International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

Network Performance Optimization based on AODV Routing in MANET

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Abstract: ***Ad hoc On-Demand Distance Vector (AODV), is based on distance vector routing, that guarantees loop-free routes by using sequence numbers that indicate how new, or fresh, a route is and select minimal length path according to less number of hop-count, as a distance metric. However, AODV routing protocol itself does not consider the current load of node's in the process of route discovery, so it may result in congestion in the path and localized network congestion. In This paper proposed mechanism combines improvement of Random Early Detection [RED] by self parameter adjustment for performance optimization and with AODV protocol optimization by diverting packet transmission from congested route to non congested route, to improve network performance. Experimental result shows that it achieves high throughput and higher packet delivery ratio in Mobile Ad hoc network.***

Keywords: Ad Hoc network; AODV routing protocol; Random Early Detection; congestion control**.**

1. Introduction

Mobile Ad hoc Network (MANET) [1] is self-organizing network of mobile devices which does not rely in any fixed infrastructure. MANET devices can be laptop, mobile phones and personal digital assistance (PDA's) is called mobile nodes. Nodes in MANET can take part in the communication only if they are in the communication range of the network, and can move freely within transmission range of the network, and nodes which are outside the transmission range of the network cannot take part in communication. The dynamic nature of MANET with limited resources that can vary with time such as battery power, storage space bandwidth makes QoS provisioning, a challenging problem. For preventing congestion, in current internet uses end-to-end congestion control [2], in this mechanism end host is responsible for detection of congestion. Packet loss is treated as an incipient congestion notification signal from routers. After detection of incipient congestion, packet transmission rate is reduced by the source to decrease the congestion.

One of recent research areas of the network is seeking some mechanism to avoid high packet loss rates. When a packet is dropped before it reaches to its destination, all the resources has been consumed in transit are inevitably wasted. In extreme cases, this situation can lead to congestion collapse in which high degrees of packet delay and loss occurs caused by routers discarding packets due to excessive queue size. Congestion control and queue management in the network have been one of the active areas of research in the past few years. Some enhancements have been made by the researchers to solve the problems of high packet loss rates, which are especially high during heavy network congestion, when a large number of connections compete for limited network bandwidth. Due to an exponential increase in network traffic, many ad hoc network congestion control mechanisms have been proposed, including the deploying explicit congestion notification (ECN), along with Random Early Detection (RED) techniques.

The rest of the paper is constructed as follows, section 2 discusses the AODV protocol, section 3 discusses about Random Early Detection process in details; section 4 discusses about related works; section 5 discusses proposed work section 6 contains results of network performance optimization in detail; section 7 concludes the paper.

2. AODV Protocol

Ad hoc On-Demand Distance Vector, AODV [2], is a distance vector routing protocol, which is reactive. This reactive property of the AODV routing protocol suggest that it only requests a route when it needs one to transmission and does not require that the mobile nodes maintain routes to destinations that are not communicating. AODV protocol guarantees loop-free routes by using route sequence numbers which indicate how new, or fresh, a route is. The AODV protocol is one of the on-demand routing protocols for ad-hoc networks which are currently developed by the IETF Mobile Ad-hoc Networks (MANET) working group. It follows the distance vector approach instead of source routing. In AODV, every node keeps a local routing table that contains the information to which of its neighbors it has to forward a data packet so that it reaches eventually the desired destination. In general, it is required to use routes which can have minimal length according to hop-count as a distance metric.

2.1 Route discovery

Whenever a source node desires a route to a destination node for which it does not al-ready have a route, it broadcasts a route request (RREQ) message to all its neighbors. The neighbors update their own information for the source and create reverse route entries for the source node in their routing table. A neighbour receiving a RREQ may send a route reply (RREP) if it is either the destination or if it has an unexpired route to the destination? If any of these two cases is satisfied, the neighbour unicast a RREP back to the source node. Along the path back to the source, intermediate nodes that receive the RREP create forward route entries for the destination node in their routing tables. If none of the two cases mentioned is satisfied, the neighbour again forwards the RREQ.

