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Improved Performance of PDR and Throughput using Enhanced RED for Congestion Control in MANET

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ABSTRACT: Congestion control methods are continuously linked with the rapid advances in internet and network technology. Congestion generally occurs when the amount of packets arriving at the router buffer cannot be accommodated. For effective load balancing, congestion control and to improve energy-routing matrices, authentic capture of the load at various locations of the network is required. Random Early Detection (RED) is one of the most prominent congestion avoidance schemes in the internet routers. To overcome the limitations of the basic RED algorithm, several variants of RED are proposed. This paper propose an algorithm, with minimal changes to the overall RED algorithm which provides effective solution to avoid congestion collapse of network services by introducing new threshold U^{th} (Upper Threshold). Our proposed algorithm is URED (Upper threshold RED). Our aim is to design an efficient congestion control algorithm to enhance throughput and packet delivery ratio. Simulation is done in 2.34 simulator environment. Simulation results shows that our new Enhance RED algorithm gives better performance than existing Random Early Detection algorithm by solving some problem in RED. Comparisons are shown in terms of throughput and packet delivery ratio.

KEYWORDS: Random Early Detection algorithm, Upper threshold Random Early Detection algorithm, Throughput, Packet delivery ratio, Energy conservation and QoS**.**

I. INTRODUCTION

Mobile Ad hoc Network (MANET) is self-organizing network of mobile devices which does not relay in any fixed infrastructure. A Mobile Ad hoc Network (MANET) is a collection of mobile nodes relying neither on fixed communication infrastructures nor on any base stations to supply connectivity each node in the MANET acts both as a router and a host. If two nodes are not under the transmission range of each other, other nodes are required to serve as mediate routers for the communication between the two nodes. The hosts are free to move around randomly, and hence the network topology may change dynamically over time [1, 2]. MANET devices can take part in the communication only if they are in the communication range of network, and can move freely within transmission range of network, and devices which are outside the transmission range of network cannot take part in communication. As the number of data packets transferring increases, the data traffic increases in the network, as a result congestion will occur. Load balancing and congestion control are difficult task in MANET [3]. Congestion is a state in communication networks in which too many packets are present in a part of the subnet. Congestion may occur when the load on the network is greater than the capacity of the network. RED (Random early detection) algorithm is used to detect congestion by monitoring the average queue length of the output of the router.

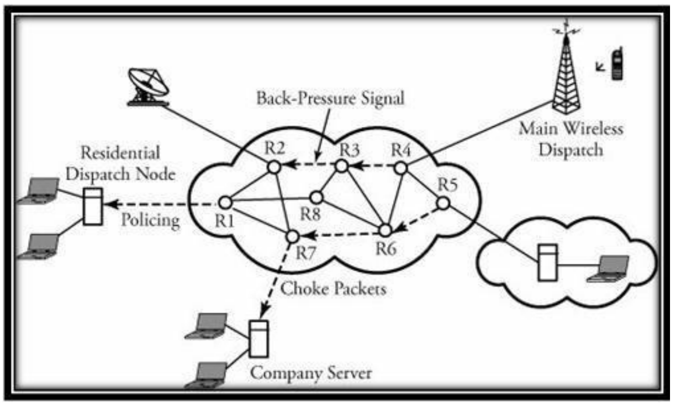

Fig.1. Congestion in network

Random Early Detection is better than tail drop, in the sense it does not have a bias against busty traffic that uses only a small portion of the bandwidth. RED is congestion avoidance technique. It also avoids global synchronization by randomly choosing packets to be marked or dropped before the queue gets full. RED achieves improved stability with reduced oscillation and higher throughout [1].The advantage of RED algorithm is simple and easy to implement, it eliminates the global synchronization, and improves the utilization of the physical links very much. [4].The key feature of RED is to calculate the average queue size length from the current queue length with the help of Exponential Weighted Moving Average (EWMA).

In this paper we are analyzing the performance of packet delivery ratio, end to end delay and throughput of MANET via enhancing Random early detection and observe how it effects to QoS of existing mobile Ad hoc network.

The rest of the paper is organized as follows: Section II presents the related work. Section III describes our proposed working model. Section IV presents the simulation experiment setup and gives the performance evaluation of our proposed strategy. Section V concludes the paper.

II. RELATED WORK

Congestion control techniques are used to reduce network failure when transmission is slower than source sending rate.
A. L. Tuan et al. [20] proposes a multipath protocol based on energy aware and congestion control. It avoids all congested and high energy consuming paths and selects lighter paths. The property of multipath connection is that it can transmit multiple flows simultaneously. The proposed algorithm measures the energy for both data transmission and data reception between two end hosts. Sender side calculates end to end energy consumption while at receiver side data and ACK cost is calculated.

