International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 3, Issue 3, September 2014)

An Energy Efficient Multicast Routing Approach for MANET

Divya Gupta[1], Madhulika Sharma[2]

[1,2]*Department of Computer Science & Engineering, AZAD Institute of Engineering and Technology, Lucknow-India*

***Abstract*— Due to highly dynamic and distributed characteristics of nodes in MANET, energy efficiency is considered an important issue. This is also important because MANET do not have fixed infrastructure and nodes are depends on their battery power. Failure of one node, due to battery energy loss, may affect the entire network. In this paper, we have proposed an energy efficient congestion control approach that minimizes the total energy cost of the multicast tree. In the first phase of the proposed solution, a multicast tree routed at the source is built by including the nodes with higher residual energy towards the receivers. In the second phase an admission control scheme is proposed in which a multicast flow is admitted or rejected depending upon on the output queue size. Because of the on-the-spot information collection and rate control, this scheme has very limited control traffic overhead and delay.**

***Keywords*— Congestion Control, Energy Efficiency, Mobile ad-hoc Network (MANET), Multicasting, Routing Protocol**

I. INTRODUCTION

All the computer network researches and best industry practices aim at providing network protocols with high degree of quality and functionality at low cost and less time. These requirements are addressed by mobile ad-hoc networks as well. Mobile ad-hoc network (MANETs) is one that comes together as needed, not necessarily with any support from the existing internet infrastructure or any kind of fixed station. We can formalized this statement by defining an ad hoc network as an autonomous system of mobile hosts (also serving as router) connected by wireless links, the union of which forms a communication network modeled in the form of any arbitrary graph. In a MANETs, no such infrastructure exists and the network topology may dynamically change in an unpredictable manner since nodes are free to move. Due to highly dynamic and distributed characteristics of nodes in MANET, energy efficiency is considered an important issue. This is also important because MANET do not have fixed infrastructure and nodes are depends on their battery power. Failure of one node, due to battery energy loss, may affect the entire network. In MANET, sometimes nodes also work as routers, so failure of such nodes may result in network partitioning. If a node runs out of energy the probability of network partitioning will be increased.

Since every node has limitation of their battery power, energy depletion has become one of the main threats to the lifetime of the mobile ad-hoc network. Energy efficient in MANETs should be in such a way that, it uses the remaining battery power in an efficient way to increase the life time of the network.

In this paper, we have proposed an energy efficient congestion control approach that minimizes the total energy cost of the multicast tree. In the first phase of the proposed solution, a multicast tree routed at the source is built by including the nodes with higher residual energy towards the receivers. In the second phase an admission control scheme is proposed in which a multicast flow is admitted or rejected depending upon on the output queue size. In this phase a scheme which adjusts the multicast traffic rate at each bottleneck of a multicast tree is proposed. Because of the on-the-spot information collection and rate control, this scheme has very limited control traffic overhead and delay. Moreover, the proposed scheme does not impose any significant changes on the queuing, scheduling or forwarding policies of existing networks.

The paper is organized as follows. Related efforts are briefly summarized in section 2. The network and energy model, for the proposed solution 'Energy Efficient Multicast Routing for Congestion Control (EEMRCC)', is described in section 3. The proposed solution is given in section 4. Finally the paper is concluded in section 5.

II. RELATED WORK

In this section, we have briefly described the work related to our approach of energy efficient congestion control protocol for mobile ad-hoc networks. Congestion control assumed as an important problem in MANET. There are several research efforts are available in the literature that put forward this issue. They are several issues related to congestion control in MANET i.e. route failure, wireless loss, shared medium issue, energy issues etc, but we have limit our discussion only for energy efficiency issue of congestion control for MANETs.

Some significant efforts are summarized here.

Kowsar and Asaduzzamanpaper [1] presented an energy efficient and cooperative congestion control protocol to control the congestion in mobile ad-hoc networks (MANETs).

