BALANCING STABLE TOPOLOGY AND NETWORK LIFETIME IN AD HOC NETWORKS

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INTRODUCTION

Mobile ad-hoc network is an independent system of mobile nodes connected by wireless links forming a short, live, on-the-fly network even when access to the Internet is unavailable. Nodes in MANETs generally operate on low power battery devices. These nodes can function both as hosts and as routers. As a host, nodes function as a source and destination in the network and as a router, nodes act as intermediate bridges between the source and the destination giving store-and-forward services to all the neighboring nodes in the network. Easy deployment, speed of development, and decreased dependency on the infrastructure is the main reasons to use ad-hoc network.

AIMS AND OBJECTIVES

Some of the topology control methods focused on low interference. Topologies are tried to indirectly reduce the interference by reducing the transmission power or by devising low degree topologies, but none of those protocols can guarantee low interference. Network Connectivity based topology is proposed to make the correct the balance between energy consumption and node connectivity to improve the network lifetime of networks. It consists of two phases. In first phase, the reduction of interference is achieved. In second phase, efficient topology control based on energy constraint is proposed to extend the network lifetime of networks. By using the extensive simulation results using Network Simulator (NS2), the proposed scheme achieves better network lifetime, packet delivery ratio, less overhead and end to end delay than the existing schemes.

RELATED WORK

Dalu et.al [1] proposed pursue mobility model which does not maintain the topology without any control message. There is no need to change routing table as the connectivity of the network is maintained all through. No node ever diverges out of the communication range. Even if any pursuer node goes out of the maximum allowable safe distance, communication with the target node would
not be hampered, since the communication range is higher than the maximum allowable safe distance. Here the system never becomes static as a whole and hence greater efficiency is achieved in terms of time.

Jie Wu and Fei Dai [2] proposed mobility-sensitive topology control method that extends many existing mobility-insensitive protocols. Two mechanisms are introduced: consistent local views that avoid inconsistent information, and delay and mobility management that tolerate outdated information. This method is based on two mechanisms: local view synchronization based on synchronous or asynchronous “Hello” messages, and buffer zone created by slightly in-creasing the actual transmission range. These two mechanisms ensure the connectivity of both logical topology and effective topology, two notions proposed for topology control in dynamic networks.

Venkatesan [3] presented a distributed algorithm for finding a minimal connected dominating set. Our algorithm has been implemented and numerous simulation experiments have been conducted. In the simulated topologies, the algorithm converges very quickly. The worst case for our algorithm consists of all nodes being arranged symmetrically and the degree of shortest paths connectivity provided by each node is the same.

Quansheng Guan [5] proposed a distributed prediction-based cognitive topology control (PCTC) scheme to provision cognition capability to routing in CR-MANETs. PCTC is a middleware-like cross-layer module residing between CRmodule and routing. It uses cognitive link availability prediction, which is aware of the interference to primary users and user mobility, to predict the available duration of links. Based on the link prediction, PCTC captures the dynamic changes of the topology and constructs an efficient and reliable topology, which is aimed at mitigating rerouting frequency and improving end-to-end network performance such as throughput and delay.

Suchismita Routa [6] proposed a two-phase DBSS protocol which deals with topology control and provides the mechanism to reduce overall energy consumption in networks. They discussed on how topology of deployment of nodes plays an important role regarding energy conservation. In DBSS protocol it takes farthest node in its transmission range for routing. That node is geographically closer to the destination. The number of nodes in packet transferring is less. They have addressed how the topology of the network can be adjusted by controlling the transmission power. In this work the node in the farthest transmission range will take part in routing and the node that was geographically closer to the destination node is the candidate. Energy conservation is based on sleep based approaches. The energy was conserved by controlling a set of neighbor to which the node communicates.

Abhishek Majumder [7] presented an energy and mobility aware clustering approach. The clustering approach is incorporated in a DSR like protocol for routing in MANET to evaluate the performance improvement gained due to clustering using proposed approach. Rate of cluster head changes, throughput of the network, delay and routing overhead is evaluated using NS2.

Quansheng Guan [8] explored Capacity-Optimized Cooperative (COCO) topology control scheme to improve the network capacity in MANETs by jointly considering both upper layer network capacity and physical layer cooperative communications. They have introduced physical layer cooperative communications, topology control, and network capacity in MANETs. To improve the network capacity of MANETs with cooperative communications.

Atsushi Yoshinari et.al [9] proposed mechanism with an adopted topology control technique, based on a localized algorithm, can maintain local connectivity which results in keeping global network connectivity although the network is dynamic. In the proposed topology update mechanism, the update interval in each node is determined based on the transmission range and mobility information of its adjacent nodes so that the network connectivity is guaranteed.

