MANET Energy efficiency analysis using MST based topology control algorithm and comparison with reactive and proactive protocols

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***Abstract* - MANET are a dynamic and infra structure less networks. The major constraint of this type of networks is Energy optimization because the nodes involved in these types of networks are battery operated. MANET has limited resources like bandwidth and energy. Due to limited battery power nodes die out early and affect the network lifetime. Both minimization of power and other QoS requirements like delay, throughputs are have to be take care properly. Mobile Ad Hoc Networks are more perceptive to these issues where each mobile device is active like a router and consequently, routing delay adds considerably to overall end-to-end delay. In this paper, we propose an energy efficiency analysis topology control algorithm. Our algorithm dynamically adjusts transmission power of mobile nodes to construct new topology which can meet bandwidth and end-to-end delay constraints as well as minimize the total energy consumption in network. This model has been compared with AODV and DSDV protocols in CBR traffic model and the simulation results show that the proposed algorithm has a better performance. Simulation and computation of energy consumed, received and transmitted energy were done with ns-2 simulator (2.34 version).**

***Keywords*- MANET, Energy minimization, topology control algorithm**

I. INTRODUCTION

MANET consists of mobile nodes which form a spontaneous network without a need of fixed infrastructure. It is an autonomous system in which mobile hosts connected by wireless links are free to move randomly and often act as routers at the same time. Hence, it forms multi-hop network. The ad-hoc networks are finding more importance likely due to the features that they can be easily deployed as well as reconfigured. This allows the use of this kind of network in special circumstances, such as disastrous events, the reduction or elimination of the wiring costs and the exchange of information among users independently from the environment. The applications for MANETs are ranging from large-scale, mobile, highly dynamic networks, to small, static networks that are constrained by power sources [1]. It can be used in military communication, commercial sectors like disaster management, emergency operations, wireless sensor networks, etc.

Mobile Ad Hoc networks have few challenges like Limited wireless transmission range, broadcast nature of the wireless medium, hidden terminal and exposed terminal problems, packet losses due to transmission errors and mobility, stimulated change of route, Battery constraints and security problem [2,3]. Quality of Service (QoS) provisioning and energy saving become more and more important [4]. The provision of QoS in MANET, is much more challenging than in wire-line network, mainly due to node mobility, multi-hop communications, contention for channel access, and a lack of central coordination [5]. Energy saving for mobile nodes is another critical issue since if a node's battery is drained, it cannot function at all. Node failures can also cause network partitioning, leading to a complete network failure and no service provisioning at all. Hence, power aware and energy efficient MAC and routing protocols have received a great deal of research attention.

Over the last several years, many researchers begin to consider adjusting the transmission power of nodes to construct a topology which can meet to QoS requirements and the total transmission power of nodes is minimized.

Cheng et al. [6] consider the approximated solutions for the minimum energy network connectivity problem in MANET. They present a theorem that reveals the relation between the energy consumption of an optimal solution and that of a spanning tree, and propose an optimization algorithm to improve the result of any spanning tree-based topology.

Wieselthier and Nguyen [7] introduce and evaluate algorithms for tree construction in infrastructureless, all-wireless applications. Energy efficiency is used as the performance metric to evaluate broadcast and multicast trees.

None of the energy efficient protocol can perform well in every condition [8, 9]. It has some advantages and inadequacy which depends on the network parameters. Energy preservation on the mobile nodes should maintain. we propose new QoS topology control algorithms that will meet the given delay and bandwidth constraints and at the same time, minimize the total transmission power for mobile nodes.

II. DESCRIPTION OF MANET PROTOCOLS

A. Dynamic Destination-Sequenced Distance-Vector Routing Protocol (DSDV)

DSDV[10] is developed on the basis of Bellman–Ford routing[2]algorithm with some modifications. In this routing protocol, each mobile node in the network keeps a routing table. Each of the routing table contains the list of all available destinations and the number of hops to each. Each table entry is tagged with a sequence number, which is originated by the destination node. Periodic transmissions of updates of the routing tables help maintaining the topology information of the network. If there is any new significant change for the routing information, the updates are transmitted immediately. So, the routing information updates might either be periodic or event driven. DSDV protocol requires each mobile node in the network to advertise its own routing table to its current neighbors. The advertisement is done either by broadcasting or by multicasting. By the advertisements, the neighboring nodes can know about any change that has occurred in the network due to the movements of nodes. The routing updates could be sent in two ways: one is called a ‘‘full dump’’ and another is ‘‘incremental.’’ In case of full dump, the entire routing table is sent to the neighbors, where as in case of incremental update, only the entries that require changes are sent.