2.2 Route maintenance

Nodes detect link status by periodically broadcasting HELLO packets. When a broken link in an active route is detected, firstly, the node lists those unreachable destination nodes in the unreachable area and any other node which uses those unreachable areas for the next hop in the local routing table, then a RERR message is used to notify other nodes that the loss of that link has occurred. The RERR message indicates those destinations which are no longer reachable in the way of the broken link. If a node receives RERR packets and use of the notified invalid route, it will do a new route discovery process. When the destination node detects an invalid link which is connected with it will not take the initiative to generate REER packets, but make its sequence number plus 1.

3. Random Early Detection

Floyds et al proposed Random Early Detection (RED) [3] in 1993. The basic idea of this mechanism is that the router can detect incipient congestion by monitoring the average queue length. Once the congestion is detected, router selects the source terminal to notify the congestion. So the source terminal can reduce the data transmission rate before the queue overflow, and try to alleviate the network congestion. RED [4][5][6] algorithm consists of two steps: the first step is to calculates the average queue length, and the second step calculate the packet drop probability. Packet drop probability to decide whether to drop that packet or not, packet drop is treated as the signal of congestion.

a. Calculation of the Average Queue Length

RED calculates the average queue length (Avgq), by using the following formula:

Avgq = (1−Wq) * Avgq + q *Wq ……………… (1)

Here, Wq represents the weighted value, and q represents the actual queue length in the sampling moments.

b. Calculation of the Packets Drop Probability

RED has two thresholds Minth and Maxth, which are related with queue length. When the packet reaches the router, RED calculates the average of the queue length Avgq immediately. Then it determines the packet drop probability based on Avgq , Minth and Maxth . When avgq is greater than Maxth, all packets are discarded, and the packet loss rate is 1. When Avgq is between Minth and Maxth, we have the following Packet Drop Probability (PDP) formula:

Pb = Maxp * (Avgq-Minth) / (Maxth-Minth) (2)

P = Pb / (1 – count* Pb) (3)

Packet drop probability is used to decide whether to drop the packet or not, packet drop is treated as the signal of congestion.

4. Related Work

Zuhong Feng, et al presented a mechanism an improved routing protocol Ad-AODV Based on AODV [7] to improve AODV routing protocol which doesn't consider the residual energy and the load situation of the nodes when choosing routes, its efficiency declines sharply in the case of the high load and fast moving velocity. To solve the above problems, author has proposed an improved protocol Advanced-AODV (Ad-AODV) of the AODV routing algorithm based on load balancing and a strategy of energy model. When Ad-AODV routing protocol performs the route request, it will consider the load situation and residual energy of nodes. In the simulation results, the Ad-AODV routing protocol improves the efficiency of network, and the packet delivery ratio, reduces the routing load and lowers the average end-to-end delay.

Ling Liu, et al [8] presented, a new QoS-aware routing protocol based on AODV named QAODV (QoS- AODV). Under the premise of available bandwidth and the delay meeting the QoS demands, the protocol defines metric for new route according to the load rate and the hop count and so as to select the best available route according to it. In this paper results show that, as compared with AODV, the performance of QAODV is better in both network throughput and end-to-end delay with small increase of control overhead.

Li Yuanzhou, et al presented a mechanism Optimization Strategy for Mobile Ad Hoc Network Based on AODV Routing Protocol [9] in this paper performance is optimized on the basis of optimization of route discovery process, in this, the intermediate nodes handle the received packets according to their load state, their load state can be determined by calculation of the average queue length in Random Early Detection [RED]. When node receives RREQ packet According to the method of RED, set a maximum and minimum threshold for judging the handle method of RREQ packet early. According to the different network environment, parameter values should be adjusted accordingly.

