Router Buffer Traffic Load Calculation based on a TCP Congestion Control Algorithm

Kulvinder Singh

Asst. Prof., Computer Science and Engineering Department,
Vaish College of Engineering,
Rohtak, India
kulvinderbhuna@gmail.com

Abstract

In this paper, instead of using the length of queue as a measure of congestion, we use traffic load, defined as the ratio of incoming rate over the outgoing rate at our router. The shape of packet marking probability used is similar to the one of RED, but the intuition of design is that using the traffic load information, will make the queue lesser oscillatory and thus increases the router's throughput compared to RED. The objectives are then to bring the values of traffic load to one and to keep a nearly empty queue length in the memory buffer, so that the queuing delay is as small as possible. However the idea of the design is heuristic, as in RED. In the stability analysis, we perform here is meant to justify its use and to give guidelines for the design of the parameters. We assume that the network configuration where sources implements the TCP protocol.

Keywords: Congestion, TCP, Queue, RED, AQM.

1. Introduction

We consider in this paper, the analysis of an Active Queue Management scheme supporting the TCP flows that is based on router's traffic load. In this scheme was first proposed in [1]. Instead of using the length of queue as a measure of congestion, we use traffic load, defined as the ratio of incoming rate over the outgoing rate at our router. The shape of packet marking probability used is similar to the one of RED, but the intuition of design is that using the traffic load information, will make the queue lesser oscillatory and thus increases the router's throughput compared to RED. The objectives are then to bring the values of traffic load to one and to keep a nearly empty queue length in the memory buffer, so that the queuing delay is as small as possible. However the idea of the design is heuristic, as in RED. In the stability analysis, we perform here is meant to justify its use and to give guidelines for the design of the parameters.

We assume that the network configuration where sources implements the TCP protocol. We propose an AQM scheme that drops packets or marks the same bits in the packets than the ones used by ECN (bits 6 and 7 in the TOS octet in IPv4, or Traffic class octet in IPv6 [2, 3]) to indicate the congestion, but the probability of dropping or marking the packets are different than the one of RED.

2. An Algorithm for calculates probability for packet marking using router buffer traffic load

Similarly to the averaging done on the queue length signal for the RED, an average is first operated on the instantaneous traffic load:

$$L_{avg}(nT) = (1-\alpha)L_{avg}\big((n-1)T\big) + \alpha L(nT), \qquad n \in N \tag{1}$$

where L(nτ) and Lavg (nτ) are respectively instantaneous and average traffic load at time $t = n\tau$, $\alpha \in (0, 1)$ is averaging weight and τ is the averaging sampling time. The probability of the packet mark or drop is shown in Figure 1, where packet is marked if the flow is ECN-capable, and drop otherwise.

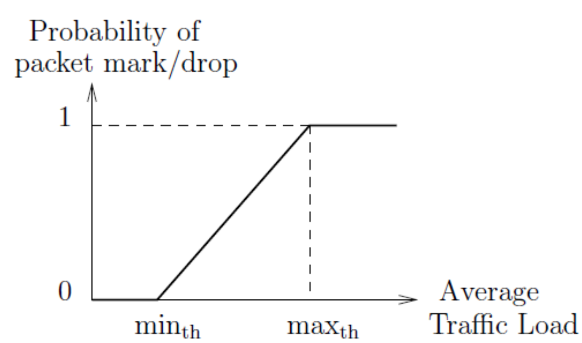


Figure 1: Probability of packet marking for the Traffic Load scheme

3. Mathematical model

In the following, we worked on a mathematical model that will allows us for justify our design by carrying out a stability analysis of implicit feedback control system. This model will helps to justify the performance improvement, we observe while comparing the Traffic Load to RED-ECN scheme and will provides guidelines for tuning design parameters.

We consider a network configuration consists of a single router supporting N homogeneous TCP flows. As shown in[4, 5] and explained in the Section 2, the congestion avoidance mode of TCP can be modeled by using a fluid flow approximation as

$$\dot{W}(t) = \frac{1}{R(t)} - \frac{W(t)}{2}\frac{W(t-R(t))}{R(t-R(t))}p(t-R(t)) \qquad (2)$$

$$\dot{q}(t) = \begin{cases} \frac{N(t)}{R(t)}W(t) - C & if\ q(t) > 0 \\ max\left\{0, \frac{N(t)}{R(t)}W(t) - C\right\} & if\ q(t) = 0 \end{cases} \qquad (3)$$

where W (t) is the TCP's congestion window size, R(t) is the round trip time delay, p(t) is probability of packet mark due to the AQM mechanism at the router, N is the number of TCP flows going through router and q is the buffer queue length. The round triptime is composed of the propagation delay Tp and queuing delay q(t)/C with q(t) the queue length of the buffer and C is outgoing link capacity, thus