B. AdHoc On-Demand Distance Vector Routing (AODV)

AODV [11] is basically an improvement of DSDV. But, AODV is a reactive routing protocol instead of proactive. It minimizes the number of broadcasts by creating routes based on demand, which is not the case for DSDV. When any source node wants to send a packet to a destination, it broadcasts a route request (RREQ) packet. The neighboring nodes in turn broadcast the packet to their neighbors and the process continues until the packet reaches the destination. During the process of forwarding the route request, intermediate nodes record the address of the neighbor from which the first copy of the broadcast packet is received. This record is stored in their route tables, which helps for establishing a reverse path. If additional copies of the same RREQ are later received, these packets are discarded. The reply is sent using the reverse path. For route maintenance, when a source node moves, it can reinitiate a route discovery process. If any intermediate node moves within a particular route, the neighbor of the drifted node can detect the link failure and sends a link failure notification to its upstream neighbor. This process continues until the failure notification reaches the source node. Based on the received information, the source might decide to re-initiate the route discovery phase.

III. ENERGY EFFICIENCY ANALYSIS

MANET can be represented by a weighted graph *G (V, E)*, where *V i*s the set of nodes in the network and *E i*s the set of links with connected nodes. In this paper, we adopt the widely used power mode in wireless network:

$$Pij=(dij)^{\alpha} \quad (1)$$

where *Pij* is the power required to ensure the normal communication between node *i* and *j*, *dij* is the distance between the two nodes and α is a parameter which is not less than 2. Assume that each node can dynamically adjust its power level, which can not exceed the maximal power *P*. Let $P(i)$ be the transmission power of node *i*. $\forall 0 \le i \le n$, we have $0 \le P(i) \le P$, where *n* is the number of nodes in network. According the value of transmission power we can judge whether two nodes stay connected. If $P(i) \ge (di,j)^{\alpha}$ then there exists a link between node *i* and *j*, i.e., edge $(i, j) \in E$. Let *Bs,d* and *Ds,d* denote the bandwidth and delay constraints of the node pair (*s*, *d*) respectively, and $P_{total}=\sum_{i=1}^{n} p(i)$. Thus, the QoStopology control problem in this paper can be described as follow.

Given a set of nodes *V* with their corresponding coordinates, *Bs,d* and *Ds,d* of node pair (*s*, *d*), where $s, d \in V$, we need calculate the transmission power $P(i)$ for each node *i.*

A. Bandwidth Calculation for Qos Formulation

Given a topology graph G (V, E) and the QoS constraints, Bs,d and Ds,d, of the given node pair, we need discover the QoS routing for the flows and minimize the maximal load of nodes, that is, the sum of bandwidth requirement for passing them. The mathematical model of the problem can be described as follows:

$$Min(B_{\max}) \tag{2}$$

$$\sum_j f_{i,j}^{s,d} - \sum_j f_{j,i}^{s,d} = \begin{cases} B_{s,d} & (s=i) \\ -B_{s,d} & (d=i) \\ 0 & otherwise \end{cases} \tag{3}$$

$$\sum_{(s,d)} \left(\sum_j f_{i,j}^{s,d} + \sum_j f_{j,i}^{s,d} \right) \le B_{\max} \quad \forall i,j \in V \tag{4}$$

$$\frac{1}{B_{s,d}} \sum_{(i,j)} f_{i,j}^{s,d} \le D_{s,d} \quad \forall i,j \in V \tag{5}$$

Note that for any node pair (s, d), if (i, j)$\in E$ then $f_{i,j}^{s,d}=0$ where $f_{i,j}^{s,d}=0$ denotes the sum of bandwidth required along link (i, j) between node s and d. formula (2) is the optical function, which aims to minimize the bandwidth flows require. formula (3) ensure that all links on (s, d) should meet the flows conservation. formula (4) requires that the nodes passed by most flows should meet the bandwidth constraints. formula (5) gives the delay constraints.

B. Minimum Spanning Tree Algorithm

Once the Bmax calculated in previous section is greater than the available bandwidth B, it means that the bandwidth requirement will not be met for some nodes in network. Obviously, it breaks down the bandwidth constraint and shows that the current network topology can not be available for the QoS traffic. Thus we need continually add some new links in the network until Bmax ≤ B.

