A Survey on Energy Efficient Protocol for Multicasting in Mobile Ad Hoc Network

Prof. Chandrashekhar Goswami
PRMITR Badnera, Maharashtra, India.

Prof. Swapnil Deshmukh
PRMITR Badnera, Maharashtra, India.

Abstract – Mobile ad-hoc networks (MANETs) allow portable mobile devices to establish communication path without having any central infrastructure. Since there is no central infrastructure and the mobile devices are moving randomly, they may give rise to various kinds of problems, such as energy efficient and multicast congestion control. In this paper the problem of multicast congestion control is considered. Energy Efficient is one of the key issues in MANETs because of highly dynamic and distributed nature of nodes. Especially energy efficient is most important because all the nodes are battery powered. Failure of one node may affect the entire network. If a node runs out of energy the probability of network partitioning will be increased. Since every mobile node has limited power supply, energy depletion has become one of the main threats to the lifetime of the mobile ad-hoc network. So 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.

This paper work presents an energy efficient and reliable congestion control (EERCC) protocol for multicasting in MANETs. The proposed scheme overcomes the disadvantages of existing multicast congestion control protocols (AODV) which depend on individual receivers to detect congestion and adjust their receiving rates. The energy efficient and reliable congestion control protocol for multicasting in MANETs is implemented in three phases:

In the first phase of EERCC protocol, 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 the third 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. Simulation results shows that the proposed EERCC protocol has better delivery ratio and throughput with less delay and energy consumption when compared with existing protocol.

Index Terms – EERCC, MANET, AODV, Protocol, Energy.

1. INTRODUCTION

A mobile ad-hoc network (MANET) is composed of mobile nodes without any infrastructure. Mobile nodes self-organize to form a network over radio links. The goal of MANETs is to extend mobility into the realm of autonomous, mobile and wireless domains, where a set of nodes form the network routing infrastructure in an ad-hoc fashion. The majority of applications of MANETs are in areas where rapid deployment and dynamic reconfiguration are necessary and wired network is not available. These include military battlefields, emergency search, rescue sites, classrooms and conventions, where participants share information dynamically using their mobile devices. These applications lend themselves well to multicast operations [1]. Multicasting can be used to improve the efficiency of the wireless link when sending multiple copies of messages to exploit the inherent broadcast nature of wireless transmission. So multicast plays an important role in MANETs Unlike typical wired multicast routing protocols, multicast routing for MANETs must address a diverse range of issues due to the characteristics of MANETs, such as low bandwidth, mobility and low power. MANETs deliver lower bandwidth than wired networks; therefore, the information collection during the formation of a routing table is expensive [1].

1.1. Proposed Solution

In this paper, we propose to design an energy efficient and reliable congestion control (EERCCP) protocol for multicasting with the following phases.

In its first phase, it builds a multicast tree routed at the source, by including the nodes with higher residual energy towards the receivers. Most of the existing schemes (AODV) depend on individual receivers to detect congestion and adjust their receiving rates which arc much disadvantageous. In the second phase, we propose an admission control scheme in which a multicast flow is admitted or rejected depending upon on the output queue size. In the third phase, we propose a scheme which adjusts the multicast traffic rate at each bottleneck of a multicast tree.

2. ENERGY EFFICIENT AND RELIABLE CONGESTION CONTROL PROTOCOL

2.1. Energy Efficient Tree Construction

In our energy efficient and reliable congestion control protocol we build a multicast tree routed at the source towards the receivers. The distance i.e. the geographical location of the nodes is assumed. Their residual energy is measured. The nodes are sorted based on its location from the source and arranged in a sequence order. A threshold value Q is set and the nodes which are less than Q (n<Q) are unicast from the source and the nodes which are greater than Q (n>Q) are multicast. In case of multicasting the node which has the minimum energy per corresponding receiver is set as the relay node. The relay node then forwards the packets from the source to the corresponding receivers.

2.2. Calculating Residual Energy of a Node

Consider a network with multicast groups G_1, G_2………………Gx. Each group {Gi} consists of N nodes. Every node in the MANET calculates its remaining energy periodically. The nodes may operate in either transmission or reception mode. Let $\{E_1, E_2 \ldots\ldots E_n\}$ are the residual energies of the nodes measured by the following method.

The power consumed for transmitting a packet is given by the Eq(1)

Consumed energy = TP * t (1)

Where TP is the transmitting power and t is transmission time. The power consumed for receiving a packet is given by Eq (2)

Consumed energy = RP * t (2)

Where RP is the reception power and t is the reception time.