Gaurav Srivastava [10] compared several topology algorithms like centralised and distributed topology control algorithms. They also provided a comparison of these algorithms and suggest
which algorithms may perform best. They also gave comment on the partitioning, routing, scheduling and latency issues that may arise due to topology adaptations in a mobile ad-hoc network.

Srinivas Rao et.al [11] proposed power management schemes looks into two directions. First is to balance power consumption during data transfer and secondly to reduce the power consumed in case of a route failure. By balancing power consumption we can avoid the death of some critical nodes caused by excessive power consumption. Reducing power consumption intends to prolong the lifetime of each node which in turn extends the lifetime of the entire network. Each approach proposed in the following sections improves the network’s performance either by balancing the power across the network or by reducing the power consumed by the nodes across the network.

Hiroki Nishiyama et.al [12] proposed a dynamic method is proposed to effectively employ k-edge connected topology control algorithms in MANETs. The proposed method automatically determines the appropriate value of k for each local graph based on local information while ensuring the required connectivity ratio of the whole network. The results show that the dynamic method can enhance the practicality and scalability of existing k-edge connected topology control algorithms while guaranteeing the network connectivity.

The paper is organized as follows. The Section 1 describes introduction about MANET, topology control problem in MANET. Section 2 deals with the previous work which is related to the topology control. Section 3 is devoted for the implementation of Network Connectivity based Topology Control. Section 4 describes the performance analysis and the last section concludes the work.

Materials and Methods

In the proposed network connectivity topology control, there are two phases involved. In first phase, we aim to minimize the maximum interference. In second phase, we propose the efficient topology control approach which consists of minimal weight estimation and exchanging information, topology estimation.

Interference Reduction

In a centralized model of sensor networks, the connected topology is constructed that minimizes the maximum interference. We have also introduced centralized and localized methods for reducing link interference with the help of property bounded Euclidean spanning ratio. In this algorithm, edges are sorted by their weights in ascending order.

Efficient Topology Control Approach

In this section, we propose the NCTC algorithm to build energy-efficient topology for wireless multihop networks. We model the topology of a wireless network with each node using its maximal transmission power an undirected graph $G = (L, R)$ in the two dimensional plane, where $L = \{l_1, l_2, ..., l_n\}$ is the set of nodes in the network and $R$ is the set of bidirectional links. The network may be heterogeneous, and hence each node $L_i$ may have its own transmission power $p_i$, which can be adjusted by itself. Here only bidirectional links are concerned. Therefore the bidirectional link $(l_i, l_j)$, $R$ implies that both $L_i$ and $L_j$ are covered by each other. We define the physical neighbor set of each node $L_i$ as

$$NT_i = \{l_k \mid (l_i, l_k) \in R(G)\}$$  \hspace{1cm} (1)

In NCTC, each bidirectional link is assigned a weight which can be derived from the weight function $w$. Thus the weight of a link $(l_i, l_j)$ can be expressed by $w(i, j)$. 

We use link weight to represent the energy consumption required in the transmission along a link and use path weight to represent the sum of all link weights of a path. Therefore, we define the minimal energy path as the path with the minimal path weight.

The computation of \( w(i, j) \) usually relates only to \( l_i \) and \( l_j \), at most to their neighbors. This makes it possible that each node runs NCTC only according to the locally collected information. However, the algorithm will not miss any logical neighbor which is placed on some minimal energy path in the original network. Therefore, NCTC preserves minimal energy paths in the main topology.

**CONSTRUCTION OF LOCAL TOPOLOGY**

In this step, each node \( l_i \) computes the local shortest path connecting it to every node \( l_j \in NT_i \). According to the derived link weights. The Dijkstra's algorithm can be employed if there is no negative link weight, and the time complexity varies from \( O(|NT_i| \cdot 1) \) to \( O(|ENT_i| \cdot \log|NT_i|) \) depending on the implementation of the algorithm where \( ENT_i \) is the set of all bidirectional links whose endpoints are in \( NT_i \). If negative link weights exist, then the Bellman-Ford algorithm can be used. Note that in some networks, transmissions along a link may reduce the power consumptions of the nearby nodes by using some strategy such as turning their radios off. In this case, the link may have a negative weight. Denote the local shortest path connecting \( l_x \) to \( l_y \in NT_i \) as

\[
P^x = (l_{p_0}x, y = l_1, l_{p_1}x, y, ..., l_{p_{n-1}}x, y = l_n)
\]

(3)

logical neighbor set \( NS_y^x \) can be represented by

\[
NS_y^x = \{ l_p | l_x \in NT_i \}
\]

