

## Chapter 3.19

# Intelligent Reasoning Approach for Active Queue Management in Wireless Ad Hoc Networks

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### ABSTRACT

Mobile ad hoc network is a network without infrastructure where every node has its own protocols and services for powerful cooperation in the network. Every node also has the ability to handle the congestion in its queues during traffic overflow. Traditionally, this was done through Drop-Tail policy where the node drops the incoming packets to its queues during overflow condition. Many studies showed that early dropping of incoming packet is an effective technique to avoid congestion and to minimize the packet

latency. Such approach is known as Active Queue Management (AQM). In this article, an enhanced algorithm called fuzzy-AQM is suggested using a fuzzy logic system to achieve the benefits of AQM. Uncertainty associated with queue congestion estimation and lack of mathematical model for estimating the time to start dropping incoming packets makes the fuzzy-AQM algorithm the best choice. Extensive performance analysis via simulation showed the effectiveness of the proposed method for congestion detection and avoidance improving overall network performance.

## INTRODUCTION

Mobile ad hoc network is a network without infrastructure where every node can work as a router. Every node has protocols and services to request and provide services to other nodes with the congestion handling capability. Traditionally, the congestion handling is done through transmission control protocol (TCP). This protocol sends congestion signal (drop incoming packets) when the node's queue is full (queue length is maximum). Some studies (Braden, Clark, Crowcroft, Davie, Deering, Estrin, et al., 1998; Floyd & Jacobson, 1993) showed that early dropping of incoming packet before reaching the maximum queue length is an effective technique to avoid congestion and to minimize the packet latency (e. g., active queue management (AQM)) drops incoming packets before the queue is full in contrast to traditional queue management which starts dropping only when the queue is overflowed.

Mobile ad hoc networks suffer high network congestion due to high bit error rate (BER) in the wireless channel, increased collisions due to the presence of hidden terminals, interference, location dependent connection, uni-directional links, frequent path breaks due to mobility of nodes, and the inherent fading properties of the wireless channel (Murthy & Manoj, 2004). This substantiates the need for high adaptive AQM algorithms with adapting capabilities to high variability and uncertainty for these types of networks. The proposed fuzzy logic based AQM (called Fuzzy-AQM) is such types of algorithms to overcome the above shortcoming in ad hoc networks. The application of fuzzy logic to the problem of congestion control allows us to specify the relationship between queue parameters and packets dropping probability using "if...then..." type of linguistic rules. The fuzzy logic algorithm would be able to translate or interpolate these rules into a nonlinear mapping.

In this study, the focus is to investigate the impact of the traditional and Fuzzy-AQM algorithms

on the ad hoc network. The considered strategy is as follows: when the congestion is detected, the node uses one of the AQM policies to drop the incoming data packets. Meanwhile, it allows the control packets to pass to the queue using Drop-Tail policy. Therefore, the data packets are dropped first when the packets drop probability exceeds a certain threshold while the control packets are still acceptable until the queue is full.

Control messages are preferred to pass to the queue during congestion time for the following reasons:

1. Control messages are used to update the changes of the network topology. Therefore, they prevent data packet to be transmitted through broken paths.
2. Data packets are "connection oriented," that is, guaranteed delivery to their destinations by TCP. In contrast, control messages are "connectionless"; that is, the dropped message will not be retransmitted again.
3. Control message size is very small compared to data packet. Normally in ad hoc routing protocols, control message size is 64 bytes while data packet is 512 bytes (i.e., the control message takes small space in the queue and fast processing time in the node).

The rest of this article is organized as follows. Section II summarizes related work on the common AQM policies issues and focuses on previous implementations of fuzzy AQM policies. Followed by congestion in ad hoc networks, the fuzzy dropping algorithm as a new AQM policy (Fuzzy-AQM), performance analyzes of the proposed algorithm, and finally the conclusions.

## RELATED WORK

The most famous AQM algorithm is random early detection (RED) (Floyd et al., 1993). The RED algorithm manages the queue in an active manner

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