International Journal of Technical Research and Applications e-ISSN: 2320-8163,
www.ijtra.com Volume 3, Issue 6 (November-December, 2015), PP. 84-88

MINIMIZING THE TRANSMISSION POWER WHILE INCREASING THE CONNECTIVITY IN MANET

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Abstract— **The demand for speed in wireless networks is incessantly rising. In recent times, supportive wireless communication has received marvelous interests as an untapped means for perking up the performance of information communication operating over the ever-demanding wireless medium. Supportive communication has became known as a novel aspect of diversity to imitate the strategies designed for various antenna systems, since a wireless mobile device might not be competent to sustain multiple transmit antennas due to cost, size, or hardware limitations. By utilizing the broadcast nature of the wireless channel, supportive communication permits single antenna radios to share their antennas to structure a virtual antenna array, and offers important performance enhancements. In this paper we introduce physical layer supportive communications, topology control, and network capacity in MANETs. We also aim to perk up the network capacity of mobile ad hoc networks with supportive communications.**

Keywords- **Supportive Communication, MANET, Ad hoc Network, Topology Control.**

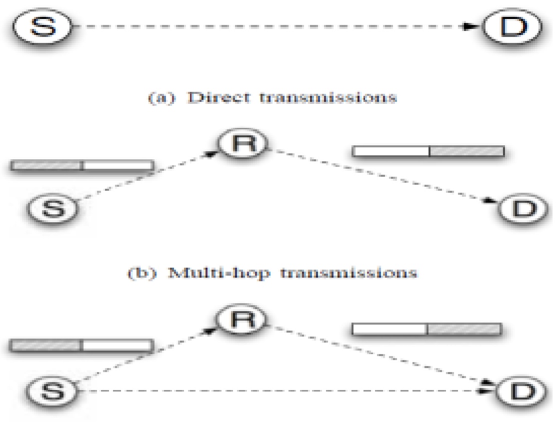
I. INTRODUCTION

The Wireless ad-hoc network has dissimilar civilian and defence applications and that's why it has gained substantial attention in recent days. The major consideration in inventing such a network is to diminish power utilization because of the truth that wireless nodes are usually charged by batteries barely. Topology control is one of the chief energy preserving practices which has been mostly considered and utilized in ad-hoc wireless network. Topology control method permits each and every wireless node to choose certain subset of neighbours and extend network connectivity by consuming the lowest amount of transmission power[2]. Therefore with the assistance and support of this method, each node becomes competent to preserve its connectivity with a variety of other nodes by one-hop or multi-hop even without utilizing the optimal transmission power. Thus by preserving energy, topology control assists in lessening interference between wireless connections by plummeting the number of links. Supportive communication (SC) permits single antenna device to receive the advantage of the multiple-input and multiple-output (MIMO) systems[1].

II. SUPPORTIVE COMMUNICATIONS (SC)

Supportive communication is identified as a process by which users contribute and mingle resources relating to transmission of data to improve their performances with the aid of each other. This method has the benefit to enhance the transmission coverage of a node in mobile ad-hoc network on account of assorted channel quality, restricted energy and restricted bandwidth wireless environment. Due to assistance in communication, users having fragile network connection can use quality channels of their partners so as to attain the required quality of service[3].

