Adaptive Virtual Queue with Choke Packets for Congestion Control in MANETs

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Abstract— During past few years, the wireless network has grown in leaps and bounds as it offered the end users more flexibility, which enabled a huge array of services. The concept of the wireless network brings lot of challenges such as energy consumption, dynamic configuration and congestion. Congestion in a network occurs when the demand on the network resources is greater than the available resources and due to increasing mismatch in link speeds caused by intermixing of heterogeneous network technologies. Queue management provides a mechanism for protecting individual flows from congestion. The basic idea behind queue management is to detect congestion and to reduce the transmission rates before queues in the network overflow and packets are dropped. Packet loss results in increased overhead in terms of energy wasted to forward a packet, which was dropped, additional energy required to retransmit this packet. The proposed approach uses virtual queue, is compared with RED and REM which have better performance over these schemes.

Keywords: Active Queue Management, Wireless Networks, Congestion Control, Quality of Service

I. INTRODUCTION

A wireless network consisting of mobile nodes equipped with wireless communication and networking capabilities, without network infrastructure. A node in the network acts both as a mobile host and a router, offering to forward traffic on behalf of other nodes within the network.

Major Challenges in Wireless Networks are [1]

a) Packet delay and drop – A poor network performance can be offered due to congestion, e.g, high dropping and queuing delay for packets, low throughput and unmaintained average queue length which may not prevent the router buffers from building up, then dropping packets.
b) Degradation of the throughput – Degradation of throughput is a n important issue in wireless networks, due to congestion throughput degraded, It is the ratio between the numbers of sent packets vs. received packets.
c) Routing - The concern of routing packets between any pair of nodes becomes a challenging task since the topology of the network is frequently changing. Due to the random movement of nodes within the network the multicast tree is no longer static so multicast routing is another challenge. Routing is becoming more complex and challenging because routes between nodes may potentially contain multiple hops, than the single hop communication.
d) Internetworking – Harmonious mobility management is a challenge in mobile device due to coexistence of routing protocols.
e) Security and Reliability – Wireless network has its particular security problem due to e.g. nasty neighbor relaying packets in spite of accumulation to the frequent vulnerabilities of wireless connection.
f) Quality of Service (QoS) - it will be a challenge on pro-viding various qualities of service levels in a persistently varying environment.
g) Power Consumption – Power-aware routing and Maintenance of power must be taken into consideration.

In order to maintain good network performance, certain mechanisms must be provided to prevent the network from being congested for any significant period of time. Two approaches to handling congestion are congestion control (or recovery) and congestion avoidance. The former is reactive in that congestion control typically comes into play after the network is overloaded, i.e., congestion is detected. The latter is proactive in that congestion avoidance comes into play before the network becomes overloaded, i.e., when congestion is expected. Congestion control involves the design of mechanisms and algorithms to statistically limit the demand-capacity mismatch, or dynamically control traffic sources when such a mismatch occurs. It has been shown that static solutions such as allocating more buffers, providing faster links or faster processors are not effective for congestion control purposes.

The design of RED and many of its variants, though intuitive, has been, for the most part, heuristic. As a result, parameter-tuning has been one of their main limitations. Some researchers discovered that by applying more formal and rigorous techniques as found in control theory (whether it be classical control, modern control, optimal control or nonlinear control), this limitation may be alleviated if not eliminated. Other researchers have also invented AQM schemes based upon optimization techniques in the context of congestion control [2]. With the growing heterogeneous communications, the focus has shifted from congestion control to quality of service. The network has to serve efficiently diverse requirements of various types of traffic flows.

In the next section we will discuss various congestion control schemes and their drawbacks. In section III we propose an alternate scheme that controls congestion to a better extent. Finally we concluded in section IV.

II. EXISTING QUEUE MANAGEMENT SCHEMES

Congestion control involves the design of mechanisms and algorithms to statistically limit the demand-capacity mismatch, or dynamically control traffic sources when such a mismatch occurs. It has been shown that static solutions such as allocating more buffers, providing faster links or faster processors are not effective for congestion control purposes.

In high-speed networks with connections with large delay-bandwidth products, gateways are likely to be designed with correspondingly large maximum queues to accommodate transient congestion. In the current Internet, the TCP transport protocol detects congestion only after a packet has been dropped at the gateway. However, it would clearly be undesirable to have large queues (possibly on the order of a delay-bandwidth product) that were full much of the time; this would significantly increase the average delay in the network. Therefore, with increasingly high-speed networks, it is increasingly important to have mechanisms that keep throughput high but average queue sizes low.

