A Comparative Study of CoDel and Adaptive CoDel AQM Mechanism for Video Optimization

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Abstract— Video data forms the major traffic in today's internet. Quality Of internet video has a great impact on user engagement. Video encoding and streaming over wireless networks become a big concern. Real time video service requires low end-to-end delay, which mainly consists of video encoding delay, queuing delay, and transmission delay. The major concern is to reduce the queuing delay which has high impact on the video quality. Bufferbloat is one of the main reasons for experiencing high queue latency at the intermediate nodes. Several AQM techniques were used in reducing queue latency, but optimization of buffer size is never achieved. In this work, a comparative study between the CoDel and Adaptive CoDel and their effectiveness of reducing the queuing delay to increase the network bandwidth utilization for video streams which will result in better quality of video are discussed briefly.

Key words: Bufferbloat, CoDel, Adaptive CoDel, Queuing Delay

I. Introduction

The major traffic in today's Internet is Video Streams. With the increasing amount of data and video traffic in the Internet requires the network devices such as routers and other end devices to be capable of handling multiple Gigabit connections at given time. Since video traffic is delay sensitive, the End-to-end Latency between the network devices is an important metric to be concerned with. This end-to-end latency can be classified as three components: transmission delay, propagation delay and queuing delay. Of these queuing delay is the main cause of uncertainty which varies frequently depending upon the buffer size of the network devices [1].

The queuing delay is the time a job waits in a queue until it can be executed. It is a key component of network delay. Mostly packets arrive at a router, where they have to be processed and transmitted to the other node. A router can route only one packet at a time. If packets arrive faster than the router can access them in the case of burst transmission the router puts them into the queue (also called the buffer) until it can get a chance for transmitting them. Delay can also vary from packet to packet so averages and statistics are usually generated when measuring and evaluating queuing delay. The maximum queuing delay is proportional to buffer size.

An optimization in buffer size is required to enhance the QoS parameters such as queuing delay, link utilization, end-to-end throughput, and packet loss. For the enhanced performance, high throughput is necessary and to reduce the queuing delay the availability of data in the buffer is to be made less as possible. While the former needs large buffer size in order to increase the sending rate, the latter case requires reduction in buffer size to prevent the problem of bufferbloat [2].The data traffic over the network requires minimum queuing delay, which can be obtained through one of the prominent AQM mechanisms called Controlled Delay (CoDel) [3]. But the drawback in CoDel is that, it does not support real-time video streaming since it uses fixed and uniform target value for processing. Adaptive CoDel is used for real-time video streaming to mitigate bufferbloat and to improve the QoS parameters [4]. Providing fairness which is not possible through CoDel is ensured by Fair queuing CoDel (FQ-CoDel). Even though fairness is achieved through the former one, it does not satisfy the real-time video streaming which experience varying RRT and queuing delay. So in this work, a comparative study between the two prominent AQM managements such as CoDel and Adaptive CoDel and their efficiency of reducing the queuing delay to increase the network bandwidth utilization for video streams which will result in better quality of video are discussed briefly.

The rest of the paper is organized as follows. Section 2 briefly describes the working of recent AQM techniques like CoDel with the fair queuing and Section 3 talk about Adaptive CoDel and a few open issues related to them in detail. Section 4 summarizes the research and concludes the paper with possible future directions.

II. Active Queue Management

In Internet routers and other network devices, Active queue management (AQM) is described as the intelligent drop of network packets within a buffer connected with a network interface controller (NIC), when that buffer becomes full or gets close to becoming packed, often with the superior goal of dropping network congestion. AQM schemes can be classified in different ways. In [6], these were classified based on two dimensions: one is based on the decision of discarding packets and the other is what information is used to make packet discard decisions. In [7], a detailed classification of the various schemes has been proposed. It was based on the networking environment, the type of congestion management mechanism implemented, the number of thresholds implied, decision details, and the queue behavior whether the static or dynamic one. The network scheduler, which for this purpose uses various AQM algorithms such as random early detection (RED), Explicit Congestion Notification (ECN), or controlled delay (CoDel). The most recent one among the AQM techniques is CoDel.

A. *Controlled Delay Algorithm*

1) *Overview*

In network routing, CoDel for controlled delay is a scheduling algorithm for the network scheduler. It is designed to overcome bufferbloat in network links (such as routers) by keeping restrictions on the delay network packets suffer due to passing through the buffer being managed by CoDel. CoDel main objective is improving the overall performance of the RED algorithm by addressing some fundamental misconceptions in the algorithm and by being easier to manage (since, unlike RED, CoDel does not require manual configuration) [3].