Step 1: Sort edges in E by length in nondecreasing order and initialize T=ϕ;
Step 2: For each edge (u, v) $\in E$ in the sorted order, if the neighbor sets of u and v are not identical, make u connected with v in T. Randomly choose a vertex r as the root of spanning tree T;
Step 3: Implement the QoS algorithm to obtain $Bmax$ in T. If $Bmax$<=B, it means that the available QoS topology is found. Record the P(u) for node u and terminate algorithm. Otherwise, goto step 4;
Step 4: If the transmission powers of all nodes have reached their maximal P, report that there is no available QoS topology and terminate algorithm.

IV. SIMULATION ENVIRONMENT

We have used energy model as given in the following table:

TABLE I. PARAMETERS FOR ENERGY MODEL

Parameter	Value
Network Interface	WirelessPhy
MAC Type	802.11
Channel	WirelessChannel
Propogation	TwoRayGround
Antenna	OmniAntenna
Radio Frequency	281.8mW (≈250m)
Initial Energy	100 Joule
Idle Power	1.0w
Receiving Power	1.1w
Transmission Power	1.65w
Transition Power	0.6w
Sleep Power	0.001w
Transition Time	0.005s

A. Performance Matrices

In order to evaluate the performances of three MANET protocols, several metrics need to consider. These metrics reflect how efficiently the data is delivered. In epidemic routing, multiple copies may be delivered to the destination. According to the literatures, some of these metrics are suggested by the MANET working group for routing protocol evaluation [12,13].

a) *Packet Delivery Ratio*: The ratio between the number of packets originated by the application layer CBR sources and the number of packets received by the CBR sink at the final destination.

b) *End-to-End Delay:* The end to end delay is the average time interval between the generation of a packet at a source node and the successfully delivery of the packet at the destination node. Low end to end delay gives better performance of the network.

c) *Packet Dropped*: The routers might fail to deliver or drop some packets or data if they arrive when their buffer are already full. Some none, or all the packets or data might be dropped, depending on the state of the network, and it is impossible to determine what will happen in advance.

d) *Routing Load*: The total number of routing packets transmitted during the simulation. For packets sent over multiple hops, each transmission of the packet or each hop counts as one transmission.

e) *Throughput*: The total successfully received packet to the destination. In the other words, the aggregate throughput is the sum of the data rates that are delivered to all nodes in a network.

V. EXPERIMANTAL RESULTS

We report the results of the simulation experiments for the DSDV and AODV protocol with the QOSUNIFIED. In this we analyze the performance metrics by the pause time. Figure 1 plots the routing overhead of two routing protocols against pause time. Observe that QOSUNIFIED has a less overhead than DSDV and AODV. The reasons for less overhead is less route discoveries are initiated in MEERP, which lead to the flooding of RREQ.

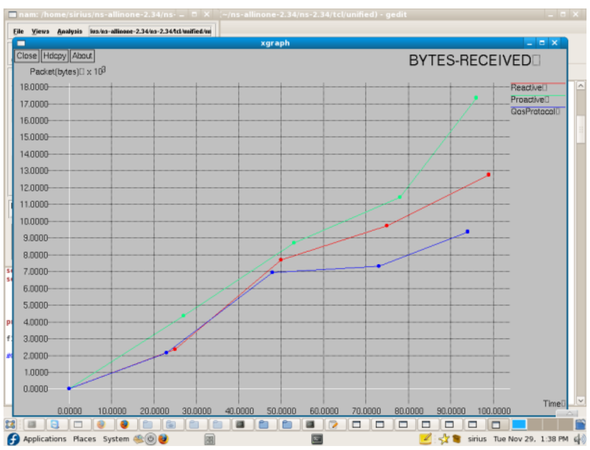

Figure 1. Bytes received in DSDV, AODV and QOSUNIFIED

Figure 2 compares the throughput for the protocols. Throughput of QOSUNIFIED is better compared to DSDV and AODV because of less Route Discovery; it saves the bandwidth and the network resources.

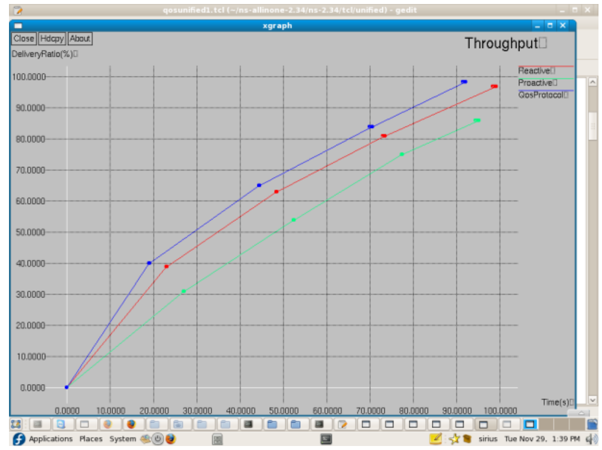

Figure 2. Throughput of DSDV,AODV and QOSUNIFIED

Figure 3 compares the packet delivery ratio of routing protocols in varying pause time. In the simulation all the nodes move the same specified speed. The graph demonstrates the QOSUNIFIED performs better than DSDV and AODV.

