Improving the Network Lifetime of MANETs through CSP routing Algorithm

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Abstract—Cooperative Communication is a technique that allows multiple node to transmit the same data. In this paper propose a Cooperative Shortest Path (CSP) Routing Algorithm for Mobile ad hoc Network (MANETs).Cooperative Shortest Path (CSP) routing algorithm that uses the Dijkstra's algorithm as the basic building block and reflects the cooperative transmission. The objective of Cooperative Shortest Path (CSP) Routing Algorithm is to improving the network lifetime and archives higher energy saving and better balanced energy consumption among network nodes, especially the network is large scale. Our empirical results indicate so as to among more nodes added in the network, more energy saving can be achieved by cooperative routing since a dense network.

Key words-Network Lifetime, Cooperative Communication, Cooperative Shortest Path (CSP) Routing Algorithm, DEL-CMAC protocol, Dijkstra's algorithm.

I. INTRODUCTION

MANET (Mobile Ad-Hoc Network) has s dynamic topology due to the nature of attaching and detaching of node at any time. A Mobile Ad hoc Network (MANET) consists of a collection of wireless mobile nodes that are capable of communicating with each other without the use of any centralized administration or network infrastructure. Mobile nodes such as cell phones, portable gaming devices, PDAs (Personal Digital Assistants) and tablets all have wireless networking capabilities. Multi-hop wireless ad hoc networks, messages may be transmitted via multiple radio hops, and thus a routing protocol is essential for the success of such networks. Most routing protocols for ad hoc networks consider a network as a point-to-point links and multiple links. Multiple links are used to transmit data from a source node to a destination node in a multi-hop fashion. Cooperative transmissions transmit multiple transmitters to one receiver simultaneously. As a result, signals with the same channel from several different nodes to the same receiver simultaneously are not considered collision but instead could be combined at the receiver to obtain stronger signal strength.

Cooperative Communication [1], [5], [6] can provide gains in terms of the required transmitting power due to the spatial diversity achieved via user cooperation. However, if we take into account the extra processing and receiving energy consumption required for cooperation, CC is not always energy efficient compared to direct transmission. There is a tradeoff between the gains in transmitting power and the losses in extra energy consumption overhead.

This fundamental difference from the traditional radio transmission model requires new routing algorithms to fully realize the power of new antenna technology. Routing problem [2], [3], [4] under the cooperative radio transmission model is called cooperative path routing with which it is allowed that multiple nodes along a path coordinate together to transmit a message to the next hop as long as the combined signal at the receiver satisfies a given SNR (Signal-to-Noise Ratio) threshold value. Cooperative path routing has two major benefits. First, cooperative path routing can achieve higher energy saving than non-cooperative shortest path routing. Our empirical results indicate that with more nodes added in the network, more energy saving can be achieved by cooperative routing since a dense network offers more opportunities for cooperative transmissions. Second, cooperative transmission greatly alleviates the scalability problem in wireless networks.

The existing DEL-CMAC protocol is based on IEEE 802.11 DCF protocol. Distributed Energy Adaptive Location Based Cooperative MAC protocol is mainly focus on the network lifetime extension while occur on the hidden and exposed terminal problem. While the work on the energy efficiency and network lifetime generally consume on physical layer or network layer. Issue in DEL-CMAC is the hidden terminal problem due to the terminal mobility.

II. MODELS AND PRELIMINARIES

A. Network Model

Network model consider an all-wireless network consisting of *N* devices, also called nodes. We assume the use of Omni-directional antennas and all nodes within communication range of a transmitting node can receive its transmission. The power level of a transmission can be chosen at each node within a given range of values, say [0, P max]. Each node can thus dynamically adjust its transmitted signal phase to possibly synchronize with other nodes, which can be realized by pre-compensation before transmitting based on the estimate of the phase and delay at each path. This assumption is reasonable for slowly varying channels in that the channel coherence time is much longer than the block transmission duration.