RED [4] measures congestion by queue length. Importantly, the choice of congestion measure determines how it is updated to reflect congestion. To avoid congestion the router has to drop packets, before the situation has become hopeless, the idea is that there is time for action to be taken before it is too late. To determine when to start discarding, maintain a running average of their queue length on some line exceeds threshold the line is said to be congested and starts discarding.

Second, identify a probability function which is a piecewise linear and increasing function of the congestion measure. Finally, the congestion information is conveyed to the users by either dropping a packet or setting its ECN bit probabilistically.

REM [5] is an active queue management scheme that aims to achieve both high utilization and negligible loss and delay in a simple and scalable manner. The first idea of REM attempts to match user rates to network capacity while clearing buffers, irrespective of number of users. The second idea embeds the sum of link prices (congestion measures), summed over all the routers in the path of the user to the end-to-end marking (or dropping) probability. Number of active flows shares a linear relationship with number of different flows in the buffer.

Adaptive Virtual Queue (AVQ)[7] is designed that results in low-loss, low-delay and high utilization operation at the link. AVQ algorithm maintains a virtual queue whose capacity is less than the actual capacity of the link. When a packet arrives in the real queue, the virtual queue is also updated to reflect the new packets in the real queue to reflect the new arrival. Packets in the real queue are marked/dropped using ECN mechanism when the virtual buffer overflows.

ECN [6] is an extension to the internet protocol that allows end-to-end notification of the network congestion without dropping packets. For detecting incipient congestion, ECN mechanism is used for notification of congestion o the end nodes prevents unnecessary packet drops. ECN is proposed by IETF to reduce packet drop rate in the internet. ECN router will set a bit in IP header instead of dropping a packet in order to signal the beginning of congestion. The receiver of the packet echoes the congestion indication to the sender, which must react as though a packet drop was detected.

Use of ECN has been found to be detrimental [9] to performance on highly congested networks when using AQM algorithms that never drop packets. ECN doesn't improve throughput for TCP transfers and also does not degrade the TCP performance. The disadvantages of ECN are that it requires changes to both the TCP header and IP header plus new information must be communicated between the source and destination. Necessitating new parameters in IP service primitives. Problems with ECN concern non-compliant ECN connections and potential loss of ECN messages in the network. A non-compliant TCP connection could set the ECN field to indicate that it was ECN-capable, and then ignore ECN notifications.

These algorithms only take the buffer utilization into account as a measure of the severity of congestion, under realistic traffic environments, proposed AQMs often do not outperform Tail Drop. This is traditional queue management technique at a router, sets a maximum queue length in terms of the number of packets for each queue. Therefore, we need a new congestion indicator and a control function for AQM that provides adaptive control to the traffic characteristics such as the amount of traffic, fluctuation of traffic load, and the traffic nature.

Problems in AQM [8]:

Many AQM strategies use average queue length to determine congestion. This causes some problems like:

a) When there is large number of bursts arrive at a gateway, the actual queue size is rapidly increased, resulting in buffer overflow, sources will reduce their sending rate after a congestion signal is triggered due to packet drop at gateway. After congestion has been rectified and the actual queue size is decreased, the average queue size is will be high due to previous peaks in the actual queue size. Therefore, packet dropping will be continued even after congestion problems have been rectified, which unfairly penalizes packets received after the congestion event.

b) The actual queue size is the early indicator of congestion. Due to the use of average the current variations in the traffic are not recognized by AQM strategies. This leads to unfair packet drops between connections. However, AQM Strategies that tend to use the actual queue size to indicate congestion, instead of using the average queue size suffer from worst cases of unfair packet drops.

c) Parameter configuration in AQM strategies is a difficult task. AQM modifications have been proposed to increase network performance which is evaluated using Analytic modeling and simulation. Unfortunately, these modifications work only for specific traffic conditions but not for realistic IP traffic.

III. VIRTUAL QUEUE WITH CHOKE PACKET MECHANISM

Techniques based on average queue length are suffering from drawbacks which lead to discard and resend the packets. However in the above algorithms the queue size is not clearly stated either it is in packets or bytes.

Assuming the size of the queue is terms of packets and maintaining optimal queue size an approach is proposed which will outperform RED and REM. The proposed approach maintains a virtual queue whose size is less than the actual queue. Whenever a packet arrives a duplicate packet will be updated in the virtual queue, when the virtual queue is full or drops a packet feedback regarding congestion will be intimated to the source using a choke packet.

