NATIONAL UNIVERSITY OF SINGAPORE

SCHOOL OF COMPUTING
MIDTERM EXAMINATION FOR
Semester 1 AY2007/2008

CS5229 Advanced Computer Networks

September 2007 Time Allowed 1.5 hours

INSTRUCTIONS TO CANDIDATES

1. This examination paper contains FIVE (5) questions and comprises FOUR (4) printed pages, including this page.
2. Answer **ALL** questions. State any additional assumption you make clearly.
3. Write **ALL** your answers in the answer book provided.
4. This is an **OPEN BOOK** examination.

1. i. (2 points) Why did the early Internet designers separate IP and TCP into two different protocols?

   ii. (3 points) Filtering of unsolicited emails, or spam, can be done either at the mail server or at the mail client. Consider the following two options: (i) Filter spams at the server by blocking the spams and prevent them from reaching a user's mailbox. (ii) Deliver all emails (including possible spams) to the user and let the mail client decides which ones are spams.

   Use end-to-end argument to argue which of the above two options is a better design choice.

2. i. (2 points) Should probe packets in Packet Bunch Mode (PBM) be sent over TCP? Why, or why not?

   ii. (1 point) Two PBM probe packets of size 1 kB are sent back-to-back over a path with a bottleneck bandwidth of 100 kBps. Assuming that there are no other flows on the path, what should the inter-arrival time between the two probe packets be at the receiver?

   iii. (2 points) In part (ii) above, if we have a clock resolution of 10 ms, what is the minimum number of probe packets we need to send back-to-back so that the maximum error in bandwidth measurement drops below 10%? The measurement error is defined as

$$\frac{|\text{measured value - actual value}|}{\text{actual value}}$$

3. i. (2 points) Draw a figure similar to Figure 5 in Chiu and Jain's paper [1] and show that the multiple increase additive decrease (MIAD) scheme never converges.

   ii. (3 points) Suppose we use a AIMD scheme with the same multiplicative decreasing factor (b_D) for both User 1 and User 2, but User 1's additive increasing factor (a_I) is twice the additive increasing factor of User 2. Use a figure similar to Figure 5 in Chiu and Jain's paper [1] to explain why resource allocation will converge to a fairness value of 0.9.

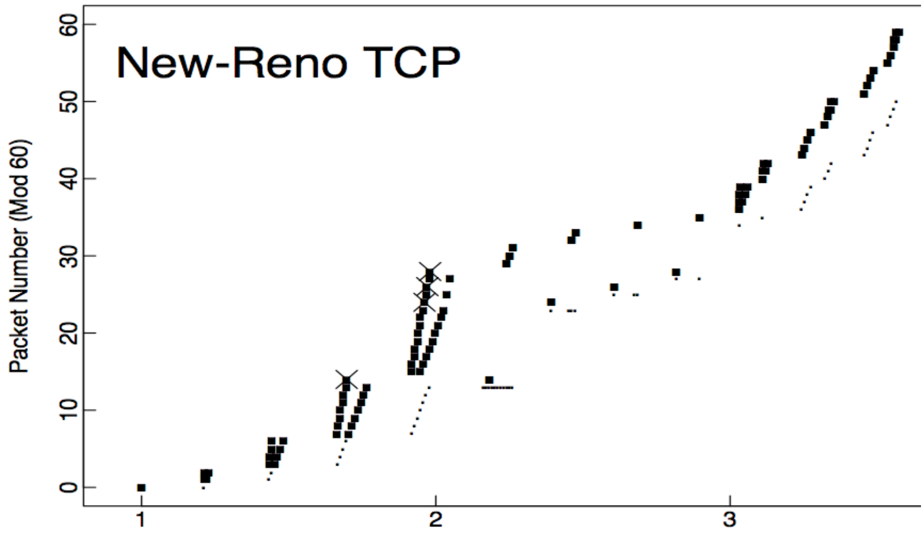

Figure 1: Simulation Trace for TCP NewReno

4. i. (2 points) Figure 1 shows a trace of TCP NewReno with four packet losses, taken from Fall and Floyd's paper [2]. How many partial ACKs are shown in the figure? Approximately what time (give the value of the x-axis) does TCP NewReno exit from the fast recovery phase in the figure?

   ii. (3 points) TCP NewReno improves over TCP Reno by reducing the possibility of timeouts when multiple packets are lost within a window. Timeouts, however, can still occur in TCP NewReno. Give two scenarios where TCP NewReno can timeout during fast recovery.

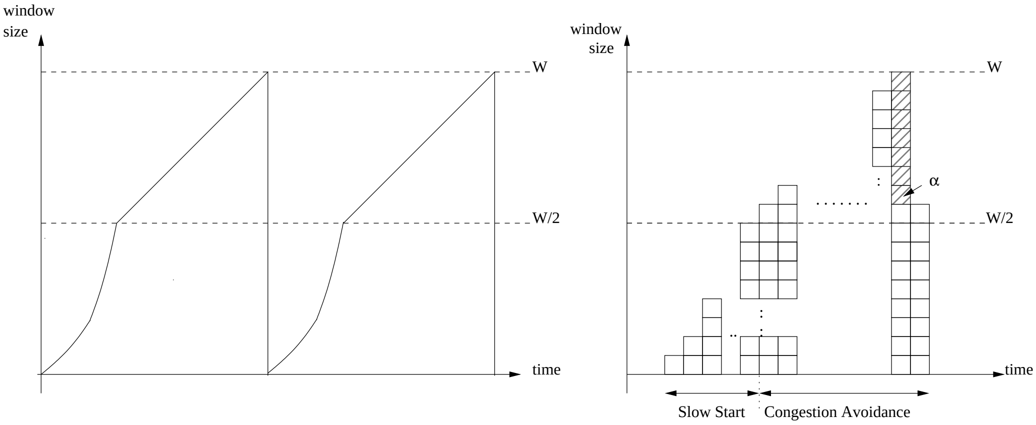

Figure 2: Left: Evolution of window size for TCP Tahoe. Right: Packets sent during a triple duplicate period. Shaded packets are lost packets.

5. In this question you will develop a formulation to estimate the throughput for TCP Tahoe, considering triple duplicate ACKs as the only type of loss indications. Recall that TCP Tahoe drops cwnd to 1 and sstresh to half of cwnd when fast retransmit occurs, and goes into slow start after that. Figure 2 shows the evolution of congestion window over time. Note that a triple duplicate period now consists of both slow start and congestion avoidance phase. Using a similar set of assumptions from Padhye et al. [3] and from our class notes,

   i. (2 points) relate W and p in an equation of the form $apW^2 + bpW + c = 0$ for some constants a, b, and c.

   ii. (3 points) show that

$$B = \frac{1}{RTT\left(\frac{p}{2}\log_2 \frac{1}{p} + \sqrt{\frac{2p}{3}}\right)}$$

   The variables p, W, RTT, and B denote the same quantity as in class (see class notes for Lecture 5). For simplicity, you may assume that W is close to a power of 2.

END OF PAPER

References

[1] D.-M. Chiu and R. Jain. Analysis of the increase and decrease algorithms for congestion avoidance in computer networks. *Computer Networks and ISDN System*, 17(1):1–14, 1989.

[2] Kevin Fall and Sally Floyd. Simulation-based comparisons of Tahoe, Reno and SACK TCP. *Computer Communication Review*, 26(3):5–21, July 1996.

[3] J. Padhye, V. Firoiu, D. Towsley, and J. Krusoe. Modeling TCP throughput: A simple model and its empirical validation. *Proceedings of SIGCOMM '98*, pages 303–314, 1998.