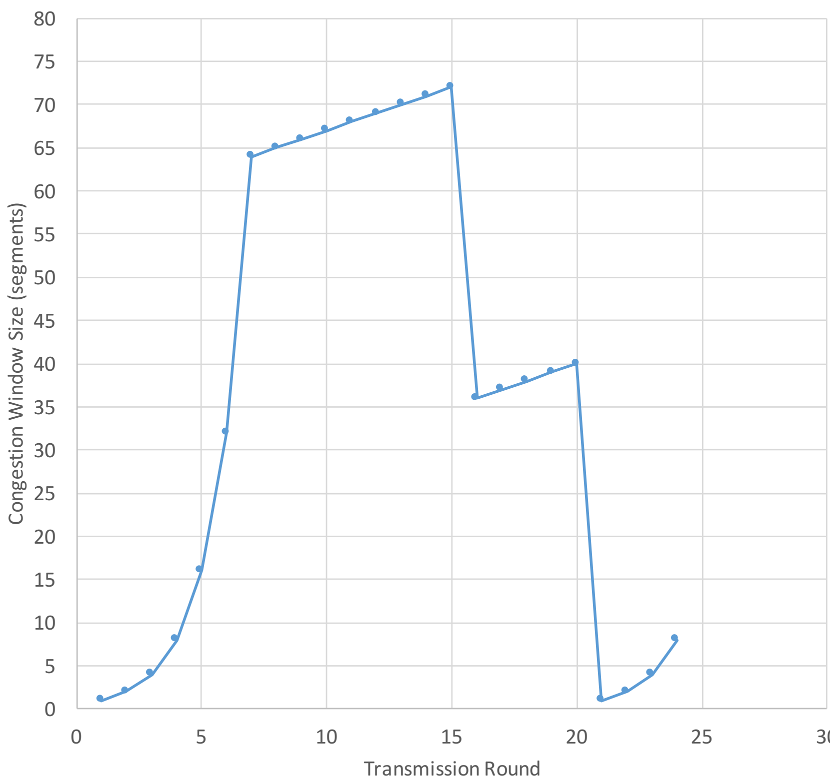
15-744 Computer Networks — Spring 2016
Homework 2
Due by 2/26/2016, 10am

Name:

1. Consider the following plot of TCP window size as a function of time:



Assuming TCP Reno is the protocol experiencing the behavior shown above, answer the following questions.

(a) Identify the intervals of time when TCP slow start is operating.

(b) Identify the intervals of time when TCP congestion avoidance is operating (AIMD).

(c) Identify the first interval of time when TCP fast recovery is operating.

(d) After the 16th transmission round, is segment loss detected by a triple duplicate ACK or by a timeout?

(e) What is the initial value of ssthreshold at the first transmission round?

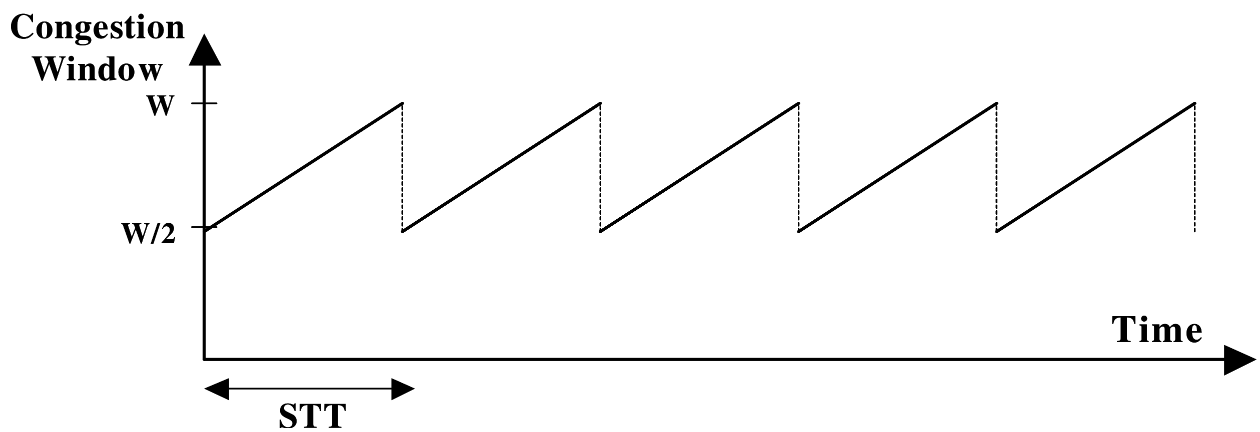
(f) What is the value of ssthreshold at the 18th transmission round?