2) Bufferbloat

The flow of packets between a fast and a slow network slows down while travelling through a network link, especially at the start of a TCP session. When a sudden burst of packets takes place, the link to the slower network may not be able to process the burst quickly enough. By the thumb rule of internet buffer, there exists a large buffer to ease this problem by giving the fast network a place to push packets, to be read by the slower network as fast as it can. In other words, buffers act like shock absorbers for converting the bursty arrivals of data packets into smooth, finite departures. Though, a buffer has a limited size, and it can hold only a specific maximum number of packets. The perfect buffer is sized so it can grip a sudden burst of communication and match the speed of that burst to the speed of the slower network. Here, the "shock absorbing" situation is realized by a temporary delay for packets in the buffer during the transmission burst, after which the delay rapidly decreases and the network reaches a balance in offering and handling packets.

In some problematic situation, packets get dropped in the queue only when the buffer is fully occupied. Having a large and regularly full buffer may causes increased transmission delays and reduced interactivity, is called bufferbloat. Present channel bandwidth can also end up being unused, as some fast destinations may not be reached due to buffers blocked with data anticipating delivery to slow destinations, which is caused by contention between synchronized transmissions competing for some space in an already loaded buffer [5].

3) CoDel Algorithm

The Main purpose of CoDel is to preserve minimum queuing delay which is set to be below 5 milliseconds. If the delay increase too high which is more than the target value, packets are discarded from the window until the delay drops below the target level.

CoDel is parameter less. One of the drawbacks of RED algorithm is that it requires manual configuring is too difficult to configure [3]. CoDel has no parameters which do not require any manual configuration.

CoDel can classify the network queue into two types: Good queue and Bad queue. A good queue in the network will posses low delay where as the bad queue exhibits high queuing delay in the network transmission so the management of queue by the algorithm in the former case can be ignored, while the latter case is considered to be more vulnerable, which requires intervention of algorithm (CoDel)in the form of dropping packets.

The algorithm works in two phases: (a) during the enqueue of packets and (b) during dequeue of network packets to the outbound link. The CoDel remains either in the dropping state or not in the dropping state. If the packet waiting time in the queue remains above the target for the specified interval of time (100 milliseconds) [3], it enters the dropping state. Here the packets are dropped at the time of dequeuing of packets from the queue rather than during the process of enqueuing

There are two important CoDel parameters are used for optimal results: target value and interval range. These values are fixed one. The target value defines the standing queue delay (5ms) and the interval value defines the time on the order of worst case round trip time (100ms).

4) Advantage

CoDel is resolute completely locally, so it is free of round-trip delays, link rates, traffic loads and other factors that seems to difficult to control or predict by the local buffer. The packets get dropped only at the time of dequeuing which prevents the starvation of packets being queued. CoDel adapts to dynamically changing link rates with less consequence on utilization.

5) Issues in Codel

CoDel has implementation advantage over other AQM techniques since the packets get dropped at the dequeue stage. It has got uniform target value to be set for optimal result. But presumptuous of uniform or unique value for the varying input and output bandwidth does not work well. Especially for the real time streaming of video, the uniform target set by the CoDel proves to be insufficient to achieve high throughput.

III. Adaptive Controlled Delay

A. Overview

The base of the Adaptive Controlled delay is the varying buffer size needed to support the incoming and outgoing bandwidth for the video traffic over the network. Here the size of the buffer remains same but the queuing delay experienced by each packet in the specified interval gets varies. Adaptive CoDel helps in refining the fixed target set by the CoDel algorithm to suit the current network parameters. CoDel is independent of any network parameters but the adaptive CoDel rely upon the RRT value for the network traffic which has the changeable nature with each segment [4]. Hence estimation of RRT for each segment is required for adaptive CoDel.

B. Target and Interval

Adaptive CoDel is based on varying RTT, the optimization of bandwidth can be obtained when the buffer size is proportional to the outbound link bandwidth. The actual dispute lies in the determination of proportionality constant. Thus the target value can be given as

$$\text{Period} = \text{SRTT}$$

$$\text{Target} = \text{SRTT}\ \text{BWout}/\sum \text{BW}$$

Where, SRTT is the smoothened RTT, BWout is the outgoing link bandwidth and ∑BW is the sum of all bandwidths in the path of the network flow [4].

Adaptive CoDel proves to be beneficial for real time video transmitting. The flow of video data can be optimized but the fairness in network flow is not discussed.

IV. Conclusion

In this paper the characters and the behavior of two most prominent AQM techniques such as CoDel and Adaptive CoDel are discussed briefly and a comparative study is made between them. CoDel has efficient link utilization when compared to other AQM mechanisms. But to support real time video traffic the function of CoDel is not sufficient , hence Adaptive CoDel is been used. Comparison shows that both the mechanisms have their equal share of advantage and drawbacks. Depending upon the network environment, the use of these mechanisms can be selected. Though it provides solution for real time video transmission, fairness can be achieved only when two techniques are combined to provide optimization for the entire network performance. Thus the combination of both CoDel and Adaptive CoDel for video optimization could be considered in future work.

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