressed as,

$$p_{s,1} = \frac{\eta_1\left(1+\sum_{i=1}^{k}\alpha_i|g_i|^2\right)}{\sum_{i=1}^{k}\alpha_i|g_i|^2|h_i|^2}, p_{s,2} = \frac{\eta_2\left(1+\sum_{i=1}^{k}\alpha_i|h_i|^2\right)}{\sum_{i=1}^{k}\alpha_i|g_i|^2|h_i|^2}$$

Where $\eta_1 = 2^{2c_1} - 1,\ \eta_2 = 2^{2c_2} - 1$ the optimization problem transforms to the following form
To obtain the global optimum of problem, an exhaustive search is needed throughout amplification vectors $\alpha_1 \times k$ to find the overall minimum transmit power. Hence, it is prohibitive in terms of computational complexity. Instead of searching the solution of problem directly, we propose an E-SRS-PA scheme with single relay selection, which is supposed to be the solution.

V. SIMULATIONS AND RESULTS

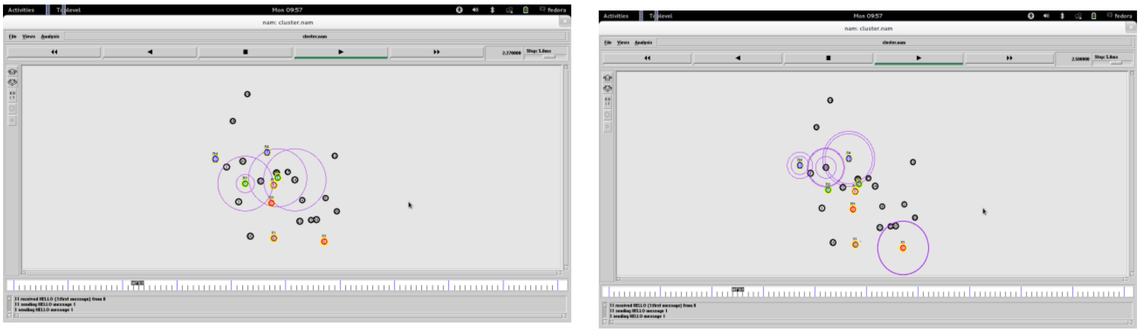


Fig: 5.1 Node forwarding message

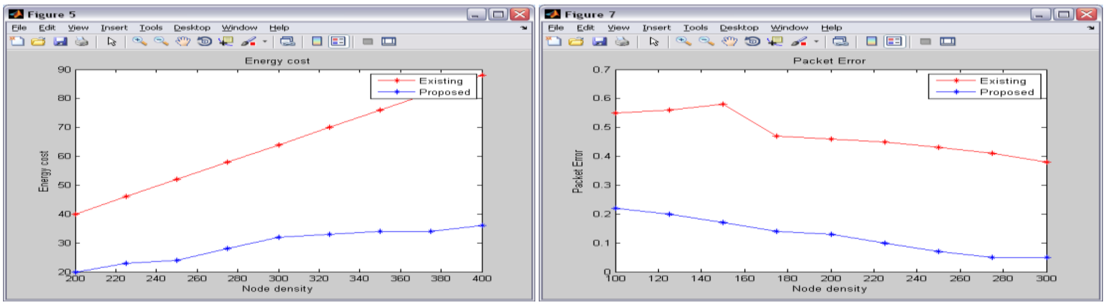


Fig: 5.1 Node Density Vs Energy Cost, Node Density Vs Packet Error

In the proposed algorithm if the node density is increased energy consumption is reduced. The above figure shows if the node density increases the packet error is reduced.

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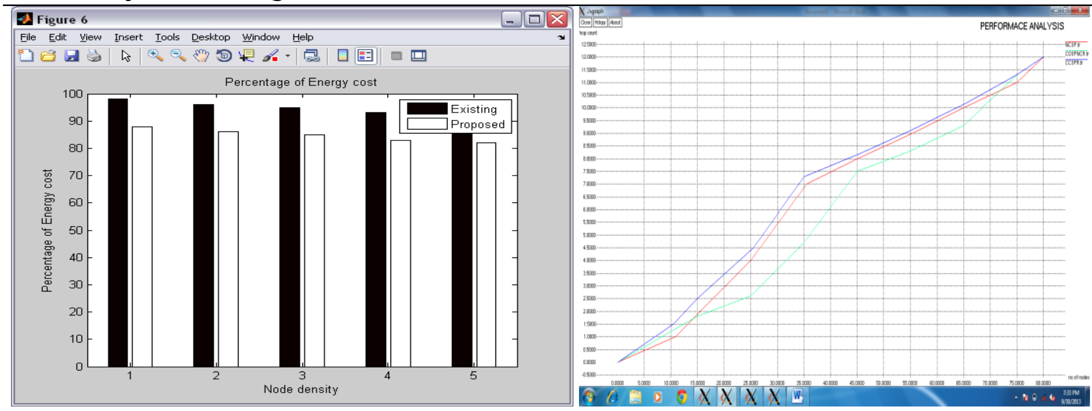

Fig: 5.2 Node Density Vs Percentage of Energy Cost, Comparison chart

VI. CONCLUSION

We focused on physical layer network coding and highlighted its potential minimize energy consumption. In this paper, we studied on the Energy-efficient RS and PA problem for ANC-based TWRC and different modes power consumption also analyzed by using Frii's transmission formula. We firstly prove that the single RS scheme is optimal for ANC-based TWRC from the viewpoint of energy efficiency. Second, an E-SRS-PA scheme is proposed with optimal energy efficiency, and the closed-form expressions of power allocation are derived. Simulations show that the higher the data rate requirements, the better the energy efficiency of ANC with E-SRS-PA compared to other relaying schemes. The proposed Co-operative Analog Network coding Algorithm (CANCA) reduced energy consumption of the network.

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