The value t can be calculated as

t=Ds/Dr (3)

Ds is Data size and Dr is Data rate

Hence, the residual energy (E) of each node can be calculated using Eq (1) or Eq (2) and Eq (3)

E = Current energy - Consumed energy

2.3. Algorithm

1. Consider a group Gj = $\{N_1, N_2 \ldots\ldots\ldots\ldots N_n\}$
2. Measure the distance d of each node from source d(S,Ni) where i = l,2……..n
3. Sort the nodes N1 in ascending order of d.
4. Create the partitions Xl and X2 of the nodes Ni such that
   $X_l = \{N_1 \ldots\ldots\ldots\ldots N_Q\}$
   $X_2 = \{N_{Q+1} \ldots\ldots\ldots N_n\}$
   Where Q is the distance threshold.
5. Source unicast the packets to X_1
6. In X_2 find a relay node Nr which has max (Ei)
7. Then S unicast the packets to N which in turn multicast the packets to the rest of the nodes in X_2.

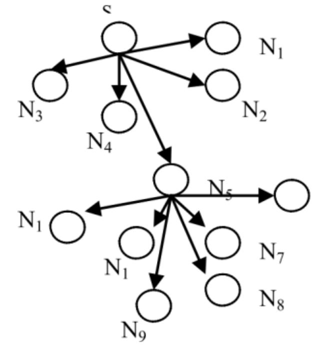

Figure 1: Energy efficient tree construction

Source S unicast the packets to nodes N1 N2 N3 N4 and N5. N5 is the relay node. N5 multicast the packets to the rest of the nodes N_6……….. N_{11}.

2.4. Multicast Admission Control

Most of the existing schemes depend on individual receivers to detect congestion and adjust their receiving rates which are much disadvantageous. 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. Based on its traffic load, it estimates the receiving rate. If the receiving rate is less than the arrival rate, it adaptively adjusts its receiving rate.

In order to adjust the total number of multicast flows which traverse a bottleneck, the following procedure is used. In our proposed scheme, based on the link's output queue state, multicast flows at a bottleneck can be blocked or released. Let the number of packets in the queue is N. Let QT1 and QT2 (QT1 <QT2) are two thresholds for the queue size. Then the flow is released or blocked based on the following conditions.

If N<= QT1, then the multicast flow is released.

If N> QT2, then the multicast flow is blocked.

In most of the existing schemes, in order to detect congestion and for adjusting the receiving rate they depend on the individual receivers. In our proposed scheme multicast traffic rate is adjusted at each bottleneck of a multicast tree. Whenever congestion happens or about to, then the multicast sessions which traverse the branch are blocked. Thus the packets are stopped from entering the branch. The blocked flows are released to traverse the branch when the branch is lightly utilized.

2.5. Multicast Traffic Rate Adjustment

When the available bandwidth is less than the required bandwidth or the queue size is less than a minimum threshold value, it indicates the possibility of congestion or packet loss. The behavior of the multicast session is expressed as

$$R(t+1) = \begin{cases} R(t) - g & R(t) > B \\ R(t) + g & R(t) <= B \\ R(t) & \text{otherwise} \end{cases}$$

Here R (t) denotes the instantaneous rate of the multicast session at time t.

B is the bottleneck bandwidth.

When R (t) > B then the network is congested and the multicast session decreases its rate by a step g.

If R (t) <=B then the network is not congested and the multicast session increases its rate by a step g.

The proposed scheme overcomes most of the disadvantages of existing schemes:

1. Link errors cannot cause the proposed scheme to wrongly block a layer, because instead of the loss information at receivers, the queue state at a bottleneck is used as the metric to adjust the multicast traffic rate at the bottleneck.
2. Link access delay caused by competition in MANETs cannot hinder the rate adjustment in this scheme, because, it blocks multicast layers right at each bottleneck of a multicast tree instead of depending on receivers to request pruning to drop layers.
3. 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.

3. SIMULATION RESULTS

3.1. Simulation Model and Parameters

NS2 is used to simulate our proposed protocol. The channel capacity of mobile hosts is set to the same value: 2 Mbps. We use the distributed coordination function (DCF) of IEEE 802.11 for wireless LANs as the MAC layer protocol. It has the functionality to notify the network layer about link breakage. In this 50 mobile nodes move in a 1000 meter x 1000 meter region for 50 seconds simulation time. By assuming, each node moves independently with the same average speed. All nodes have the same transmission range of 250 meters. The minimal speed is 5 m/s and maximal speed is 5 m/s. The simulated traffic is Constant Bit Rate (CBR). Simulation settings and parameters are summarized in table 1.

No. of Nodes	40
Area Size	500 X500
Mac	802.11
Radio Range	250m
Simulation Time	30 sec
Traffic Source	CBR
Packet Size	250,500,…1000
Mobility Model	Random Way Point
Speed	5m/s
Receivers	5,10,…25
Pause time	5 s
Transmit Power	0.660 w
Receiving Power	0.395 w
Idle Power	0.335 w
Initial Energy	3.1 J

Table1: Simulation Parameters

3.2. Based On Receivers

In this experiment, we vary the group size or the number of receivers per group as 5,10…..25.