S. Sridhara, et al [10] discusses the General AODV routing problems like long route, time delay, mobility and many others while routing. Due to low energy level in the nodes, it will not be in a position to complete the routing. Then the QoS parameters like throughput, delay and Packet Delivery Ratio are affected directly. Author has proposed Energy based AODV protocol named (EN-AODV) announces energy based on nodes, receiving and sending rates and the amount of the data transmitted. It checks whether its energy level is maintained or decreased. It also calculates the nodes energy level before they are selected for routing path. In this a threshold value is defined and nodes consider routing only if its energy level is above this threshold. The simulation results have shown a decrease in delay, an increase in PDR, and throughput is maintained.

5. Proposed Work

Due to the limited range of each mobile host's wireless transmission, each device needs to work in collaboration for communication in the network. In AODV protocol route is established by broadcasting route request packet without considering their load which may cause congestion, in the proposed mechanism intermediate nodes will handle the route request packets according to their load state, whether it is congested or not . When node receives RREQ packet, it can apply delay on RREQ packet to force to follow the route which is less congested and this method is also combined with Enhanced Random Early Detection (ERED) which is based on optimize queue utilization and reducing parameter sensitivity of RED by more accurate calculation of Packet Drop Probability (PDP) by applying some sets of thresholds into a queue between minimum threshold and a maximum threshold.

5.1 Proposed Algorithm

Algorithm for AODV protocol

```
Length=ifqueue->length();
limit=ifqueue->limit();
if (length <= 0.4*limit)
{ T = 0.0; } // T is applied delay
else if (length <= 0.7*limit)
{ T = 0.2; }
else { T = 0.5;}
```

In this algorithm first AODV protocol fetch the length and limit of queue in each node, length of queue in node is number of packets in the queue at any time and limit of queue is maximum number of packets that can store at any time. According to the queue status nodes can apply the delay (T) in Route Reply packets (RREP) during route discovery process when it receives Route Request packet (RREQ) according to their load state and follow the route which less congested.

Algorithm for ERED mechanism

```
Step 1: Check whether average queue size (avg) is
 less th_min then

cur_max_p = 0;

Step 2: Check whether average queue size is greater
than th_max then increase th_max by size of
incoming packet by using following function
th_max += size;
a =( 1.0 - max_p) / th_max;
b = 2.0 * cur_max_p - 1.0;
p = a * avg + b; }

Step 3: check whether avg is between min_th and t1
where t1 is midpoint of th_min and th_max

if (avg >= th_min && avg <= t1)
{ if (th_diff > (0.5*qlim))
 { th_max -=size; }
p =(avg - th_min)/(th_max - th_min) }

Step 4: check whether avg is between t1 and th_max

p = (avg - t1)/(th_max - th_min);
}
p *= cur_max_p;
 }
 if (p > 1.0)
 p = 1.0;
 return p; }
```

Proposed ERED algorithm attempts to dynamically modify its parameters as a function of average queue size. Proposed algorithm combines the RED and window adjustment methods [11], leveraging the advantages from both while mitigating the drawbacks. Specifically, this algorithm estimates the average queue size (avg) to estimate congestion level in the network. In the meanwhile, the packet dropping probability is monitored. This proposed algorithm makes accurate estimation because of applying extra threshold for that purpose in queue. This algorithm applies queue window adjustment to mitigate the packet dropping probability and traffic oscillation. As a result, the proposed approach can perform TCP flow control with fast response and improved stability.

6. Result and Graph

Under the Linux system in a virtual machine, we used NS2 (version 2.34) to simulate the network environment and carried result analysis on the performance of existing mechanism and proposed mechanism.

A. Packet delivery Ratio

Packet Delivery Ratio is calculated as the number of packets delivered at destination to the number of packet transmitted by the source.