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 3, Issue 3, September 2014)

In the first phase of the proposed protocol, it builds a cooperative multicast tree rooted at the source, by including the nodes with higher residual energy towards the receivers. In the second phase of the proposed protocol, it proposes an admission control scheme in which a cooperative multicast flow is admitted or rejected depending upon on the output queue size. Vijayan, Mareeswari and Samyukta [2], in their paper, presented a solution to energy conservation by a cross layered approach. They achieved this by applying congestion control algorithm for the MAC layer and then finding the maximum residual energy route in the network layer for packet transfer. Srinivas and Chari [3], in their paper, proposed a MAC layer level congestion detection mechanism. The proposed model aims to deliver an energy efficient mechanism to quantify the degree of congestion at victim node with maximal accuracy. This congestion detection mechanism is integrated with a Two-Step Cross Layer Congestion Control Routing Protocol. Reddy and Reddy [4], in their article, put forward a new cross layer and path restoration procedure. They also put forwarded two algorithms namely Path discovery Algorithm and congestion handling algorithm. Their approach of cross layer comprises of three kinds of layers called network, MAC and transport layers. Paliwal and Prakash [5], in their paper, provided energy efficient and congestion controlled relay selection algorithm ECRA which selects the best possible relay for transmission while maintaining the polynomial time complexity provided by the optimal relay assignment algorithm. Baboo and Narasimhan [6], in their paper, based on the data rate, queuing delay, link quality, residual energy and MAC overhead, they proposed to develop an energy efficient congestion aware routing protocol which uses a combined weight values as a routing metric. Based on the node weight of all the in-network nodes, the route with minimum cost index is selected among the discovered routes. They proposed to develop an Energy efficient congestion aware routing protocol (EECARP) which employs the following routing metrics: Data-rate, Buffer queuing delay, Link Quality, Residual Energy, MAC Overhead With preference given to less congested high throughput links to improve channel utilization.

It can be observed that there are several efforts available for energy efficient congestion control in the literature. The present work extend the above contributions further by proposing an energy efficient multicasting protocol for congestion control in MANET which has slightly better performance. In the next section, we have described the problem formulation and our proposed approach.

III. Network Model And Energy Model

Congestion control is a very important issue in MANETs. A mobile ad-hoc network does not have an infrastructure and also the devices do not require being within each other's communication range in order to communicate each other. The congestion control mechanisms implemented for wireless networks cannot be used as it is in MANET environment due to specific characteristics of MANET. These characteristics include the lossy wireless channels due to noise, fading and interference, and the frequent route breakage and changes due to node mobility [7]. Either one have to modify the existing congestion control approaches for traditional networks (wired networks) to make them suitable for MANET or suggest a newer approach for the purpose. An appropriate congestion control is widely considered to be a key issue for MANET. Furthermore, due to comparatively low bandwidth of mobile ad hoc networks, one single sender is able to cause a collapse of the network due to congestion [8]. The extreme effect of a single traffic flow on the network congestion can cause serious unfairness between flows. Thus wireless ad-hoc networks are much more prone to overload related problem than traditional wireless networks. Therefore an appropriate congestion control is absolutely vital for network stability and acceptable performance.

The Network Model

The network is modelled by a directed graph G = (M, L) where M represents the set of nodes (mobile devices) and L represents the set of links (between mobile devices) in the network. Here we assume that each mobile device has fixed transmission power and the locations of nodes are static or change slowly. Here we did not consider the node mobility issues. Each node m of set M is embedded in the plane i.e. there are no great differences in distance between nodes. Let s be the source node in the network and T is a multicast directed tree sourced from s. The nodes, in the network, can be categorized in two ways: the one set of the nodes that help to communicate the multicast messages from the source node s; the other set of nodes that receive multicast messages only. The farmer can be named as non-terminal nodes and the later one as terminal nodes. We further assume that the nodes that transmit messages consume energy for a multicast i.e. the nodes that only receives messages are assumed to incur little amount of energy cost for a multicast.

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 3, Issue 3, September 2014)

The Energy Model

A mobile ad-hoc network interface can be in one of the following four states: transmit, receive, idle or sleep [9]. Each state represents a different level of energy consumption.

Transmit: node is transmitting a frame with transmission power P_{tx};

Receive: node is receiving a frame with reception power P_{rx}. That energy is consumed even if the frame is discarded by the node (because it was intended for another destination, or it was not correctly decoded);

Idle (listening): even when no messages are being transmitted over the medium, the nodes stay idle and keep listening the medium with P_{idle};

Sleep: when the radio is turned off and the node is not capable of detecting signals. No communication is possible. The node uses P_{sleep} that is largely smaller than any other power.

There are different energy models that can be used to estimate the energy required by a node n to send a message for enough to read a specific neighbor place at distance d. Transmitting data packets directly to a node may consume more energy than going through some intermediate nodes. Based on this observation, most of the proposed energy models have tried to find a path that has many short range hops in order to consume the least amount of total energy.