(g) What is the value of ssthreshold at the 23th transmission round?

(h) During what transmission round is the 70th segment sent?

(i) Assuming a packet loss is detected after the 26th round by the receipt of a triple duplicate ACK, what will be the value of the congesion-window size? What will be the value of ssthreshold?

(j) Suppose TCP Tahoe is the protocol experiencing the behavior, and a timeout is detected between the 15th and 16th transmission round. What will be the value of congestion-window size at the 16th transmission round? What will be the value of ssthreshold?



2. The picture above shows the famous TCP saw tooth behavior. We are assuming that fast retransmit and fast recovery always work, i.e. there are no timeouts and there is exactly one packet lost at the end of each "tooth". We are assuming that the flow control window is large and that the sender always has data to send, i.e. throughput will be determined by TCP congestion control.

   In the picture, W represents the congestion window size at which a congestion packet loss occurs (expressed in maximum transfer units). You can assume that W is large, so feel free to approximate (W-1) or (W+1) by W. STT represents the "saw tooth time" expressed in seconds.

   In this question, we will calculate the average throughput T for this connection as a function of the roundtrip time (RTT), the maximum transfer unit size (MTU), and packet loss rate p for this connection. Please use the notation suggested by the figure, i.e. W and STT, as intermediate values if you need them.

   (a) Based on the shap of saw tooth, how many units can be sent within each STT?

   (b) Assume one packet (unit) loss event happens at the end of each STT. How many units can be sent in each STT given the packet loss rate is p?

   (c) Given that the previous two questions should yield the same answer, please calculate W as a function of p.

   (d) TCP throughput is in general defined as number of bytes divided by the duration of time to send them. Given the results in the previous questions, please calculate the TCP throughput as a function of RTT, MTU and p.

3. Two connections experience the same loss rate and use the same packet size. Connection A has RTT 5ms, and connection B has RTT 10ms. Two connections share the same congested gateway and have no other congested gateways.

   (a) Suppose the congested gateway uses drop-tail queueing. Express the throughput of connection B ($tput_B$) in terms of the throughput achieved by connection A ($tput_A$), or indicate if there is no relationship between the two.

   (b) Suppose the congested gateway uses fair queueing. This is *not* weighted — all weights are the same. Express the throughput of connection B ($tput_B$) in terms of the throughput achieved by connection A ($tput_A$), or indicate if there is no relationship between the two.

   (c) Two connections traverse the same congested gateway, but *also* traverse some other unshared congested gateways. Express the throughput of connection B ($tput_B$) in terms of the throughput achieved by connection A ($tput_A$), or indicate if there is no relationship between the two.

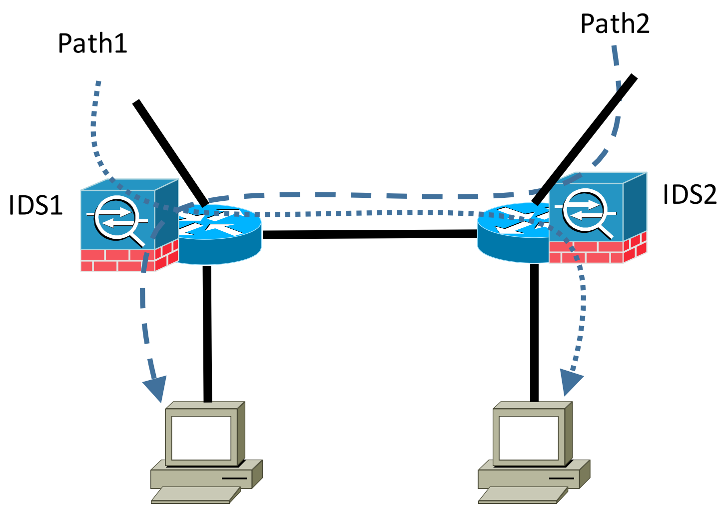
   (d) List two advantages that RED provides over drop-tail queueing.

