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Wenjia Fang
Princeton University
Nabil Seddigh
Biswajit Nandy
Nortel Networks
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A Time Sliding Window Three Colour Marker (TSWTCM)
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Abstract

This draft defines a Time Sliding Window Three Colour Marker (TSWTCM), which can be used as a component in a Diff-Serv traffic conditioner [RFC2475, [RFC2474](#)]. The marker is intended to mark packets that will be treated by the Assured Forwarding (AF) Per Hop Behaviour (PHB) [[AFPHB](#)] in downstream routers. The TSWTCM meters a traffic stream and marks packets to be either green, yellow or red based on the measured throughput relative to two specified rates: Committed Target Rate (CTR) and Peak Target Rate (PTR).

[1.0](#) Introduction

The Time Sliding Window Three Colour Marker (TSWTCM) is designed to mark packets of an IP traffic stream with colour of red, yellow or green. The marking is performed based on the measured throughput of the traffic stream as compared against the Committed Target Rate

(CTR) and the Peak Target Rate (PTR). The TSWTCM is designed to mark packets contributing to sending rate below or equal to the CTR with

green colour, packets contributing to the portion of the rate between the CTR and PTR are marked yellow. Packets causing the rate to exceed PTR are marked with red colour.

The TSWTCM has been primarily designed for traffic streams that will be forwarded based on the AF PHB in core routers.

The TSWTCM operates based on simple control theory principles of proportionally regulated feedback control.

2.0 Overview of TSWTCM

The TSWTCM consists of two independent components: a rate estimator, and a scheme to associate a colour (drop precedence) with each packet (marker). The marker uses the algorithm specified in section 4 to associate packets with a particular colour.

The rate estimator provides an estimate of the running average bandwidth. It takes into account burstiness and smooths out its estimate to approximate the longer-term measured sending rate of the traffic stream.

The marker uses the estimated rate to probabilistically associate packets with one of the three colours. Using a probabilistic function in the marker is beneficial to TCP flows as it reduces the likelihood of dropping multiple packets within a window. It is also beneficial for certain low bandwidth voice UDP flows. Such flows can benefit from Forward Error Correction methods to reconstruct lost packets if the number of consecutively lost packets is kept low.

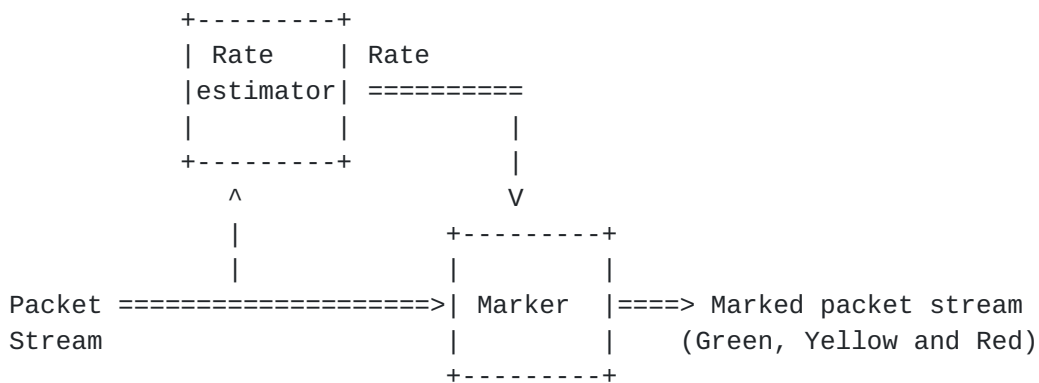


Figure 1. Block diagram for the TSWTCM

The colour of the packet is translated into a DS field packet marking. The colours red, yellow and green translate into DS

codepoints representing drop precedence 2, 1 and 0 of a single AF class respectively.

3.0 Rate Estimator

The Rate Estimator provides an estimate of the traffic stream's arrival rate. This rate is a running average bandwidth of the traffic stream over a window of time. This draft does not dictate a particular algorithm for the Rate Estimator.

The Rate Estimator MAY operate in the Router Forwarding Path or as a background function. In the latter case, the implementation MUST ensure that the Estimator provides a reasonably accurate estimation of the sending rate over a window of time. The Rate Estimator may use all packets or may sample only certain packets to determine the rate.

Examples of Rate Estimation algorithms include: exponential weighted moving average (EWMA) and the rate estimation algorithm provided in [TON98]. The following [TON98] is one possible example of a rate estimator that is designed for TCP rate estimation.

```
=====
| Initially:
|
|     Win-Length = a constant;
|     avg-rate   = CTR;
|     t-front   = 0;
|
| Upon each packet's arrival, the rate estimator updates its variables:
|
|     Bytes_in_win = avg-rate * Win-Length;
|     New_bytes    = Bytes_in_win + pkt_size;
|     avg-rate     = New_bytes / ( now - t-front + Win-Length );
|     t-front     = now;
|
| Where:
|     now          = The time of the current packet arrival
|     pkt_size     = The packet size in bytes of the arriving packet
|     avg-rate     = Measured Arrival Rate of traffic stream
|
|
|     Figure 2. Example Rate Estimator Algorithm
|
=====
```

4.0 Marker

The Marker determines the colour of a packet based on the algorithm presented in Figure 3.