Here, we represented the network as G, which consists of different multicast group M1, M2, ----Mn. Each group M(i) consists of n nodes. The further assumption is that the MANET estimates its remaining energy periodically. Here we did not consider the energy consumption during sleep mode and idle mode and assume energy consumption either at packet transmission or packet receiving time.

Let the total energy consumption (for a node in multicast group M(i)) per unit multicast message as E, which includes packet transmission energy and packet reception energy. The limitation of the present work is that it considers only the data packets to analyze the total energy consumption and do not consider control packets under this discussion.

According to the first-order radio model [10]:

$$E = E_{TX} + E_{RX}$$
$$= N_{TX} * e_{TX} + N_{RX} * e_{RX}$$

Where N_{TX} and N_{RX} are the number of transmissions and receivers respectively and e_{TX} and e_{RX} are the energy consumed to transmit and receive a unit multicast message via a wireless link respectively.

If e_{TX} and e_{RX} are assumed to be same and denoted by e, the total energy consumption is:

$$E= (N_{TX} + N_{RX}) * e$$

Hence, the residual energy (E_R) of each node can be calculated as

$$E_R= (\text{Current energy} – \text{Consumed energy})$$

IV. THE PROPOSED MODEL

The proposed solution for "***an energy efficient congestion control approach that minimizes the total energy cost of the multicast tree"*** is described in following two phases:

In the first phase of the proposed solution, a multicast tree routed at the source is built by including the nodes with higher residual energy towards the receivers.

In the second phase an admission control scheme is proposed in which a multicast flow is admitted or rejected depending upon on the output queue size. In this phase a scheme which adjusts the multicast traffic rate at each bottleneck of a multicast tree is proposed. Because of the on-the-spot information collection and rate control, this scheme has very limited control traffic overhead and delay. Moreover, the proposed scheme does not impose any significant changes on the queuing, scheduling or forwarding policies of existing networks.

Phase 1: Extended Energy Efficient Multicast Routing Protocol

In this section we define the how to construct the tree in Extended energy efficient Multicast Routing protocol and the algorithm that is developed in this dissertation work. The distance i.e. the geographical location of the nodes is assumed. Their residual energy is measured.

A MANET consists of dynamic collection of low power nodes with quickly changing multi-hop topologies that usually composed of relatively low bandwidth wireless links. These constraints makes multicasting in MANETs challenging. We present ***Energy Efficient Multicast Routing for Congestion Control (EEMRCC)*** algorithm which is a new localized and energy efficient routing algorithm for MANETs.

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 3, Issue 3, September 2014)

The basic idea of the proposed algorithm is to progress as much as possible in each step but using as low energy as possible. To do it, the algorithm is as conservative as possible about the goodness of the direction locally selected in each decision.

The proposed algorithm '***EEMRCC'*** works as follows.

Here we proposed three sets:

First-Set 'F': This set contains the nodes which either transmit the message or help in communicate the message to destination nodes.

Second-Set 'S': This set contains the nodes that are not included yet in the existing multicast tree.

Candidate-Set 'C': This set contains the candidates to be selected either as next transmit node or relay node.

The set *'D'* is the set of *destination nodes*.

This algorithm starts from source node 's'. Initially F contains only source node s and S is assigned to D. All outgoing neighbours of s are added to C and are removed from S if any of them are in S. The next, a node in C is selected to be included in F (based on the proposed criteria explained below) and its outgoing neighbours are added into C and also removed from S. This operation is repeated until S become empty.

In order to choose the nodes into cover set such that the total energy cost of the multicast tree is minimized, we consider a threshold energy value (E_T). If any node has energy equal or more then the threshold energy value (E_T) then it will be included otherwise it will be discarded. By doing so, the total energy cost of multicast tree can be made as small as possible. In order to guide the growth of the tree towards the destinations when there is no nodes in C that covers any node in S (i.e. there is no uncovered destination in the set of outgoing neighbors of any node in C). We select a node that is a shortest path from s to some node in S.

(If Residual energy (E_R) >= Threshold energy value (E_T), then new node will be included in the network otherwise it will be discarded.)

The algorithm of the '*EEMRCC*' is as follows:

Input: A directed graph G = (M, L) and a multicast request (s, D).

Output: An energy efficient multicast tree for request (s, D).