S. Karunakaran and P. Thangaraj [21] have proposed a cluster based congestion control mechanism. This scheme provides a scalable and distributed way of creating clusters. The schemes automatically create clusters of entire network based on its localization scope.

Y. Yuang et al. [22] has proposed a hop by hop congestion control scheme. Channel access time is taken as a parameter in MAC. The proposed algorithm outperforms in absence of delay. While in case of delay the algorithm varies in results of simulations. By providing the peak load to the algorithm is simulated both in hop by hop fashion and delay. It is concluded that proposed scheme works better in hop-by-hop fashion rather than end-to-end delay.

S. Harion et al. [23] propose a technique named Random Early Detection (RED). In this technique an active queue is managed to in such a way that limited number of data packets are allowed to enter into queue. A threshold value is set after that all incoming packets are dropped. It shows that packet drop is a common problem in all congestion control mechanisms. RED anticipates congestion and also predicts its level. RED performs following two steps to detect congestion and estimate its level. Two threshold values Min_ and Max__ representing minimum and maximum values respectively are used to calculated average queue length. Then Avg queue, min and max threshold are used to determine packet drop ratio.

- **Random Early Detection Algorithm**

To avoid congestion in Manet, researchers have proposed the use of Active Queue Management (AQM) techniques, in which packets are dropped before the queue gets full. RED is a congestion avoidance algorithm, because it forecast the congestion by monitoring the average queue size. It avoids global synchronization by randomly choosing packets to

mark or drop before the queue gets full. The performance of RED is known to be delicate to its parameters such as the Maximum threshold (Max_{th}), the Minimum threshold (Min_{th}), the maximum packet marking probability (Max_p) and the weighting factor [3].
There are two steps in Random early Detection algorithm:
1) Calculate the packet drop probability. This mechanism is based on controlling congestion before it occurs.
2) Calculate the average queue length.

The average length of queue is calculated by given equation.

$$avg_q = (1-W_q)*avg_a + W_q*q \qquad (1)$$

The formula for packet dropped probability of RED is calculated as:

$$p_b = \begin{cases} 0, & avg_q < min_{th} \\ 1, & avg\ q > max_{th} \\ \dfrac{avg_q - min_{th}}{max_{th} - min_{th}} * max_p & min_{th} <= avg_q <= max_{th} \end{cases}$$

Where max p- largest packet drop probability. Equation 2 shows the packet drop probability that depends upon the value of the average queue length. Fig 1 shows the drop function of RED.

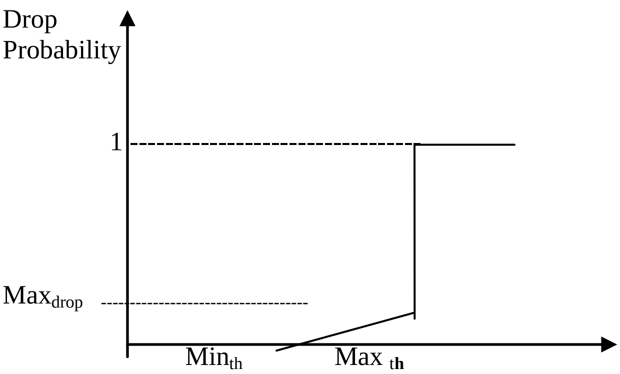

Fig. 1 RED Drop Function

- **Disadvantage of Random Early Detection**

Random Early Detection performance is sensitive to the number of competing source/flows. It is highly sensitive to its parameter settings. In RED, at least 4 parameters, namely, minimum threshold (min_{th}), maximum threshold (max_{th}), maximum packet dropping probability (max_p), and weighted factor (w_q), have to be properly set. Performance of RED is sensitive to the packet size.

- **Upper threshold RED**

A new algorithm after RED is URED (upper threshold RED) in which we introduced new extra threshold U_{th} (Upper threshold) for better use of buffer space. In RED algorithm probability of dropped packet p_a increases linearly up to packet dropping probability max_p .when average queue size is greater than max_{th} then p_a is set to 1 and all incoming packets are dropped. In URED, by adding U_{th} probability of dropping packet is slow from max_{th} to U_{th} .That means probability of dropped packet is 1 when average queue size reaches to Uth [1].