B. Power consumptional Model

Consider a commonly used wireless propagation model the received signal power attenuates –ƛ *d*, where *d* stands for the distance between transmitting node antenna and receiving node antenna and ƛ takes a value between 2 and 4 depending on the characteristics of the communication medium. We assume that the communication medium is uniform, thus ƛ is a constant throughout the region. Wireless link at a given data rate between node *i* and node *j* is given by

$$P_{i,j}=d_{i,j}^{\lambda} \quad (1)$$

Where $d_{i,j}$ denotes the distance between node *i* and node *j* . We say node *i* can reach node *j* if and only if the transmitting power at node *i* is greater than or equal to $d_{i,j}^{\lambda}$. Notably, each node can add or remove links by adjusting its transmitting power hence the network topology totally depends on the transmitting range of each node.Let $d_{t1,r}^{\lambda}$,..,$d_{tm,r}^{\lambda}$ denote the required power for point-to-point transmission to the given destination node *r* from transmitting nodes *m t* , *t* ,...,*t* 1 2 respectively. The total required power for this cooperative transmission is given by:

$$P_{coop} = \; 1/\sum_{I=1}^{M} \frac{1}{d_{ti,r}^{\lambda}} \quad (2)$$

Consider an energy cost graph *G* = (*V*, *E*) with Weights, where *V* is the set of nodes, *E* is the set of links, $d_{i,j}^{\lambda}$ is the weight on the edge < *i*, *j* >, < *i*, *j* >£ *E* and *i*, *j*£ I*V* .For a source-destination pair *S*,*D* £*V* , assume that *V* = *N* and the last *L* predecessor nodes along the path are allowed for cooperative transmission to the next hop. We want to find a *S* - *D* path, say *Path S*-> t_1 , t_1 , t_2 , t_k , -->D and a corresponding transmission sequence arrangement. The total required energy

$$\sum_{x \epsilon \{S, t_1, t_{2,\dots} t_{k,D}} P_x \quad (3)$$

P stands for the required power for node x. Cooperative transmission procedure operates as some follows: The Cooperative transmission corresponding path can be stated as *S*-> *A*-> *B*->*D*. node *S* first transmits to node *A* , then node *S* and node *A* cooperatively transmit to node *B* , then node *A* and node *B* cooperatively transmit to node *D* .

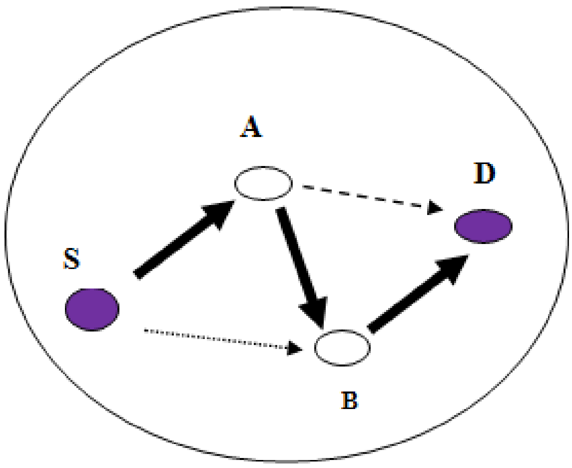

Figure 1 Cooperative transmission

The total energy cost for this path is give by $P_{S-D} = d_{S,A}^{\lambda} + \frac{1}{\frac{1}{d_{S,B}^{\lambda}} + \frac{1}{d_{A,B}^{\lambda}}} + \frac{1}{\frac{1}{d_{A,D}^{\lambda}} + \frac{1}{d_{B,D}^{\lambda}}}$

The minimum energy cooperative path could be a combination of multicast (one to many), cooperative transmissions (many to one), and point-to-point transmissions (one to one).

III. THE PROPOSED CSP ROUTING ALGORITHM

Cooperative Shortest Path (**CSP**) Routing Algorithm that uses the Dijkstra's algorithm as the basic building block and reflects the cooperative transmission properties in the relaxation procedure. The CSP algorithm takes as input an energy cost graph *G* = (*V*, *E*) with weights $d_{i,j}^{\lambda}$ source-destination pair *S*, *D£ V*. We assume that the last *L* predecessor nodes along the path for cooperative transmission to the next hop. The CSP algorithm uses the basic structure of the Dijkstra's algorithm and uses a modified relaxation procedure to reflect the cooperative transmission cost along the path.