Procedure:

- *F = { s } //F: the first set*
- *S= D- Ms //S: the second set and Ms is the s node in set of nodes*
- *C=Ms   //C: the candidate set*
- *While (S ≠ NULL) do*
  Choose m(i) ϵ (C – F) such that
  Er (m(i)) > E_T
  - *F = F U {m(i)}*
  - *S = S - {m(i)}*
  - *C = C U {m(i)}*

Construct the multicast tree T from F.

It can be easily observed that the present algorithm can output a multicast tree. In the while loop, there is at most n loop and for each loop, finding max value takes O(n), then the while loop can finish in the time of $O(n^2)$ and the construction of the multicast tree in the last line takes the time $O(n^2)$. Therefore the whole algorithm ends in the time $O(n^2)$.

In the next section we demonstrate the proposed algorithm by example.

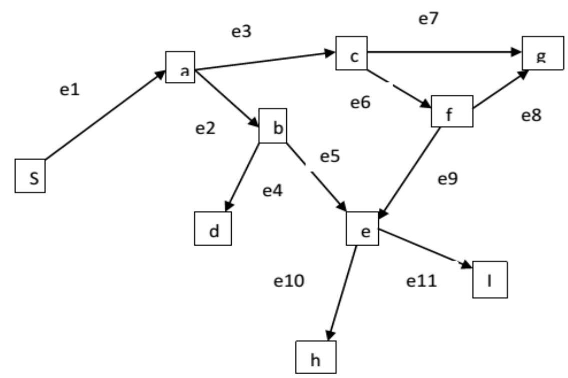

Figure 1: Multicast Tree as a Graph

In the above figure, a multicast tree is represented as a graph. In the above graph, nodes represent mobile devices and edges represent connections between nodes. The residual energy is taken as a weight of the edge that shows the current energy of each node. The node s is taken as a source node.

The algorithm will proceed as follows.

At the beginning, the sets are initialized as follows.

F = {s}
S= {a ,b ,c ,d, e, f, g, h, i}
C= {a}

Here, we compare the residual energy of s with threshold energy (E_T) and assume (e1 > (E_T)). Then after first iteration the values will be as follows.

F = {s, a}
S= {b ,c ,d, e, f, g, h, i}
C= {b, c}

Assume the residual energy of node 'a' is more than threshold energy value.

After second iteration the values will be as follows:

F = {s, a, b, c}
S= {d, e, f, g, h, i}
C= {b, c, f, g}

Now, we compare residual energy of node 'b' and 'c' with threshold value. Assume that node 'b' has energy value above the threshold value and node 'c' has energy value less than threshold value.

After third iteration the values will be as follows:

F = {s, a, b, d, e}
S= {e, f, g, h, i}
C= {h, i}

If proceed the algorithm in this manner, the message can be multicast to all member of multicast tree in an energy efficient manner.

Phase 2: Multicast Admission Control

The frequent change of the network topology and the shared nature of the wireless channel generate significant challenges for congestion control in mobile ad-hoc networks. In such a network, mobile device act as a router and message packets are communicated by intermediate nodes to their final destination. The main congestion related problems include severe throughput degradation and massive fairness problem. Data rate should be adjusted in such a way to avoid the network overload. The environment of the multi-hop wireless networks is very heterogeneous in nature, so the efficient congestion control solution depends on the properties of the respective network also.

We propose a scheme which adjusts the multicast traffic rate at each bottleneck of a multicast tree. Each node estimates its current traffic load and arrival rate.

Here we use a term 'Packet Arrival Difference (PAD)' in context of receiver node, which means the time elapsing between two successive packet arrivals. If the packet arrival difference increases at receiver node, then the probability of congestion in the ad-hoc network may increase. Each node estimates its PAD and uses this value for admission control in order to resolve the network congestion in ad-hoc network. If the PAD value is more than the threshold value, then an acknowledgment will be sent to the sender for admission control. Here we use two acknowledge message. The first acknowledge message is 'ACKB' that means to sender to block the flow of data for some time period. The second acknowledgement message is 'ACKR' that means to the sender to release the flow of data.

Assume the threshold value for packet arrival difference is 'X'.

- If PAD > X then the acknowledgement message ACKB will be send for admission control i.e. to block the flow of data for some time period.
- If PAD<X then the acknowledgement message ACKR will be send to sender to release the flow of data.