$$R(t) = \frac{q(t)}{C} + T_p \qquad (4)$$

The Network Load L(t), being defined as the ratio between aggregate incoming rate at router and the outgoing link capacity, satisfies

$$L(t) = \frac{NW(t)}{R(t)C} \qquad (5)$$

Then if a queue builds up at the router we have

$$\frac{\dot{q}(t)}{C} = L(t) - 1 \qquad (6)$$

Note that Equation (6) is true for RED and Traffic Load schemes. Using these similar techniques to those used in [4], (1) is equivalent to frequency-domain relationship

$$L_{avg}(s) = \frac{L(s)}{1+\frac{s}{k_{TL}}} \qquad (7)$$

with kTL = − (1/τ) loge (1− α), and the packet marking probability shown in Figure 1 obeys

$$p(t) = \frac{L_{avg}(t) - min_{th}}{max_{th} - min_{th}} \qquad (8)$$

From the above equations equilibrium of the dynamical system is (W0 , L0 , p0 , R0 , q0) that satisfies

$$W_0^2 p_0 = 2, \qquad (9)$$

$$P_0 = \frac{L_0 - min_{th}}{max_{th} - min_{th}}, \qquad (10)$$

$$L_0 = \frac{NW_0}{R_0 C} \qquad (11)$$

$$R_0 = \frac{q_0}{C} + T_p \qquad (12)$$

In addition, if a queue build up (i.e. q0 > 0) we have from Equation 3

$$\frac{NW_0}{R_0} = C \qquad (13)$$

and thus L0 = 1. In order to derive a linear model of the system, we distinguish whether a queue is formed at equilibrium or not.

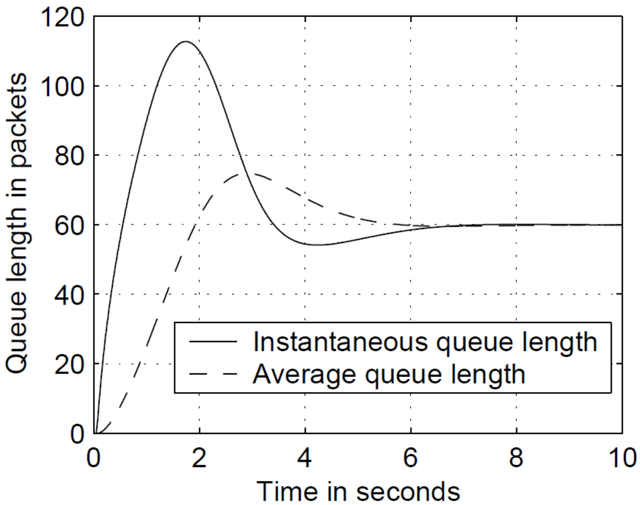
4. MATLAB simulations

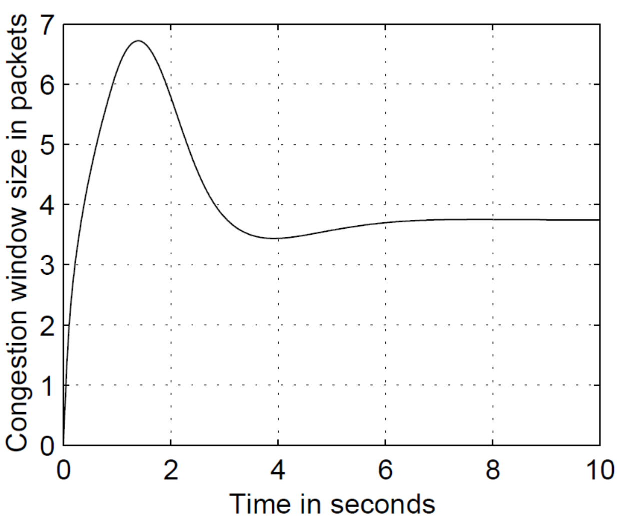
We simulate in MATLAB, the system formed by Equations (2), (3), (4), (5), (7) and (8) with RED. In the Figures 2 and 3 are shown time responses of the queue length, congestion window size, probability of packets marking and traffic load corresponding to the parameters.