In Supportive Communications in Existing Network Architectures, the prime network model is a mobile ad hoc network with an existing clustered communications, in which supportive transmission is centrally stimulated and controlled by the cluster access points. All terminals converse through a cluster access a point, which manages routing to other clusters. In the traditional multi-hop architecture, each cluster is accountable for transmitting the message to a "gateway" node in the next cluster. In our supportive network architecture, between clusters the access points utilizes multiple gateway nodes, which disseminate the message providing supportive gains compared to the single gateway solution. Improved links translate into improved network connectivity compared to multi-hop solutions. Relying on existing methods to decide the clustering structure, our intention is to portray how the access points can choose the supportive nodes by means of matching algorithms and how this profits the network connectivity. Naturally the supportive communication refers to a system where users share and systematize their resources to perk up the information transmission worth. The generalization of relay communication in which manifold sources also serves as relays for each other. At the start study of relaying troubles appears in the information theory community to improve communication between the source and target. The basic idea of supportive relaying is that some nodes which eavesdropped the information transmitted from the source node and relay nodes the supportive multiplicity is attained. Communication could be realized using two general strategies. These strategies are Amplify and forward and Decoding and forward. In the amplifying and forwarding method, the relay nodes merely improve the muscle of the signal received from the sender and transmit it again to the receiver. In decode and forward method the nodes will execute physical layer decoding and after that forward the decoding outcome to the destinations. The cooperation between manifold nodes and their antennas are employing a space time code in transmitting the relay signals. The collaboration at the physical layer can attain full levels of assortment analogous to a MIMO system and consequently, to diminish the interference and then enhance the strength of connectivity in wireless network[4].



(c) Supportive transmissions

Fig. 1. Three transmission protocols. (a) Transmission in direct mode via a point-to-point conventional link. (b) transmissions (Multi-hop)via a two-hop manner occupying two time slots. (c) Supportive transmissions via a supportive diversity occupying two consecutive slots.

III. Topology Control

The network topology in a mobile ad hoc network is changing vigorously due to traffic, user mobility, node batteries, etc. In the meantime, the topology in a mobile ad hoc network is controllable by adjusting some parameters for instance the channel assignment, transmission power, etc. Generally, topology control is such a method to decide where to deploy the links and how the links work in wireless networks to create a superior network topology, which will optimize the, the capacity of the network, energy expenditure or end-to-end routing performance. Topology control is primarily developed for mobile ad hoc networks, wireless sensor networks and wireless mesh networks to diminish energy consumption and interference. It typically results in a simpler network topology with small node degree and little transmission radius, which will have high-quality links and less disputation in medium access control layer. Spatial/spectrum reuse will turn feasible due to the smaller radio coverage. Other properties analogous to symmetry and planarity are expected to attain in the resulting topology. Symmetry can assist wireless communication and two-way handshake methods for link acknowledgment while planarity boosts the possibility for parallel transmissions and space reuse.

IV. Literature Review

Yu, F.R. , Shengming Jiang , Leung, V.C.M. [6] proposed a Capacity-Optimized Cooperative (COCO) topology control proposal to perk up the network capacity in MANETs by mutually considering both upper layer network capacity and physical layer cooperative communications. Cabrera, J.B.D. , Sci. Syst. Co., Woburn, Ramanathan, Ram, Gutierrez, C., Mehra, R.K.[7] presented the first control- theoretic examination of topology control in Ad hoc Networks. They take a uncomplicated representative completely distributed topology control algorithm called LINT and show that it is unstable under certain conditions. They then formulated LINT in a control-theoretic context, and develop a novel mechanism called CLINT that is publicized to be steady for a wide range of parameter variations. They compare the in- practice performance of LINT and CLINT using comprehensive simulations and show that CLINT offers a superior throughput.

Jie Wu , Florida Atlantic Univ., Boca Raton, FL, Fei Dai [8] showed some issues in existing topology control. Then, they proposed a mobility-sensitive topology control scheme that expands numerous existing mobility-insensitive protocols. Two mechanisms are commenced: consistent local views that evade inconsistent information and delay and mobility management that endure outdated information. The efficiency of the proposed approach is confirmed through an extensive study.

V. Problem Formulation

In this segment, we describe a supportive communication model and a network model for our topology control system.