Additionally we also measure the throughput 'C' (in a certain time interval) of the nodes in the mobile ad-hoc network. If the throughput decreases significantly as compare to the previous value, then the probability of network congestion may occur. Here we consider the threshold value of throughput as C(t). If the measured throughput C is below than threshold value C(t), then acknowledgement message ACKB will be send to sender for block the flow of the data. If the measured throughput C is above than threshold value C(t), then acknowledgement message ACKR will be send to sender for release the flow of the data.

We combine the above two measurements for efficient congestion control mechanism in mobile ad-hoc network. Both sender and receiver behavior are altered appropriately for avoiding the congestion in network.

The proposed scheme overcomes most of the disadvantages of existing schemes. Link errors cannot cause the proposed scheme to wrongly block a layer, because instead of the loss information at receivers, the PAD is used as the metric to adjust the multicast traffic rate at the bottleneck. Because of the on-the-spot information collection and rate control this scheme has very limited control traffic overhead. Moreover, the proposed scheme does not impose any significant changes on the queuing, scheduling or forwarding policies of existing networks.

IJRDET

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 3, Issue 3, September 2014)

V. CONCLUSION

The proposed scheme overcomes most of the disadvantages of existing schemes: Link errors cannot cause the proposed scheme to wrongly block a layer, because instead of the loss information at receivers, the PAD is used as the metric to adjust the multicast traffic rate at the bottleneck. Because of the on-the-spot information collection and rate control this scheme has very limited control traffic overhead. Moreover, the proposed scheme does not impose any significant changes on the queuing, scheduling or forwarding policies of existing networks.

The observations of this work contribute, in a humble manner, in terms of necessary understandings that may be purposefully utilized in working out design and development of energy efficient congestion control protocols for MANET. It is understood that use of energy efficient MANET would provide reduction in cost and perhaps enhancement of quality if properly practiced. This calls for initiation of a sort of 'ad-hoc culture' with an objective of achieving maturity and perfection in such protocols so as to become capable of obtaining reduction in cost and enhancement in quality as envisioned.

REFERENCES

[1] Kowsar, S., and Asaduzzaman, I. C., 2012. An Energy Efficient and Cooperative Congestion Control Protocol in MANET, International Journal of Computer Applications, Volume 58, Number 17, pp.27-34, November 2012.

[2] Vijayan, R., Mareeswari,V., Samyukta, V. 2013. Enhancing Energy Efficiency of Routing Protocol through Cross Layer Interactions in MANET, International Journal of Engineering & Technology (0975-4024);Apr/May2013, Vol. 5 Issue 2, pp. 1147.

[3] Sreenivasa, B. C., BhanuPrakash,G. C.and Ramakrishnan,K. V. 2011. A survey on congestion control techniques in AD-HOC network, Adoc Network, Elixir Adoc Net. 32 (2011),pp. 2061-2067

[4] Reddy, T. S., Reddy; P. C., 2012. OCC: Ordered congestion control with cross layer support in Manet routing. (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 3, No. 3, 2012.

[5] Paliwal, N. & Prakash, S., 2013. Energy Efficient And Congestion Controlled Relay Node assignment in Cooperative Ad Hoc Network, International Journal Of Computer Networking, Wireless And Mobile Communications (IJCNWMC), Vol. 3, Issue 4, Oct 2013, Pp. 67-76.

[6] Baboo, S. and Narasimhan, B., 2009. An Energy-Efficient Congestion-Aware Routing Protocol for Heterogeneous Mobile Ad Hoc Networks, International Conference on Advances in Computing, Control, & Telecommunication Technologies, 2009. ACT '09, Kerala, 28-29 Dec 2009, pp. 344-350.

[7] Mirhosseini, S. M. and Torgheh, F.,2011. ADHOCTCP: Improving TCP Performance in Ad Hoc Networks, Mobile Ad-Hoc Networks: Protocol Design, Prof. Xin Wang (Ed), pp. 121-140.

[8] Lochert, C., Scheuermann, B. and Mauve, M., 2007. A survey on congestion control for mobile ad hoc networks: Research Articles.Wireless Communiation and Mobile Computing, 2007.

[9] Fotino, M. and De Rango, F, 2010. Energy Issues and Energy aware Routing in Wireless Ad-hoc Networks, nternational Journal of Communication System, Mobile Ad-Hoc Networks: Protocol Design pp. 281-296.

[10] Heinzelman, W. R., Chandrakasan, A. and Balakrishnan, H., 2000. Energy-efficient communication protocol for wireless microsensor networks, in Proceedings of the 33rd Annual Hawaii International Conference on System Siences (HICSS-33 '00), January 2000.