Dijkstra's algorithm

This algorithm builds a ***shortest-path spanning tree*** for the router such a tree has a route to all possible destinations. Example, let's follow the steps of the algorithm run by router A

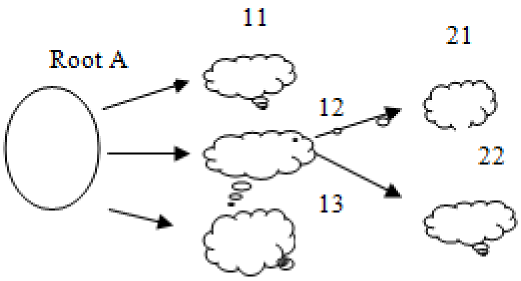

Figure 2 Example of Dijkstra's algorithm

Root is A, network 11, 12 and 13 are added and the root is 12, network 21 and 22 is added. More number of nodes added in the network, more energy saving can be achieved for Cooperative shortest-path Routing algorithm. The CSP algorithm has the same structure as that of Dijkstra's algorithm. Notably, the algorithm maintains two labels for each node: *d*[*u*] to represent the estimated total cost of the cooperative shortest path from the source node *S* to node *u* with respect to the cooperative transmission cost along the path and π (*u*) to represent predecessors of node *u* along the cooperative shortest path. π (*u*) only needs to keep as many as *L* -1 predecessors, i.e. , the last *L* -1 predecessors along the cooperative shortest path.

Relax (u,v)

1. **if** d[v] >d[u] + **Coop** (u,v) then
2. d[v] = d[u] + **Coop** (u,v);
3. set node u as node v's predecessor;
4. End if

Coop(u,v)

// calculate the cooperative transmission cost from node u
// and its predecessors to node v

1. Assume $path_u^*$={S,t_1,....., t_k,u}
2. If(k+2)≤L
3. Cost=$\frac{1}{\frac{1}{d_{S,v}}+\sum_{i=1}^{k}\frac{1}{d_{t_i,v}^{\lambda}}+\frac{1}{d_{u,v}^{\lambda}}}$
4. Else if (k+1)==L
5. Cost=$\frac{1}{\sum_{i=1}^{k}\frac{1}{d_{t_i,v}^{\lambda}}+\frac{1}{d_{u,v}^{\lambda}}}$
6. Else if (k+1).L
7. Cost=$\frac{1}{\sum_{i=k-L-2}^{k}\frac{1}{d_{t_i,v}^{\lambda}}+\frac{1}{d_{u,v}^{\lambda}}}$
8. End if
9. End if
10. End if
11. Return cost

Figure 3 New relaxation procedures for CSP algorithm

IV. PERFORMANCE EVALUATIONS

In this section, Performance evaluation are made for Cooperative Shortest Path Routing Algorithm comparing with Distributed Energy adaptive Location based cooperative MAC (DEL-CMAC) protocol. The main purpose of CSP algorithm increasing the network lifetime and more energy saving are archived. Some evaluations metrics are used in this paper are payload length, node density, network size, aggregated throughput and average delay.

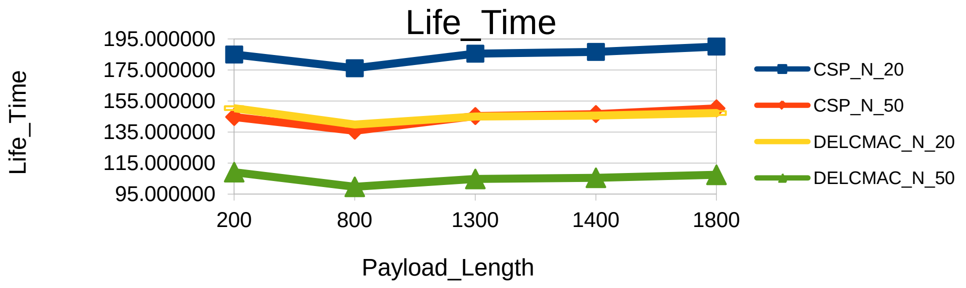

Figure 4 Payload Length versus Lifetime

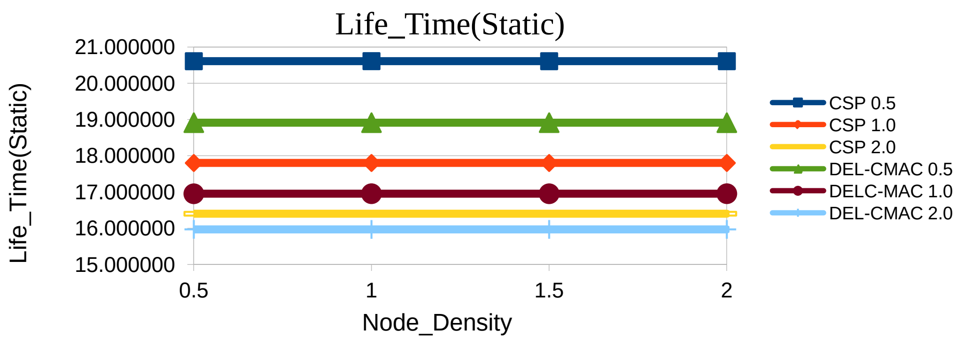

Figure 5 Node Density versus Lifetime (Static)