A. Supportive Communication Model

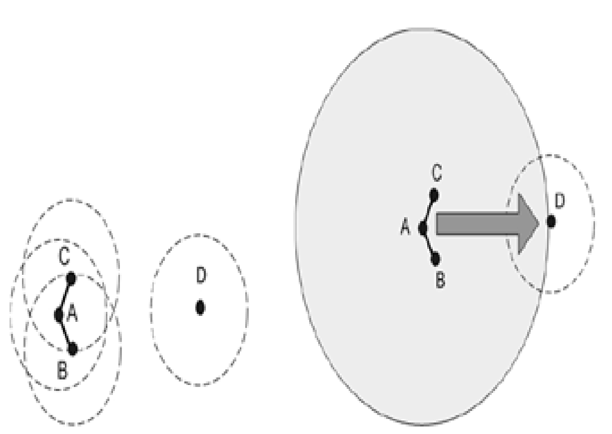
Each node has a utmost transmission power limit P_{MAX} . P_i is the transmission power of node i. α is the path loss exponent and τ is the minimum average SNR for decoding received data. d_{ij} is the distance between node i and node j. For a source node i to talk with node j in a straight line (figure 2(a)), they must persuade

$$P_i (d_{ij})-\alpha \geq \tau \qquad (Pi \leq P_{MAX}). \qquad (1)$$

Ω denotes the set of a source node and helper nodes. If nodes in Ω transmit at the same time, i.e., use supportive communication, the next formula must be satisfied for accurate decoding at destination node j.

$$\sum_{i \in \Omega} P_i (d_{ij})^{-\alpha} \geq \tau \qquad (Pi \leq P_{MAX}) \quad (2)$$

SC escorts to extended transmission coverage. For illustration, in figure 2(a), node A cannot converse with node D, since D is not in the maximum transmission range of A. In contrast, in figure 2(b), node A can transmit a cooperation-appeal message and data to nodes B and C, and then the three nodes all together transmit the data to D. Consequently, D can accept it due to the extended transmission range of nodes A, B, and C. Conversely, in figure 2(a), if node B uses SC with helper A to converse with C, which is already reachable to B by direct links, the network can diminish the sum of node transmission power.



(a)Direct links. (b) Supportive link (SC link).
Fig. 2: Coverage Extension using SC.

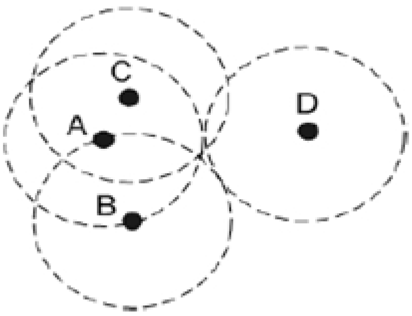


Fig. 3: A case that power required for helper links is higher than that for a SC link.

B. Network Model

The Ad hoc network topology is represented as a 2-dimensional graph: G = (V, E). where $V = (v_1, ..., v_n)$ is a set of arbitrarily disseminated nodes and E is a set of pairs of nodes (v_i, v_j), with $v_i, v_j \in V$. The weight of a directional link from u to v is designated as $w(u \rightarrow v)$. Edge (u, v) has weight, w(u, v), which indicates the average power expenditure for maintaining a bi-directional link (u, v). The average weight for bi-directional SC link is calculated as follows:

w(u, v), is $(w(u \rightarrow v) + w(v \rightarrow u))/2$.

N (v) is the set of neighbor nodes within the utmost transmission range of node v. All elements in N (v) are the candidate nodes, which are entitled as helper nodes for v. The power set of N (v) signifies $\wp(N(v))=\{X|X \subset N(v)\}$, which is the set having all subsets of N (v). Node v is able to communicate with its neighbors directly within one hop. R(u) is the set of nodes which are reachable to node u by one-hop or multi-hop, i.e., have a path to a node u.

C. Problem Formulation

The available topology control tried to diminish the transmission power of nodes and conserve the given connectivity. Nevertheless, the objective of this research work is to diminish the transmission power while enhancing the connectivity. We properly describe this difficulty as follows.