- **Problem Description in Upper threshold RED**

Upper threshold is better than RED, for better buffer space. In U_{th} additional condition is required for Max_{th} to U_{th} when the average queue size is greater than Max_{th} to buffer size for maximum utilizing of the buffer size. U_{th} is unnecessary overburden and extra condition $Max_{th}<=avg<=U_{th}$ is not required [1]

III. PROPOSED ALGORITHM

Because of some drawback of URED, in our work we will work on Max_{th} rather than U_{th}. Whose value is variable, and increased or decreased according to situation. In proposed mechanism there is no need for U_{th} (upper threshold) for U_{th} there is some unnecessary condition is to be used, but using this approach there is not any extra condition is required.

If
  $avg_q >= Max_{th}$
{
 $Max_{th} = Max_{th} + 1$
 $avg_q < Min_{th}$
 $Max_{th} = Max_{th} - 1$

In above algorithm Max_{th} is equal to $Max_{th} + 1$ that means Max_{th} will be increased to the maximum size of the buffer will be far, and Max – 1 that means Max_{th} will be decreased to the minimum size of the buffer.

- **Solution Approach**

Random Early Detection algorithm, measures the average queue size to evaluate the degree of network congestion. Average queue size is calculated by Exponential Weighted Moving Average (EWMA) of the original average queue size as:

$$Avg = (1-w)*Avg + Q*w \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.1)$$

Here
Avg = Average queue size
Q = Instantaneous queue size.
W= Weighted factor and generally equal to negative power of two.

RED algorithm uses the average queue size (Avg) to estimate the network congestion condition and determine the packet drop probability. The packet drop probability depends upon the relationship between the average queue size and two thresholds, maximum threshold Max_{th} and minimum threshold Max_{th}.

The weighted factor w is a constant that determines the sensitivity of RED gateway to the instantaneous queue size. It is often set to slightly small in order to prevent the average queue size (Avg) from varying too rapidly and dynamically.

As the average queue size Avg is under the minimum threshold Min_{th}, all incoming packets are enqueued sequentially. As the average queue size Avg is over the maximum threshold Max_{th}, all arriving packet are dropped unconditionally. As the average queue size Avg ranges between the minimum threshold Min_{th} and the maximum threshold Min_{th}, the nominal packet dropping probability P is given by the following equation

$$P = Max_p * (Avg - Min_{th}) / (Max_{th} - Min_{th}) \ldots\ldots\ldots\ldots (4.2)$$

Random Early Detection algorithm uses packet dropping probability P to decide whether packet drop/ mark will occur or not. Early packet drop is use to detect incipient congestion so that action is taken before it become burst.

- **Proposed Solution for Enhanced Random Early Detection Mechanism**

The proposed Enhanced mechanism is using the basic idea of Random Early Detection with some modification in working is mentioned below:

Random Early Detection algorithm, initialize the threshold parameters (Min_{th}, Max_{th}) to the fixed value when simulation starts, these values cannot change during the simulation. In MANET, due to quick diversity of changing the network condition, fixed threshold parameters are not appropriate and can degrade network performance. Proposed Enhanced mechanism works on variable threshold parameters which are changing according to the network congestion condition.

Random Early Detection doesn't utilize queue space fully due to setting of Max_{th} to the fixed value, To solve this problem Proposed Enhanced mechanism gradually adjust the maximum threshold value Max_{th} to maximum available queue size, purpose is maximum utilization of available queue space because all the incoming packet are dropped after queue size reached to the maximum threshold (Max_{th}).

- **Proposed Algorithm for Enhanced mechanism**

Algorithm of Enhanced is based on parameter setting to improve the network performance; pseudo code of this algorithm is given below:

List of variables which contain RED variables used in Enhanced mechanism

Min_{th} = Minimum threshold value

Max_{th} = Max threshold value

Q = Instantaneous queue size

P = Packet drop probability

P_{max} = Maximum packet drop probability

Proposed Enhanced mechanism same functionality of random early detection with some additional functionality as explained in algorithm 3.1, this algorithm is divided in three steps for easy understanding of working procedure.

```
Step 1:  if (v_ave <= th_min )
{
        max_p = 0;
        th_max = th_max - 1;
}
Step 2: If(v_ave > th_min && v_ave <= th_max)
{
        p = (v_ave - th_min) / (th_max - th_min);
        p *= max_p;
}
Step 3: if ( v_ave >= th_max)
 {
        th_max = th_max + 1;
        p = (v_ave - th_max) / (th_max - th_min);
        p = (1 - max_p) *p;
    }
        if (p > 1.0)
{
        p = 1.0;
        return p;
 }
```

Algorithm 3.1: Proposed algorithm of Enhanced mechanism

IV. SIMULATION RESULTS

- **Simulation Parameters**

To calculate performance of the network i have used the following parameters mentioned in table 4.1. I have used these parameters for calculation of result both for existing mechanism and also for proposed solution approach of Enhanced mechanism

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|| Volume 8, Issue 10, October 2020 ||

Table 4.1 Network parameters used in simulation.

