Packet Loss Estimation of TCP Flows Based on the Delayed ACK Mechanism

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Abstract. Based on the Delayed ACK mechanism in TCP protocol, a new method is proposed to estimate the packet loss based on the variation of the rate between the bidirectional TCP packet numbers. This method made it possible to estimate the TCP packet loss based on the export of Netflow quickly.

Keywords: Congestion window (CWND); packet lose; delayed ACK;TCP;Netflow.

1 Introduction

Packet loss is one of the most important basic metrics in the network SLA (Service Level Agreement), but the measurement of packet loss is a difficult problem. There are two kinds of methods to measure packet loss: active method [1] and passive method.

Paul Barford[2] have compared the active and passive methods, it is found that current methods for active probing for packet loss suffer from high variance inherent in standard sampling techniques and from effects of end-host interfaces loss. The level of agreement between passive measures and active measures is quite low. In order to get the feelings of the network users, passive method should be used.

This paper proposes a packet loss estimation model base on the TCP Delayed ACK(acknowledgment) mechanism proposed in rfc1122. Since almost all of the systems in the Internet use the delayed ACK mechanism to improve the performance of TCP transfers, the ration between the bidirectional packet numbers of the TCP flow reflects the packet loss of the TCP flow. Most of the network equipments provide the Netflow[4] data, this method made it possible to estimate the TCP packet loss based on the output of the Netflow, and the real time packet loss estimation of transport layer that reflect the user feelings is possible.

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2 Packet Loss Estimation Based On the Delayed ACK Mechanism

2.1 The TCP delayed ACK mechanism

In the implementation of TCP protocol, delayed ACK is used to improve the TCP transfer performance. A host that is receiving a flow of TCP data packets can increase efficiency in both the Internet and the hosts by sending few than one ACK packet per data packet received.

Because a packet loss event will cause the change of the behavior pattern of the end points, investigation of the ration between the bidirectional packet numbers give clues of network packet loss.

We define two metrics as follows:

$Rate_{data/ack}$: The number rate of the data packets and the ACK packets of a TCP bulk transfer flow.

$Rate_{drop\_data/data}$: The number rate between the lost data packets and all the data packets of a TCP bulk transfer flow. This is the metric we want to estimate.

If there are no drop evens, $Rate_{data/ack}$ is 2:1.But actually, $Rate_{data/ack}$ is between 1 and 2, because when a drop event happens, $Rate_{data/ack}$ will change from 2:1 to 1:1 until the lost packets is arrived by retransmission. Compared to the packet loss, the packet numbers of data packets and ACK packets is easy to obtain, the export format of Netflow have the statistical value of the bidirectional packet number, it is easy to obtain $Rate_{data/ack}$, the important thing is to investigate the relationship between $Rate_{data/ack}$ and $Rate_{drop\_data/data}$.

2.2 Relationship between $Rate_{data/ack}$ and $Rate_{drop\_data/data}$

The main control algorithms of TCP are slow start, congestion avoidance and fast retransmit. Actually the slow start period is not slow, CWND(Congestion window) have an exponential growth and the time is relatively short, it is a detection process to achieve the equilibrium state. We do not consider this period in the bulk data transfer.

After a lost event is detected, according to the Fast Retransmit/Fast Recovery algorithms[rfc2581], after receiving 3 duplicate ACKs, TCP performs a retransmission of what appears to be the missing packet. CWND will decrease to half of the current value and the connection change to the congestion avoidance statue. This kind of transmission will happen when the TCP bulk transfer performance is limited by the network bandwidth. And the random drop event is ignored. Fig. 1 is such a transfer process and one cycle of the stable transfer statue. This cycle begins from a drop event and ends at the next drop event.

During this cycle in Fig.1, suppose the drop event happens when CWND is w, after a drop event, CWND is decreased to half of w. before the drop event, the receive host send one ACK for every two data packets, after the drop event, it sent one ACK for every data packet, until the lost packet was received, then the rate change to 2:1.