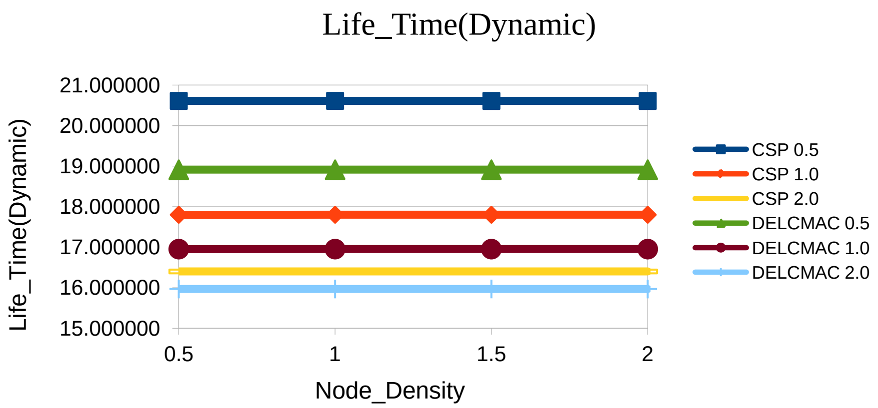

Figure 6 Node Density versus Lifetime (Dynamic)

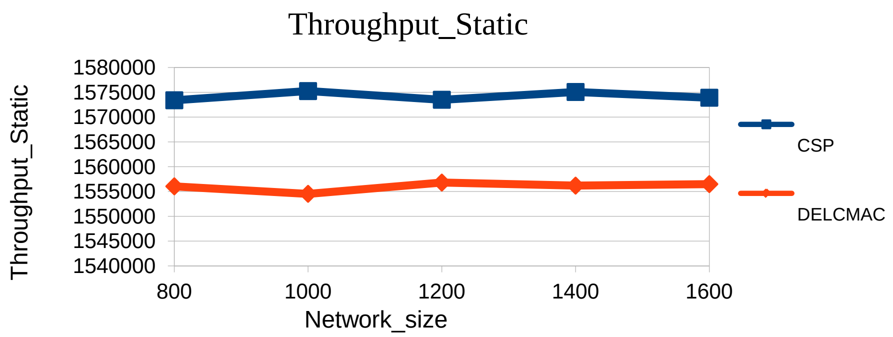

Figure 7 Network size versus Throughput (Static)

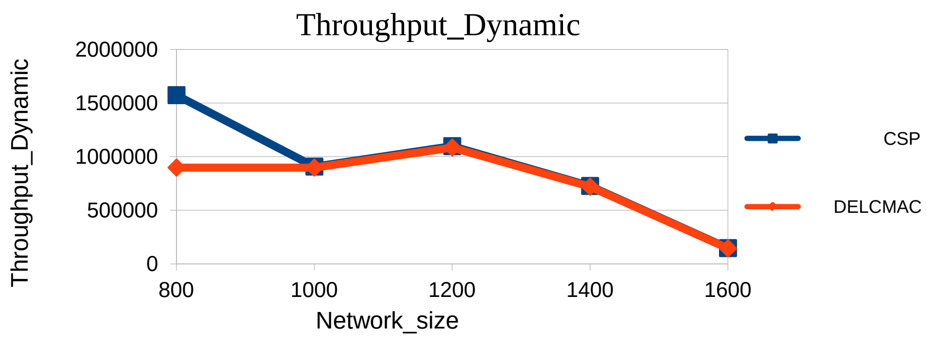

Figure 8 Network size versus throughput (dynamic)

In Fig 4 graph is plotted between payload length versus lifetime. Lifetime is defined as the duration from the network initialization to the time that the first terminal runs out of power. The payload length is calculated by payload length is multiplied is 10^3. This graph depicts the network lifetime is increased by using cooperative Shortest Path Routing Algorithm when compared to DEL-CMAC protocol.