Problem 1: (Topology Control in view of Extended Links caused by Supportive Communication) For a known wireless multi-hop network G = (V, E), which can comprise clusters, with n nodes, allocate a power level to each node such that the network connectivity of the induced graph is maximized by SC links, and the summation of power of all nodes, $\sum_{i \in V(G)} P_i$, is minimized.

We recommend a heuristic algorithm to solve it. To handle problem 1, we also necessitate an energy- competent algorithm that makes an extended link with SC. Let $P_u^d(i)$ be the minimum power of node u required for helper link (u, i), and $P_{u \cup h}^c(v)$ be that for SC link (u, v) with helper h. As the number of selected helper nodes increases, each node needs less. $P_{u \cup h}^c(v)$. Nevertheless, when the selected helper node h is comparatively far-away from source node u, $P_u^d(h)$ is greatly increased. For instance, in figure 2 (a), neighbour nodes B and C are near source node A but destination node D is far from A. Assume that $\tau = 1, \alpha = 1$, $P_A(B) = d_{AB}$. In figure 2(a), d_{AD} is about three times as long as r (the radius of maximum transmission range of A), i.e., $d_{AD} = 3r$. Consequently, A should use B and C as helper nodes with greatest power. Subsequently, it permits the value of $P_{A \cup \{B,C,\}}^c(D)$ to be higher than $P_A^d(B)$ because $P_{A \cup \{B,C,\}}^c(D)$ and $P_A^d(B)$ $< P_{MAX}$. On the other hand, in figure 3, destination node D is relatively nearer to source node A ($d_{AD} = 2r$) but neighbour node B is at the boundary of the maximum transmission range of A ($d_{AB} = r$). The value of $P_A^d(B)$ becomes larger than $P_{A \cup \{B,C,\}}^c(D)$ if A selects both B and C as helper nodes because $P_A^d(B) = P_{MAX}$ and $P_{A \cup \{B,C\}}$. Considering this tradeoff, we need the strategy that source node A selects helper nodes such that it minimizes the sum of transmission power of source node A and the helper nodes. Section 4 describes how to compute $P_A^d(B)$ and $P_{A \cup \{B,C,\}}^c(D)$

Problem 2: (Energy-Efficient Extended Link with Supportive Communication) Given nodes u and v, (which belong to two different clusters and can mutually construct a bi- directional SC link because Eq. (2) is satisfied), find H (u) and H (v) such that w(u, v) is minimized.

D. Proposed Topology Control Scheme

We present the proposed Capacity-Optimized Supportive Topology(COST) control scheme for mobile ad hoc networks with supportive communications.

In the following subsections, graph G handles only direct links and G* deals with SC links. A graph G** is transformed from G* .

Step 1: Construction of Clusters with P_{MAX} in G

Given graph G where V (G) = φ, E(G) = φ, edge (u, v) is constructed when there exists a direct path (i.e., without SC technology) between node u and v if the nodes operate with P_{MAX}. There exist at least two clusters in G when the network is disconnected.

Step 2: Construction of Candidates of SC Links among Clusters in G*

Given graph *G** where *V* (*G**) = *V* (*G*) and *E*(*G'*) = *φ*, if *C*(*u*) ≠ *C*(*v*)) and *u* and *v* mutually satisfy Eq. (2), a SC link (*u*, *v*) is constructed in *G**. Consequently, *G** becomes a bipartite graph where *E*(*G'*) connects two nodes that belong to different clusters. SC links in *G** and direct links in G are shown as dotted and solid lines respectively. The elements in *E*(*G**) will become the candidates for SC links connecting two separated clusters. Given that Eq. (2) is satisfied where *u* is a source node and *v* is a destination node on edge (*u*, *v*) and vice versa, edge (*u*, *v*) becomes a bidirectional SC link. If any SC link is not bi-directional, which means that connectivity is not established even if SC technology is applied, the edge does not exist in *G**. We do not consider directional edges, since these are not practical. If a link is indeed regarded as a bidirectional SC link, helper nodes and a weight are assigned to it.