Simulator Used	NS-2.34
Number of nodes	30
Number of sources	1-5
Number of destinations	1-5
Dimension of simulated area	500m×500m
Routing Protocol	AODV
Simulation time	60 sec
Packet size	2000 bytes
Node movement at average Speed (m/s)	5 m/s
Transmission range	250m

- **Scenarios of Enhanced RED mechanism.**

Scenario of Enhanced RED mechanism consists of details about the scenario used in calculation of result such as no of nodes used, connection establishment mechanism, and packet transmission policy.

- **Sensing for Connection Establishment and Packet Transferring.**

In the simulation all nodes are scattered and moving with average speed of 5m/s in predefined area. When source node wants to send data to the destination node, source node initiate route request procedure, till destination node is found with strong connection. This dissertation work is using AODV routing protocol which is reactive routing protocol. First connection is established from source to destination through intermediate node. When strong connection is established, source node starts transferring data packets through establish route to the destination node. When all data packets are reached to destination, connection is closed.

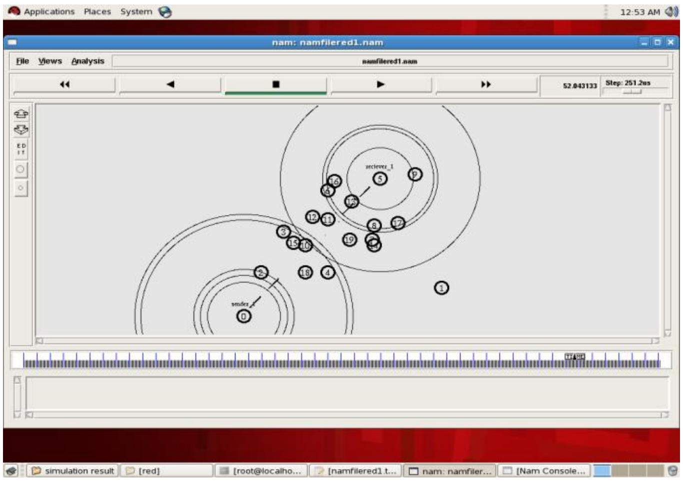

Figure 4.1 Simulation scenario of ad hoc network

Figure 4.1 show the relative position of nodes in the network. This contains one source and one destination node. In the above figure node (0) is working as source node and node (5) is working as destination or sink node. Circle shows the transmission range of respective node.

- **Connection Establishment and Packet Transmission**

Here nodes are scattered in predefined boundary and ready for establish connection and transmit their data. According to simulation scenario each node sense their neighbours which is in radio range 250m then establish connection. This simulation scenerio having two sources and destination pair. When connection is established between any source and destination pair this will start sending packets to the destination without waiting to other source to establish connection with other destination, both sources and destinations pair will work separatly. When establishment connection will be strong connection between source and destination after that they will start the communication and terminate connection when processes of packet transmission is completed or path is broken due to node movement.

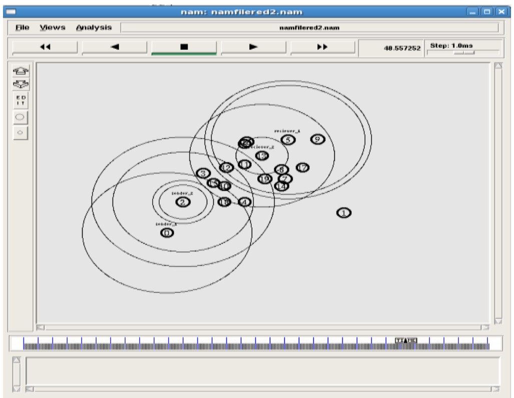

Figure 4.2 Connection establishment and packet transmission.

Figure 4.2 show the relative position of a node in the network, in which some nodes are working as source and some as a destination or sink nodes and rest of other nodes are working as intermediate node. Circle shows the transmission range of respective nodes [1].

- **Packet delivery ratio v/s number of sources**

Packet delivery ratio is the ratio of the number of delivered data packet to the destination to the number of packet generated. Mobile wireless Ad hoc networks use packet delivery ratio (PDR) as a metric to select the best route, transmission rate or power. PDR is normally estimated either by counting the number of received hello/data messages in a small period of time, i.e., less than 1 second, or by taking the history of PDR into account.