(4)

That is, all the second nodes on the paths compose the logical neighbor set. Note that the path is bidirectional since every link on the path is bidirectional. However, the path pathj, i is not the reverse of path i,j. Another point we should mention is that not every neighbor close to \( l_i \) is its logical neighbor and meanwhile not every logical neighbor of \( l_i \) is close to it since the short link is not always energy efficient according to some realistic energy model. Through the construction of the local shortest paths, each node can derive a local route table which is described as

<table>
<thead>
<tr>
<th>Destination</th>
<th>Next hop</th>
<th>Link weight</th>
<th>Hop count</th>
<th>IR</th>
<th>CRC</th>
</tr>
</thead>
</table>

*Fig.1: Proposed Packet format*

In fig1, IR describes Interference ratio of each link. Cyclic Redundancy Check (CRC) for error correction and detection. Each physical neighbor (the destination) has an entry in the table. The link weight represents the weight of the link connecting the current node and the next hop. It can be used by upper level routing algorithm to find a least weighted path. The network topology under NCTC is all the nodes in L and their individually perceived logical neighbor relations.

**RESULTS AND DISCUSSION**

Network Simulator (NS) is an event driven network simulator developed at UC Berkeley that simulates variety of IP networks. It implements network protocols such as TCP and UPD, traffic source behavior such as FTP, Telnet, Web, CBR and VBR, router queue management mechanism.
such as Drop Tail, RED and CBQ, routing algorithms such as Dijkstra, and more. NS also implements multicasting and some of the MAC layer protocols for LAN simulations. Currently, NS (version 2) written in C++ and OTcl (Tcl script language with Object-oriented extensions developed at MIT) is available.

We use NS3 to simulate our proposed algorithm. In our simulation, 200 mobile nodes move in a 1000 meter x 1000 meter square region for 80 seconds simulation time. All nodes have the same transmission range of 300 meters. The simulated traffic is Constant Bit Rate (CBR). Our simulation settings and parameters are summarized in table 1.

<table>
<thead>
<tr>
<th>No. of Nodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Area Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 X 1000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mac</th>
</tr>
</thead>
<tbody>
<tr>
<td>802.11</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Radio Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>300m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Simulation Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 sec</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Traffic Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBR</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Packet Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>512 bytes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mobility Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random Way Point</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>AODV</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Packet rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>6pkts/sec</td>
</tr>
</tbody>
</table>

We evaluate mainly the performance according to the following metrics.

**Control overhead:** The control overhead is defined as the total number of routing control packets normalized by the total number of received data packets.

**Packet Delivery Ratio:** The packet delivery ratio (PDR) of a network is defined as the ratio of total number of data packets actually received and total number of data packets transmitted by senders.

**Node degree:** It is the important metric to evaluate the performance of topology control algorithms. If the node degree is higher, it indicates that higher collision will be. So value of node degree should be kept small.

**Network connectivity ratio:** It determines the nodes are connected in the intermediate region. It should be kept small while varying the average speed.

**End-to-End Delay:** The End-to-End delay is defined as the difference between two time instances: one when packet is generated at the sender and the other, when packet is received by the receiving application.

The simulation results are presented in the next part. We compare our proposed algorithm NCTC with DM [12] in presence of topology control environment.

Figure 2 shows the results of connectivity ratio for varying the mobility from 5 to 25. From the results, we can see that NCTC scheme has slightly lower connectivity ratio than the DM method because of light weight calculations.
Fig. 2: Mobility Vs Connectivity Ratio

Fig. 3 presents the comparison of node degree. It is clearly shown that the node degree of NCTC has low overhead than the DM.

Fig. 3: Speed Vs Node degree

Figure 4 shows the results of Time Vs End to end delay. From the results, we can see that NCTC scheme has slightly lower delay than the DM scheme because of stable routines.
CONCLUSION

Mobile nodes are communicating without any access point in MANETs. Due to the uncontrolled topologies, the more interference and more energy consumption is introduced in the networks which leads to less performance of network connectivity. In this paper, we have introduced the network connectivity based topology control to make the correct balance between the energy efficiency and interference to improve the network connectivity. In first phase, we have achieved low interference using based on the recommendation of neighbor nodes. In second phase, the efficient topology control scheme is introduced to extend the network lifetime of MANET. By simulation results we have shown that the NCTC achieves good packet delivery ratio, better network lifetime while attaining low delay, overhead, while varying the number of nodes, node velocity and mobility.

REFERENCES


Gaurav Srivastava, Paul Boustead and Joe F.Chicharo, “A Comparison of Topology Control Algorithms for Ad-hoc Networks”,