The weight of a direct link (u, v) can be decided easily, since it is closely related to d_{uv}. However, for determining the weight of a SC link, we have to consider the location of helper nodes as well as d_{uv}. Thus, we need a helper decision method to minimize the weight, namely the transmission power, considering the trade- off between the cost for a SC link and that for the helper links. The basic idea is to minimize the sum of power of a source node and the helper nodes. The following subsections introduce an optimal method and a greedy heuristic algorithm, which allocate the weight and the helper nodes for each SC link in step 2.

Step 3: Reducing SC Link(s) in Graph G* and G**

*G*** is generated from *G** by converting every cluster of *G** to *V* (*G***). SC links among clusters in *G** also become *E*(*G***) which connects *V* (*G***). The number of SC links is reduced by applying the minimum spanning tree (MST) algorithm to *G***. In order to make MSTs, we use Kruskal's algorithm that does not need to select a root node. The SC links that do not belong to MSTs in *G*** are also eliminated from *G**. *G* and *G** at step 3.

Step 4: Reducing Link(s) in Each Cluster of Graph G

Within each cluster of graph G, direct links, which do not apply SC technology and are not energy efficient, are discarded by using the MST algorithm again. However, if *u* maintains a SC link chosen as a link of MST in step 3 and *v* is selected as the helper of *u* (i.e., *v* ∈ *H*(*u*)), link (*u*, *v*) should not be discarded due to the constraint of the guarantee on SC links. Thus, all helper links are chosen as links of MST in advance, before the MST algorithm is applied. Accordingly, some clusters may not be constructed as a tree. The purpose of applying the minimum spanning tree algorithm for graph *G* is to reduce the overall power consumption in each cluster. The reason why we do not apply MST in step 1 in advance is that each node needs to consider all 1-hop neighbors as possible helper node candidates in step 2.

Step 5: Combining Two Graphs, G and G*

At last, we combine the two graphs by adding *E*(*G**) to *G*. In other words, the final topology is as follows: the connection among clusters becomes the MST of the SC links, while the topology within clusters is comprised of the MST of the direct links. After the two topologies are combined, the power of each node *i* is decided by following equation.

$$P_i = \max\left\{ \max_{(i,j)\in E(G)} P_i^d(j),\ \max_{(i,j)\in E(G^*)} P_{i\cup H(i)}^c(j) \right\}$$

VI. Prototype Implementation

We built a custom simulator prototype for simulating the MANET with supportive communications that can improve the network capacity. The implementation is done using Microsoft .NET platform. C# programming language is used to attain this. The computing environment used for the application and experiments is a PC with 4 GB RAM, Quad core processor running Windows 7 operating system.

The screenshots are as follows:

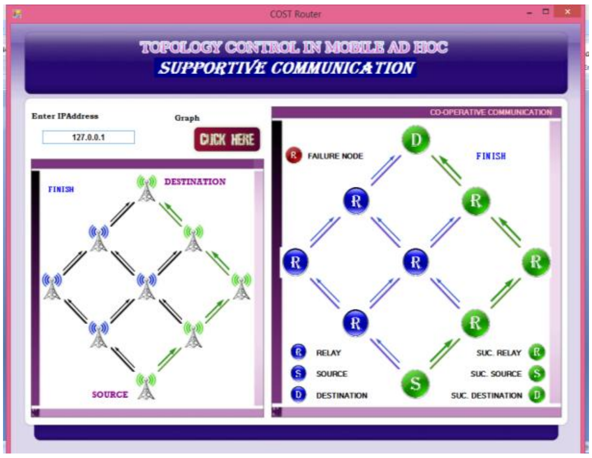


Figure 4: COST Router

VII. Conclusion

In this work, we have introduced physical layer supportive communications, topology control, as well as network capacity in MANETs. To perk up the network capacity of MANETs with supportive communications, we have proposed a Capacity-Optimized Supportive topology control scheme that considers both upper layer network capacity and physical layer relay selection in supportive communications.

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