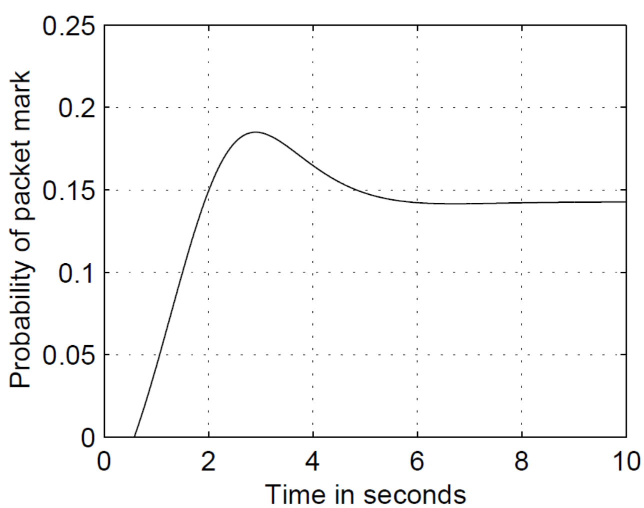
T_p = 0.05
N = 20
C = 300
P_{max} = 0.2
RED min_{th} = 10
RED max_{th} = 80
αRED = 0.002
kTL = 1
TL min_{th} = 0.3
TL max_{th} = 1.1

Parameters for simulations in MATLAB

We can see that the queue length settle much faster to it's steady state value for Traffic Load scheme than for the RED, while having a much smallest overshoot. The RED AQM scheme is well known to be hard to tune[6] for best performance corresponds to a typical RED parameter sets







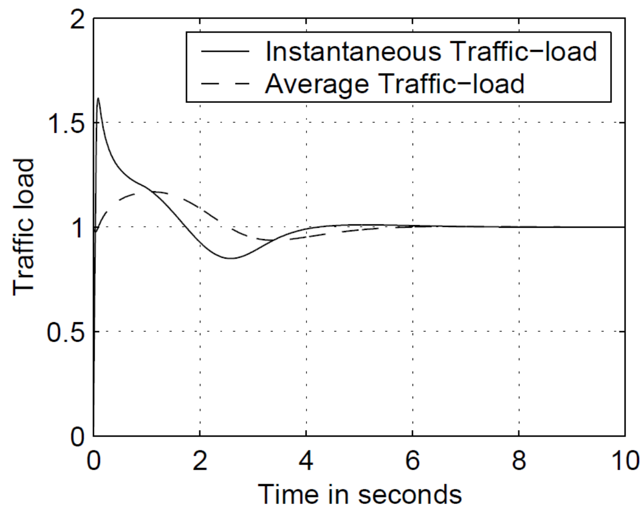
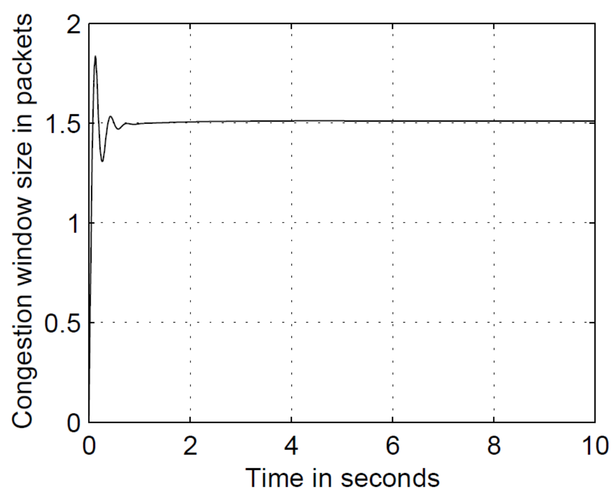
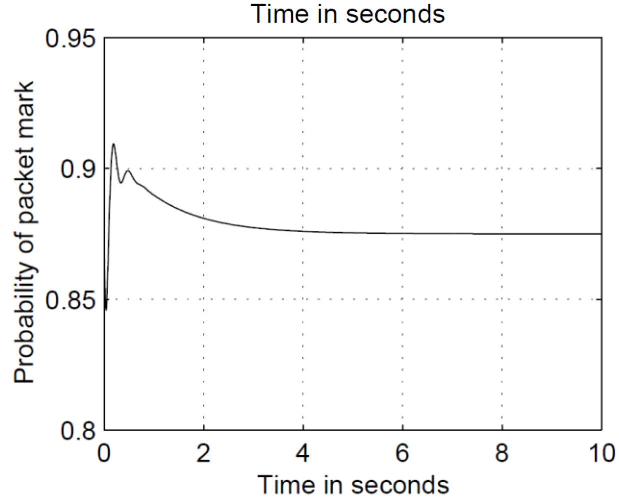


Figure 2: RED scheme.

in this case. We can see that the queue length is much lesser oscillatory for the Traffic Load scheme, which will translates into a best throughput and lower jitter. It has been noticed consistantly that Traffic Load scheme is much easy to tune than RED for better performance.