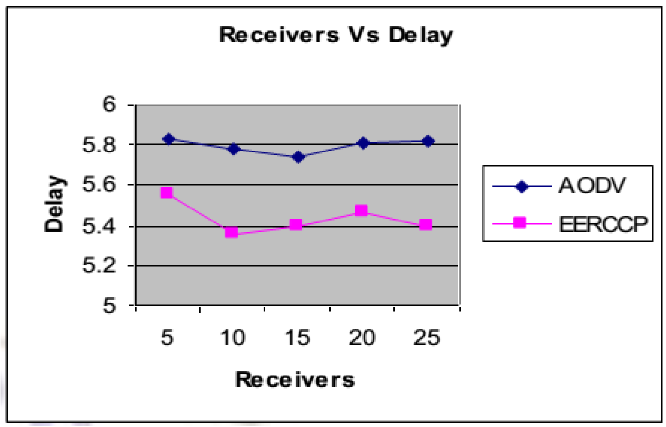

Fig 2: Receiver Vs Delay

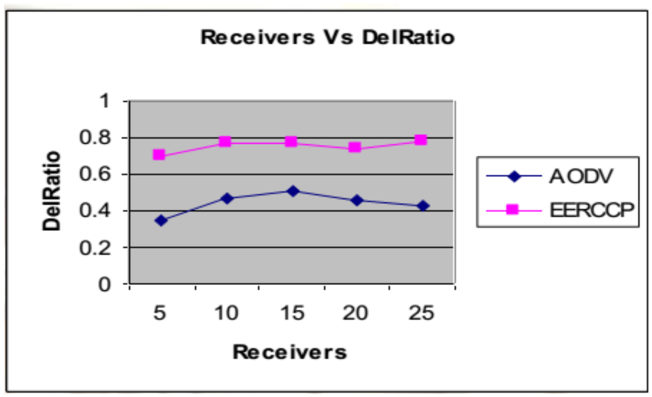

Fig. 3: Receivers Vs Delivery Ratio

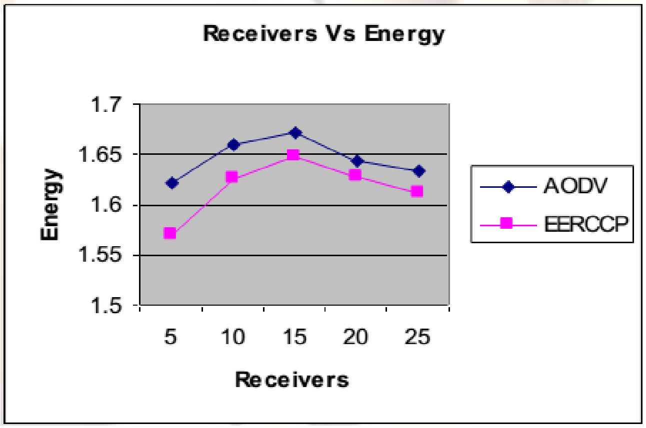

Fig. 4: Receivers Vs Energy

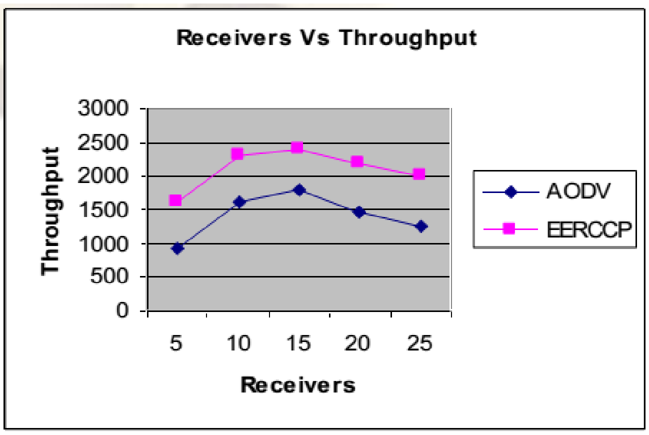

Fig. 5: Receivers Vs Throughput

When the number of receivers is increased, Figure 2 shows the end-to-end delay occurred for both AODV and EERCCP. As we can see from the figure, the delay is less for EERCCP, when compared to AODV. Figure 3 shows the delivery ratio for both AODV and EERCCP. As we can see from the figure, the delivery ratio is high for EERCCP, when compared to AODV. Figure 4 shows the energy consumption for both the cases. As we can see from the figure, the energy consumption is less for EERCCP, when compared to AODV. Figure 5 shows the throughput occurred for both the cases. As we can see from the figure, the throughput is high for EERCCP, when compared to AODV.

4. CONCLUSION

In this paper MANET, its properties and challenges in the energy efficiency, congestion control and the different types of routing algorithms and its properties are analyzed. An energy efficient and reliable congestion control protocol for multicasting in mobile ad-hoc networks (MANETs) is proposed. EERCC protocol overcomes the disadvantages of existing multicast congestion control protocols which depend on individual receivers to detect congestion and adjust their receiving rates. 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. Simulation results have shown that our proposed protocol has better delivery ratio and throughput with less delay and energy consumption when compared with existing protocol and the performance is better than existing multicast congestion control protocols. EERCC concluded that energy efficient and congestion control for multicasting in mobile ad hoc networks works far better than multicast congestion control protocols in giving more lifetimes to the network.

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