The overall effect of the marker on the packets of a traffic stream

is to ensure that:

- If the estimated average rate is less than or equal to the CTR, packets of the stream are green.

- If the estimated average rate is greater than the CTR but less than or equal to the PTR, packets are designated yellow with probability P0 and designated green with probability (1-P0). P0 is the fraction of packets contributing to the measured rate beyond the CTR.

```

=====
|      avg-rate = Estimated Avg Sending Rate of Traffic Stream |
|      |
|      if (avg-rate <= CTR) |
|          the packet is green; |
|      else if (avg-rate <= PTR) AND (avg-rate > CTR) |
|          (avg-rate - CTR) |
|          calculate P0 = ----- |
|                          avg-rate |
|          with probability P0 the packet is yellow; |
|          with probability (1-P0) the packet is green; |
|      else |
|          (avg-rate - PTR) |
|          calculate P1 = ----- |
|                          avg-rate |
|          (PTR - CTR) |
|          calculate P2 = ----- |
|                          avg-rate |
|          with probability P1 the packet is red; |
|          with probability P2 the packet is yellow; |
|          with probability (1-(P1+P2)) the packet is green; |
|      |
|          Figure 3. TSWTCM Marking Algorithm |
|      |
=====

```

- If the estimated average rate is greater than the PTR, packets are designated red with probability P1, designated yellow with probability P2 and designated green with probability (1-(P1+P2)). P1 is the fraction of packets contributing to the measured rate beyond the PTR. P2 is the fraction of packets contributing to that part of the measured rate between CTR and PTR.

The marker MUST operate in the forwarding path of all packets.

5.0 Configuration

5.1 Rate estimator

The TSWTCM Rate Estimator is configured with one parameter - AVG_INTERVAL. AVG_INTERVAL is the amount of history (recent time) that should be used by the algorithm in estimating the rate.

The AVG_INTERVAL parameter MUST be configurable and MAY be specified in either milliseconds or seconds.

Research into appropriate AVG_INTERVAL values for TSWTCM with TCP flows can be found in [[TON98](#)].

The Rate Estimator measures the average sending rate of the traffic stream based on the bytes in the IP header and IP payload. It does not include link-specific headers in its estimation of the sending rate.

[5.2](#) Marker

The TSWTCM marker is configured by assigning values to its two traffic parameters: Committed Target Rate (CTR) and Peak Target Rate (PTR).

The PTR MUST be equal to or greater than the CTR.

The CTR and PTR MAY be specifiable in bits per second or bytes per second.

The TSWTCM can be configured so that it essentially operates with a single rate. If the PTR is set to the same value as the CTR then all packets will be coloured either green or red. There will be no yellow packets.

If the PTR is set to link speed and the CTR is set below the PTR then all packets will be coloured either green or yellow. There will be no red packets.

[6.0](#) Scaling properties

The TSWTCM can work with both sender-based service level agreements and receiver-based service level agreements.

[7.0](#) Services

There are no restrictions on the type of traffic stream for which the TSWTCM can be utilized. It can be used to meter and mark individual TCP flows, aggregated TCP flows, aggregates with both TCP and UDP flows [[UDPTCP](#)] etc.

The TSWTCM can be used in conjunction with the AF PHB to create a service where a service provider can provide decreasing levels of bandwidth assurance for packets originating from customer sites.

With sufficient over-provisioning, customers are assured of mostly achieving their CTR. Sending rates beyond the CTR will have lesser assurance of being achieved. Sending rates beyond the PTR have the least chance of being achieved due to high drop probability of red packets.

Based on the above, the Service Provider can charge a tiered level of service based on the final achieved rate.

8.0 Security Considerations

TSWTM has no known security concerns.

9.0 References:

- [RFC2474] K. Nichols, S. Blake, F. Baker, and D. Black, "Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers", Internet [RFC 2474](#), December 1998.
- [RFC2475] D. Black, S. Blake, M. Carlson, E. Davies, Z. Wang, and W. Weiss, "An Architecture for Differentiated Services", Internet [RFC 2475](#), December 1998.
- [TON98] D.D. Clark, W. Fang, "Explicit Allocation of Best Effort Packet Delivery Service", IEEE/ACM Transactions on Networking, August, 1998, Vol 6. No. 4, pp. 362-373.
- [AFPHB] J. Heinanen, F. Baker, W. Weiss, J. Wroclawski, "Assured Forwarding PHB Group", [RFC 2597](#), June 1999
- [UDPTCP] N. Seddigh, B. Nandy, P. Piedad, "Study of TCP and UDP Interaction for the AF PHB," Internet Draft, <[draft-nsbnpp-diffserv-tcpudpaf-01.pdf](#)>, September 1999.

10.0 Author Addresses

Wenjia Fang
Computer Science Dept.
35 Olden Street,
Princeton, NJ08540
Email: wfang@cs.princeton.edu

Nabil Seddigh
Nortel Networks,
3500 Carling Ave
Ottawa, ON, K2H 8E9
Canada
Email: nseddigh@nortelnetworks.com

Biswajit Nandy
Nortel Networks,
3500 Carling Ave
Ottawa, ON, K2H 8E9
Canada
Email: bndandy@nortelnetworks.com