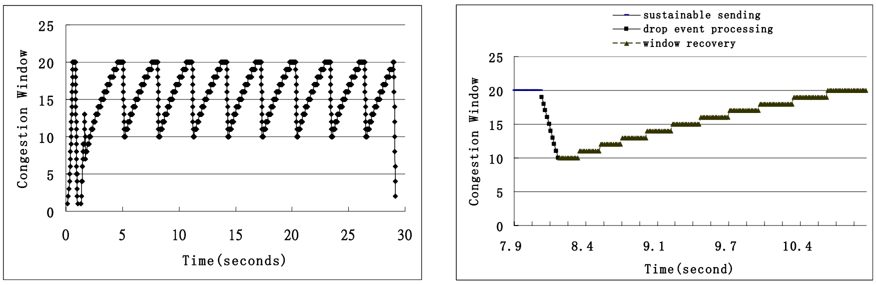

Fig. 1. CWND change pattern of the stable bulk data transfer and one cycle of the stable transfer statue

If the flow is in a stable state and long enough, the packet rate and the drop rate in one cycle can be deemed as the packet rate and drop rate of this flow, that is $Rate_{data/ack}$ and $Rate_{drop\_data/data}$. There are three stages in one cycle, we call the three stages as sustainable sending, drop event processing and window recovery.

Since the receiver will send ACK every two packets, whether w is even or odd when the drop event happens will result in different results. Because of the page limit, we will not discuss that situations in detail and only give the results in Table 1.

TABLE 1. PACKET NUMBERS IN DIFFERNET STAGES

		CWND is even when drop event happens	**CWND is odd when drop event happens**
Data packets of one cycle	Sustainable sending	w	w-1
	Drop event processing	3	4
	Window recovery	$\frac{3}{4}w^2+\frac{3w}{2}$	$\frac{3}{4}w^2+2w+\frac{1}{4}$
ACK packets of one cycle	Sustainable sending	$w/2$	$(w-1)/2$
	Drop event processing	$3+\frac{w}{2}$	$(w-1)/2+4$
	Window recovery	$\frac{3}{8}w^2+\frac{3}{4}w$	$\frac{3}{8}w^2+w+\frac{5}{8}$
$Rate_{data/ack}$		$\frac{\frac{3}{4}w^2+\frac{5}{2}w+3}{\frac{3}{8}w^2+\frac{7}{4}w+3}$,	$\frac{\frac{3}{4}w^2+3w+\frac{13}{4}}{\frac{3}{8}w^2+2w+\frac{29}{8}}$
$Rate_{drop\_data/data}$		$\frac{1}{\frac{3}{4}w^2+\frac{5}{2}w+3}$	$\frac{1}{\frac{3}{4}w^2+3w+\frac{13}{4}}$

2.3 Simulation Results

In order to verify the accuracy of the above analysis, we use ns2 to validate. We change the bandwidth at bottleneck from 0.1Mb/s to 2 M b/s at interval of 0.1 M b/s, at the same time, change the delay from 10ms to 20ms at every bottleneck bandwidth. The simulation results show that, no matter how the link parameters changes, when delayed ACK mechanism is used ,in such a stable transfer statue, $Rate_{data/ack}$ and $Rate_{drop\_data/data}$ are decided by CWND when the packet is dropped. The experiment result is showed in Fig. 2.

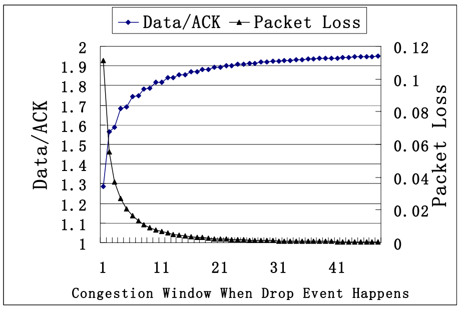

Fig. 2. Relationship between $Rate_{data/ack}$ and $Rate_{drop\_data/data}$

3 Conclusions

This paper proposes a method to estimate the packet loss easily based on the TCP delayed ACK mechanism. The export of Netflow can be used to estimated the packet loss . But two important things should be noticed when this method is applied. One is to find the suitable flow records in Netflow export, the flow should be a TCP bulk data transfer flow which is long enough to ignore the slow start period. Another thing is the estimation result will have errors because of the bandwidth variations of the flow, a correction method should be found to make the result more accurately.

References

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