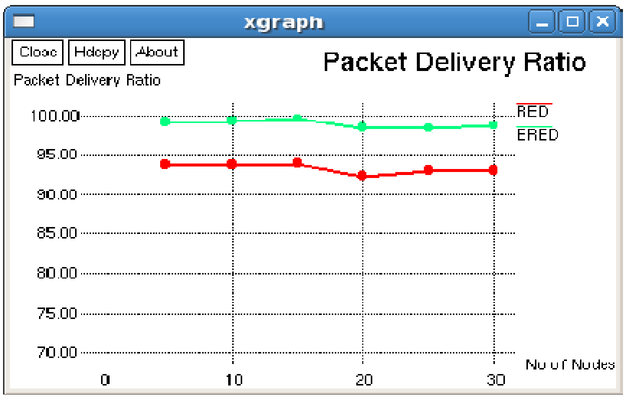

Figure 1: Packet delivery Ratio

From the figure 1, it is shown that the packet delivery ratio line is constantly above the line that of standard Random Early Detection, which shows that packet delivery ratio, is consistently above in each case of using different no of nodes configuration from 5 nodes to 30 nodes. From figure 1 it is shown that Random Early Detection, having Packet

Delivery Ratio (PDR) consistent around 92 and proposed mechanism having PDR around 98 to approaching 100.

Table 1: Packet delivery Ratio

Number of nodes	*RED*	*ERED*
5	93.35	99.132
10	93.59	99.308
15	93.62	99.500
20	92.33	98.422
25	93.02	98.32
30	92.99	98.657

Figure 1 shows that the packet delivery ratio of ERED is higher than standard RED. Numerical analysis is done in Table 1. Numerical analysis shows that PDR is consistently higher in ERED than standard RED.

B. Throughput

Throughput is the average rate of successful data delivery over the communication channel. Throughput is generally measured in bits per second (bit/s) or in kbps, and sometimes in data packets per second or data packets per time slot.

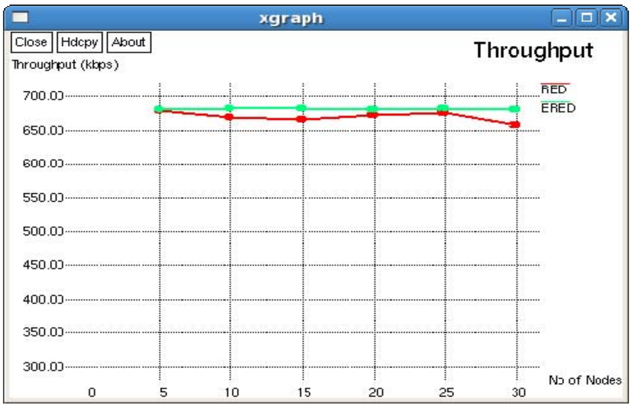

Figure 2: Throughput

Figure 2 shows the throughput of both standard Random Early Detection and the proposed Enhanced random Early Detection. Comparing of both mechanisms, it shows that proposed mechanism ERED having higher throughput than standard RED.

Table 2: Throughput

Number of nodes	*RED*	*ERED*
5	659.4	681.01
10	669.41	683.18
15	654.99	681.58
20	672.57	680.27
25	676.22	681.83
30	657.69	680.43

Figure 2 shows that throughput of ERED is higher than standard RED. Numerical analysis is done in Table 2. Numerical analysis shows that throughput is consistently higher in ERED than standard RED.

7. Conclusion

This paper discusses about the characteristics of the wireless ad hoc networks and the AQM algorithms and AODV protocol available in the wireless networks. Due to the inconsistent nature of the wireless ad hoc network, this paper motivated the need for Improved Active Queue Management and presented a new scheme to Enhance Random Early Detection (ERED) which, is easy to implement and imposes minimal computational burden on resource constrained devices. Results from this paper have shown that MANET performance can be improved by using ERED as it increases the packet delivery ratio and increases Throughput. Moreover, as its computational burden is negligible, it can be ideally suited for resource constrained environments such as MANETs.

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