In figure 5 and 6 graph is plotted between node density versus Lifetime. The network lifetime is increased by using cooperative shortest path routing algorithm when compared to Distributed Location based cooperative MAC protocol in static and dynamic environment. The number of node density is indicated by node density is multiplied with 10^3.

In Figure 7 and 8 graph is plotted between network size versus throughput in static and dynamic environment. The throughput it is important to reduce collisions, maximize the channel utilization and keep the control overhead to a minimum. Throughput has been increased using cooperative shortest path routing algorithm when compared to DEL-CMAC protocol.

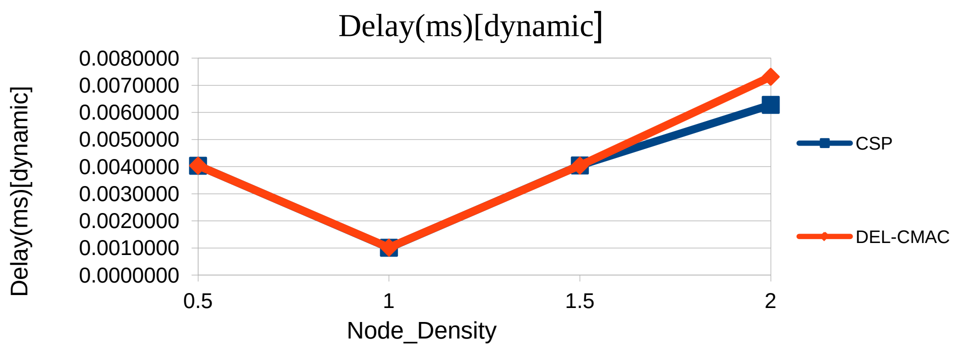

Figure 9 Node Density versus Delay (Dynamic)

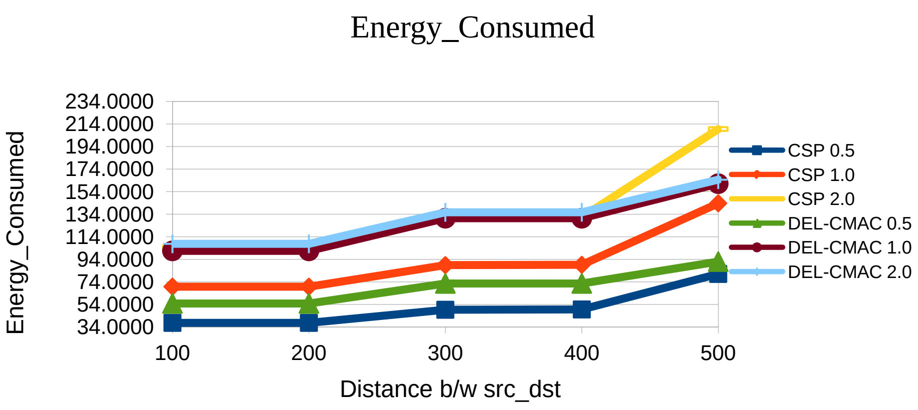

Figure 10 Distance between Source to destination versus Energy Consumed

In figure 9 graph is plotted between node density versus delay. The delay has been minimized using Cooperative Shortest Path Routing algorithm when is compared to DEL-CMAC Protocol. Figure 10 is plotted between Distance between Source to destination versus Energy Consumed on CSP routing Algorithm when is compared to a Distributed location based cooperative MAC protocol. The lifetime of a network totally depends on the energy consumption of each node. To increase a network lifetime, power efficient and power aware protocols and techniques at different network layer has been used to minimize the power consumption.

V. CONCLUSIONS

In this proposed work the use of Cooperative Shortest Path (CSP) Routing Algorithm for mobile ad hoc networks.CSP Routing algorithm that uses the Dijkstra's algorithm as the basic building block and reflects the cooperative transmission properties in the relaxation procedure. Energy consumption has been minimized when compared to DEL-CMAC protocol. Our empirical results indicate so as to among more nodes added in the network, more energy saving can be achieved by cooperative routing since a dense network. The network lifetime has been increased and aggregate throughput and minimum delay has been archived this algorithm. The proposed work overcomes the distributed implementation of the CSP algorithm as well as collaborative MAC protocols, adaptive scheduling algorithms, node mobility issues as our future directions.

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