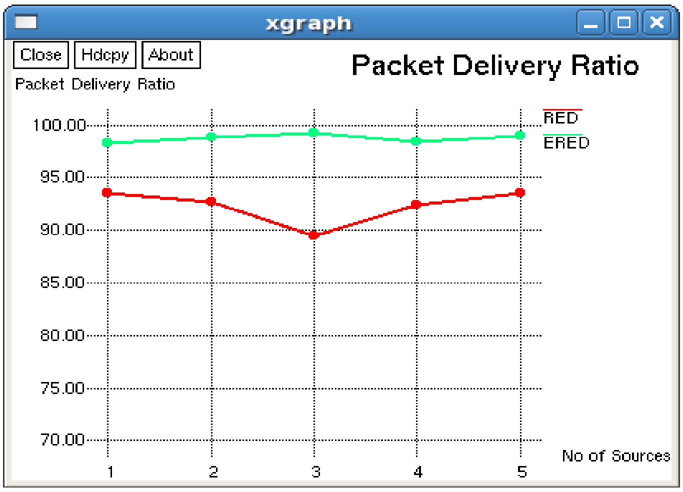

Figure 4.3 Packet delivery ratio v/s number of sources

Figure 4.3 is showing the packets delivery ratio of both random Early Detection method and Enhanced Random Early Detection mechanism with respect to number of source. Packets delivery ratio is plotted in y axis, and x axis plots the number of source used in calculation of the packet delivery ratio in the simulation. Graph is drawn between conventional Random Early Detection [RED] mechanism and proposed solution mechanism v/s number of source.

Figure 4.3 shows that packet delivery ratio of ERED is higher than RED. Numerical analysis is done in Table 4.3. Numerical analysis shows that PDR is consistently higher in ERED than RED. Numerical result also shows that PDR has been dropped in both mechanisms by increasing number of source due to increasing of network congestion.

Table 4.3 Packet delivery ratio v/s number of sources

Packet Delivery Ratio		
No.of source	**RED**	**ERED**
1	93.56	98.26
2	92.76	98.85
3	89.53	99.25
4	92.35	98.47
5	93.51	99.04

- **Network Throughput v/s number of source comaprision**

Network throughput is the average rate of successful message delivery over a communication channel. This data may be delivered over a logical or physical link, or pass through a certain network node. The throughput is generally measured in bits per second (bit/s or bps), and sometimes in data packets per second or data packets per time slot.

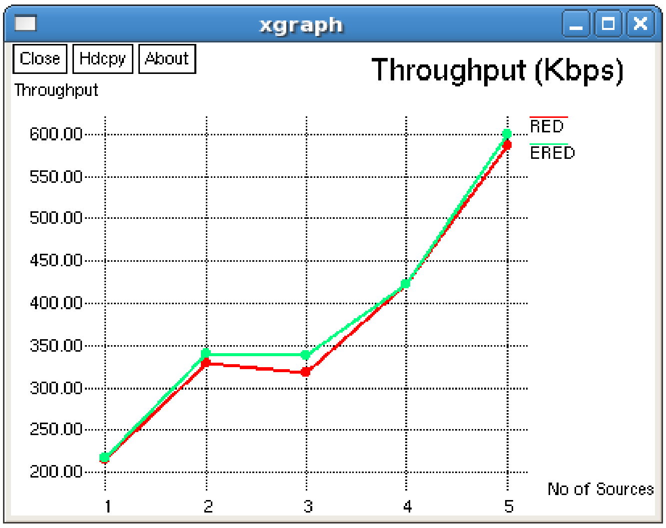

Figure 4.4:- Throughput v/s number of source comparison

Table 4.4 Throughput v/s number of source comparison table

Throughput		
No.of source	**RED**	**ERED**
1	216.27	217.7
2	329.99	341.03
3	317.86	339.35
4	422.02	422.40
5	587.03	599.56

Figure 4.4 is showing the Throughput of both random Early Detection method and Enhanced Random Early Detection mechanism with respect to number of source. Throughput is plotted in y axis, and x axis plots the number of source used in calculation of the throughput in the simulation. Graph is drawn between conventional Random Early Detection [RED] mechanism and proposed solution mechanism v/s number of source.

Table 4.4 Shows that throughput of ERED is higher than RED. Numerical analysis is done in Table 4.4. Numerical analysis shows that throughput is consistently higher in ERED than RED. Numerical result also shows that throughput has been increased by increasing number of source due to increasing of multiple TCP flows.

V. Conclusion and Future Work

In this paper ERED (enhanced random early detection) algorithm is proposed based on the study of existing RED algorithm by introducing variable (min, max) threshold. Performance of ERED is improved in terms of throughput and packet delivery ratio. Simulation results show that ERED is more efficient than existing RED algorithm. It has lower packet drops and higher throughput than RED.

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