Choke packets [10] are sent to the source when the virtual buffer overflows. Then source reduces its traffic sent to a particular destination by some percentage when it receives a choke packet. Sources ignore repeating choke packet for a fixed interval of time. If no further choke packets arrive after a certain time, the source will again increase the traffic.

We have conducted experiment using Network Simulator [11] and simulated Mobile adhoc network with sixteen nodes with mobility and routing protocol AODV is used for Communication. The experiment is carried for a period of one hundred and twenty seconds. The model of our system is shown in Fig.1.

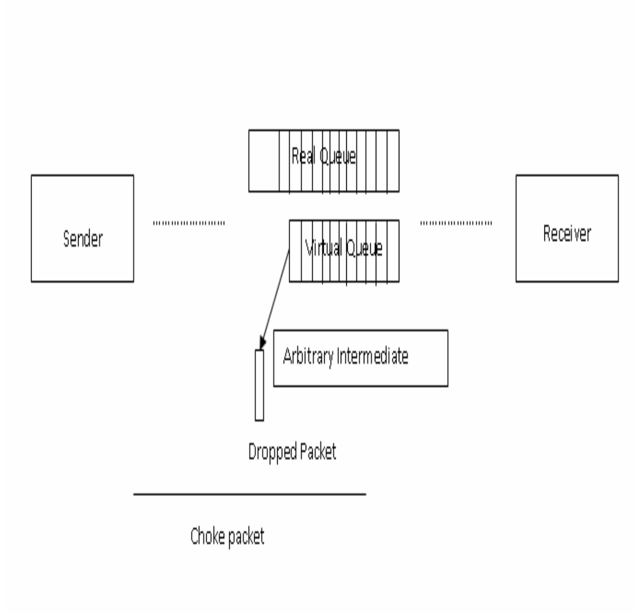

Fig.1. Model Representing the System

All nodes in the system can forward packets to the neighboring nodes and will have a real queue and virtual queue. The size of the virtual queue (C_v) is less than the size of the real queue (C_r).

$$C_v < C_r \text{ ……………….. Eqn.1}$$

When a packet enters the queue a duplicate packet is updated in the virtual queue. As per Eqn.1 it is clear that virtual queue overflow prior to the filling of real queue. When the virtual queue overflows a choke packet is sent to the packet sender so as to decrease the rate of sending. The experiment simulation is shown in Fig.2. The experiment is carried for existing queue mechanisms like RED and REM.

Adaptive Virtual Queue with Choke Packets (AVQCP) mechanism is implemented. The AVQCP performance is compared and shown in Fig.3. The performance of AVQCP is comparatively good when compared to other mechanisms.

Fig.2. Simulation of MANET

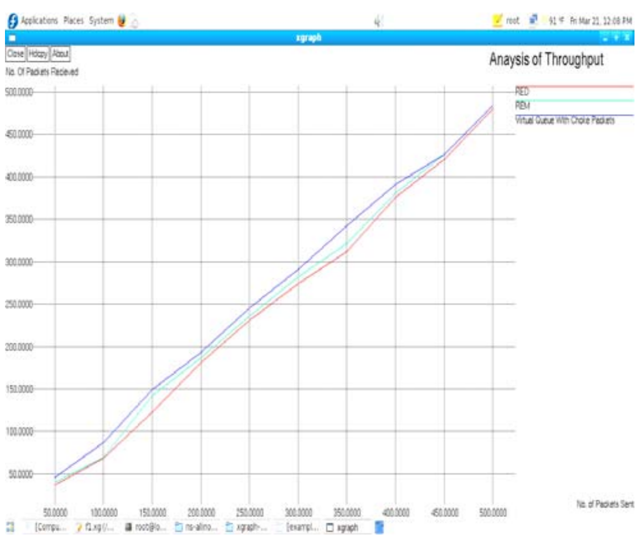

Fig.3. Comparison of RED, REM and AVQCP

IV. CONCLUSION AND FUTURE WORK

In this paper we made an effort to present a queue management approach. However the approach has outperformed existing queue management techniques RED and REM. Here choke packet mechanism is used to send the feedback to sender. It involves additional overhead to the traffic. Maintenance of virtual queue consumes additional buffer space. Decreasing of the size of virtual queue can be carried in future.

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