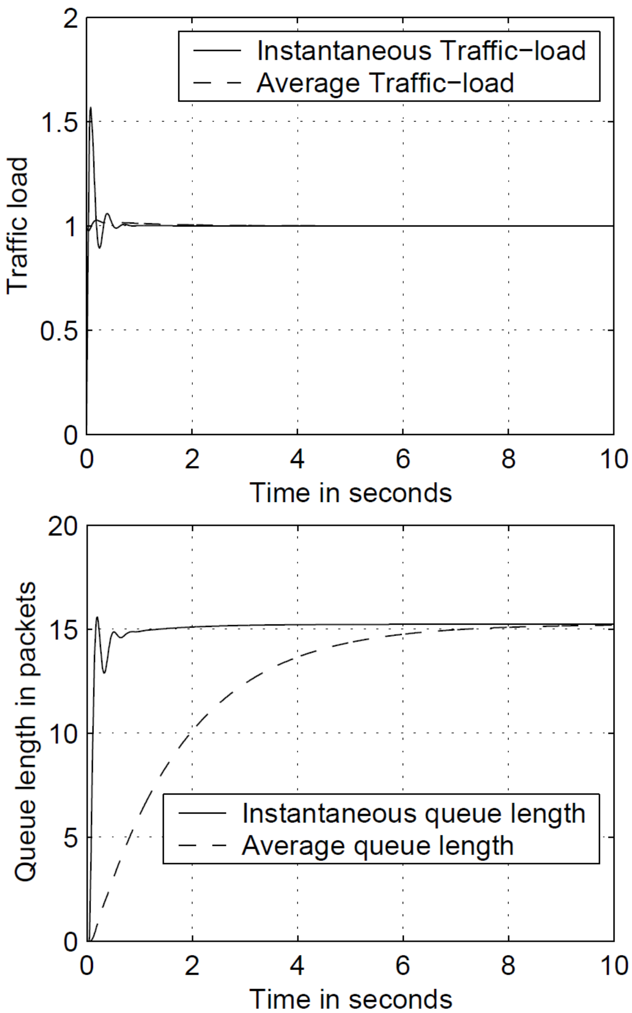


Figure 3: Traffic Load scheme.

5. Conclusion

We studied in this research work, an Effective AQM control scheme assisting ECN and TCP flows. The simulation experiments are based on a nonlinear fluid flow model, that includes delays, show that proposed AQM scheme performs better than RED and proportional integral scheme by obtaining faster transients, less oscillatory responses. Which translates into higher link utilizations, low packet loss rates and small queue fluctuations.

In these cases the design comprised justified for an individual chokepoint node. This is a basic approach in window based congestion control, where it is commonly accepted that an AQM strategy planned for a single router linked to N sources would still act fairly in an absolute network topology. Preliminary solutions consider more composite topologies for the design of AQM controllers supporting TCP flows. Also the authors conceive more general topologies for congestion controller design in rate based networks. Design of over-crowding controllers for an absolute network topology is still a topic of research interest. But the extension is not insignificant since the controllers carried out at dissimilar chokepoints will interact with each other.

References

[1] M. Sridharan, P. Kandikuppa, S. Chellappan, P.-F. Quet, A. Durresi, R. Jain, and H. ÄOzbay, A congestion control algorithm based on router Traffic Load." submitted for presentation at INFOCOM 2003, July 2002.

[2] K. Ramakrishnan and S. Floyd, A proposal to add explicit congestion notification (ECN) to IP." RFC 2481, January 1999.

[3] S. Floyd, TCP and explicit congestion notification," ACM Computer Communication Review, vol. 24, pp. 10-23, October 1995.

[4] V. Misra, W. B. Gong, and D. Towsley, Fluid-based analysis of a network of AQM routers assisting TCP flows with an application to RED," in Proc. of ACM/SIGCOMM, pp. 151-160, 2000.

[5] C. V. Hollot, V. Misra, D. Towsley, and W. B. Gong, \Analysis and design of controllers for AQM routers assisting TCP flows," IEEE Trans. on Automatic Control, vol. 47, pp. 945-959, June 2002.

[6] M. Christiansen, K. Jeray, D. Ott, and F. D. Smith, Tuning RED for web traffic," in Proc. of ACM SIGCOMM'00, (Stockholm, Sweden), September 2000.

About Author: Kulvinder Singh received the M.Tech.(CSE) degree in 2006 and the M.Phil.(CS) degree in 2008 from Ch. Devi Lal University Sirsa(Haryana), India. He is pursuing Ph.D. in Computer Science. At present he is working as Assistant Professor in Vaish College of Engineering, Rohtak, India. He is having more than 6 years of experience both in industry and academia. He is a member of IEC. He presents many research papers in national and international conferences. He published many research papers in various International Journals. His interest areas are Networking, Web Security, Internet Congestion and Fuzzy Database.