4. Consider the following scenarios and identify the opportunity of a consolidated middlebox architecture.

   (a) Consider an IDS and a firewall sharing the hardware resources on the same machine. The table below shows how much hardware resource (expressed in # of units) each middlebox application needs at different time slots. How much total hardware resources (expressed in # of units) are needed to be provisioned if the IDS and the firewall use the resource separately? How much less hardware resources can be provisioned if a consolidated middlebox architecture is used?

Table 1:

Time	IDS	Proxy
T1	10	5
T2	1	50
T3	4	20
T4	50	10



   (b) Consider an enterprise network with the topology in the above figure. Two border routers connect to two internal servers, and each border router has an IDS. IDS1 serves the border router of Path1, and IDS2 serves the border router of Path2. The table below shows how much traffic (expressed in # of units) on each path at different time slots. How much traffic (expressed in # of units) each IDS needs to be provisioned to handle if all traffic must be handled by the IDS on the border router? How much traffic (expressed in # of units) each IDS needs to be provisioned to handle if the traffic can be handled by any IDS on the path? Please give one viable assignment of traffic to each IDS in each time slot.

Table 2:

Time	Path1	Path2
T1	10	5
T2	1	50
T3	4	20
T4	50	10

“relax
“newlabel–1@@exam@lbl”—1”–1””
“PgInfo–question@1”–1”
“newlabel–2@@exam@lbl”—a”–1””
“PgInfo–part@1@1”–1”
“newlabel–3@@exam@lbl”—b”–1””
“PgInfo–part@1@2”–1”
“newlabel–4@@exam@lbl”—c”–1””
“PgInfo–part@1@3”–2”
“newlabel–5@@exam@lbl”—d”–2””
“PgInfo–part@1@4”–2”
“newlabel–6@@exam@lbl”—e”–2””
“PgInfo–part@1@5”–2”
“newlabel–7@@exam@lbl”—f”–2””
“PgInfo–part@1@6”–2”
“newlabel–8@@exam@lbl”—g”–2””
“PgInfo–part@1@7”–2”
“newlabel–9@@exam@lbl”—h”–2””
“PgInfo–part@1@8”–2”
“newlabel–10@@exam@lbl”—i”–2””
“PgInfo–part@1@9”–2”
“newlabel–11@@exam@lbl”—j”–2””
“PgInfo–part@1@10”–2”
“gdef“pointsofq@i–0”
“newlabel–12@@exam@lbl”—2”–3””
“PgInfo–question@2”–3”
“newlabel–13@@exam@lbl”—a”–3””
“PgInfo–part@2@1”–3”
“newlabel–14@@exam@lbl”—b”–3””
“PgInfo–part@2@2”–3”
“newlabel–15@@exam@lbl”—c”–3””
“PgInfo–part@2@3”–3”
“newlabel–16@@exam@lbl”—d”–3””
“PgInfo–part@2@4”–3”
“gdef“pointsofq@ii–0”
“newlabel–17@@exam@lbl”—3”–4””
“PgInfo–question@3”–4”
“newlabel–18@@exam@lbl”—a”–4””
“PgInfo–part@3@1”–4”
“newlabel–19@@exam@lbl”—b”–4””
“PgInfo–part@3@2”–4”
“newlabel–20@@exam@lbl”—c”–4””
“PgInfo–part@3@3”–4”
“newlabel–21@@exam@lbl”—d”–4””
“PgInfo–part@3@4”–4”
“gdef“pointsofq@iii–0”
“newlabel–22@@exam@lbl”—4”–5””
“PgInfo–question@4”–5”
“newlabel–23@@exam@lbl”—a”–5””
“PgInfo–part@4@1”–5”
“@writefile–lot”–“contentsline´–table”–“numberline´–1”–“ignorespaces´””–5””
“newlabel–my-label”—1”–5””
“newlabel–24@@exam@lbl”—b”–5””