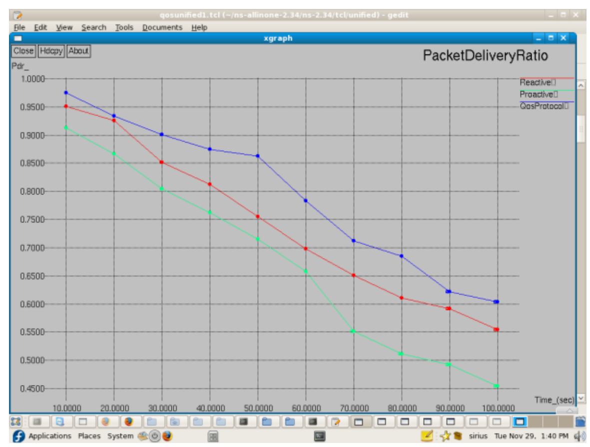

Figure3. Packet delivery ratio of DSDV,AODV and QOSUNIFIED

Figure 4 compares packet drop rate of DSDV,AODV and QOSUNIFIED. It shows that packet drop rate of QOSUNIFIED is reduced as compared to other protocols.

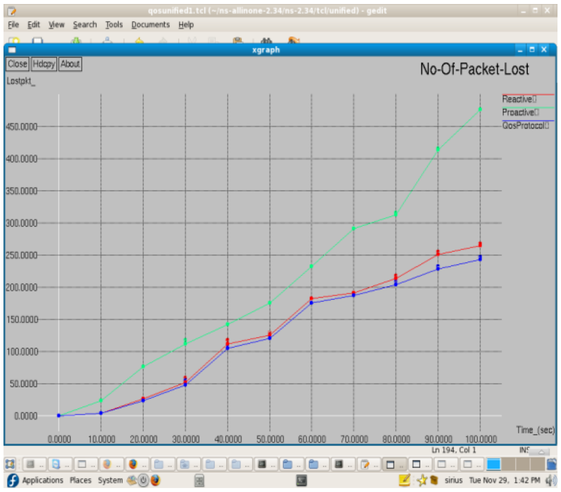

Figure 4. Packets lost in DSDV,AODV and QOSUNIFIED

Figure 5 compares the Average end-to-end delay by the different pause time. The graph demonstrates the QOSUNIFIED performs better than the other protocols; End-to-End delay is less Because of less route discovery.

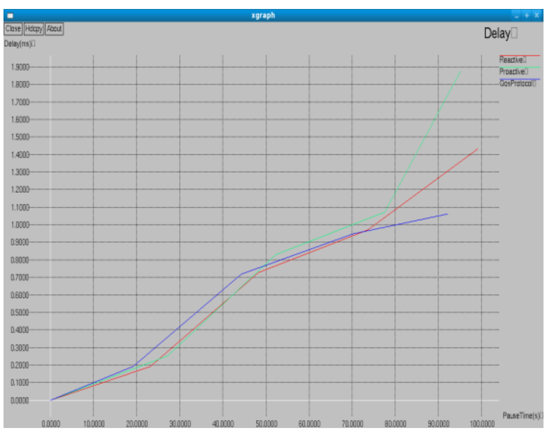

Figure 5. Delay in DSDV,AODV and QOSUNIFIED

VI. CONCLUSION

In this paper, we have discussed the energy efficient QoS topology control problem. For each node pair in network, we can adjust the transmission power of nodes and add new links into the topology so as to meet the QoS requirements. MST based algorithm namely QOSUNIFIED is proposed to construct an QoS topology. Simulation results shows that the algorithm can effectively reduce the total energy consumption of the network and achieve better performance. We test DSDV,AODV AND QOSUNIFIED protocol using ns-2 simulator, we got result that on the basis of routing overhead, throughput, packet delivery ratio, no of packet drop and End to end Delay. QOSUNIFIED give significantly good performance over other two protocols. While comparing AODV and DSDV our simulation shows that AODV protocol performs good compared to DSDV.

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