Read before starting:
1. Put down your name on the first page NOW.
2. Put down your initials on the top right corner of each page
3. This answer book has 10 pages.
4. In all answers, clearly state the units. Use standard units such as bps, Kbps, or Mbps, not KB/msec and such. Bps means bytes per second and bps means bits per second.
5. Assign and use variable names before plugging in actual numbers. This way, you are likely to get more partial credit if your final answer is incorrect.
6. Be precise for “explain”-type questions. Giving long-winded vague answers is unlikely to get you much partial credit. You will also lose time.
7. Be a smart exam-taker. Answer questions you are confident of first. The points roughly reflect the most number of minutes you should spend on the question.
8. The space provided roughly reflects how long your answer should be. Feel free to ask the TA for rough sheets. Attach any rough sheets used.
9. Different parts of a question are mostly independent. So, if you can not do one part, don’t let it bother you. Just move on to the next part.
10. If you feel a question does not provide some information necessary to solve a problem, make the most reasonable assumption. Or ask.
11. There is no negative scoring in any question.
12. You have 80 minutes to score 100 points.

Name: _____________________________

| Problem 1 | _____ out of 27 |
| Problem 2 | _____ out of 25 |
| Problem 3 | _____ out of 25 |
| Problem 4 | _____ out of 23 |
| **Total** | _____ out of 100 |
Problem 1 (Quickies, 27 points): For non-objective type questions below, there may be more than one correct answer. You should try to provide the best one.

A. (True or false) In slow start, TCP doubles its sending rate every second. (1)

B. (True or false) Suppose there are N senders generating data to be reliably sent to their respective receivers in a network where every link has a capacity greater than the sum of the rates at which the N senders generate data. Congestion control is unnecessary in this setting. (2)

C. (True or false) If TCP ignored triple-duplicate acks, but left everything else in the protocol unchanged, it would still be a correct reliable transport protocol for a network with loss and corruption. (2)

D. Give three differences between IPv4 and IPv6. (3)

E. TCP’s current EstimatedRTT is 100ms. Upon receipt of the next sample, the EstimatedRTT is 5ms. Is this possible? If so, when? If not, why not? (1)
F. Does TCP throughput depend on the bottleneck capacity of the path? If so, how? If not, why not? (2)

G. If IP addresses behind a NAT are not globally visible, how can you make Skype call from your house to a friend assuming both of you are behind NATs? (3)

H. Give a pictorial example of head-of-the-line blocking in a router. (2)

I. Can a NAT use a single port number to demultiplex packets to internal hosts? If so, give an example of when it is possible. If not, why not? (2)
J. Give three reasons for delay occurring at routers and specify where exactly in the router they occur. (3)

K. If a router A uses link-state routing to compute route to C that goes via B, then the computed route from B to C is the corresponding suffix of the route from A to B. When would this statement be false? (3)

L. Name three fields in an IP header other than the IP addresses. (3)

End of Problem 1.
Problem 2 (IP addressing, 25 points): Consider the topology shown below.

A. Assign network addresses to each of the six subnets, with the following constraints: All addresses must be allocated from 214.97.254/23; Subnet A should have enough addresses to support 250 interfaces; Subnet B should have enough addresses to support 120 interfaces; and Subnet C should have enough addresses to support 120 interfaces. Of course, subnets D, E, and F should each be able to support two interfaces. For each subnet, the assignment should take the form a.b.c.d/x or a.b.c.d/x – e.f.g.h/y. (15)
B. Using your answer to part (a), provide the forwarding tables (using longest prefix matching) for each of the three routers. (10)

End of Problem 2.
Problem 3 (Pigeon TCP, 23 points): Ancient Babylonians found that pigeons were pretty convenient to exchange messages with their relatives across the Euphrates river. After a few test runs, the emperor opened the pigeon mail service to the people. The problem was that some pigeons would drop into the Euphrates because of exhaustion during days of bad weather that were difficult to predict. The Babylonians (i) did not want to lose too many pigeons all at once, (ii) needed a timeout estimation scheme to retransmit messages, (iii) wanted to prevent overloading the pigeon processing center on the other side. They did some calculations using recently invented Arabic numerals and decided to use --- AIMD, exponentially weighted moving average, and flow control, --- just like in TCP to respectively address the three problems. Answer the following.

A. Until day 42, a pigeon took about a day plus or minus half a day to come back. The next few pigeons recorded round-trip times of 1, 2, 1.75, 1.25 days respectively. What is their current estimate of the timeout? (12)

B. On day 45, the pigeon fleet consisted of 13 pigeons. The next day’s fleet consisted of 17 pigeons. What could be the reason? Assume all pigeons on day 45 successfully came back. (4)
C. The Babylonians fixed a maximum message length to 1000 words as they found that up that length, the weight was comfortable for the pigeons. Beyond that, the probability of pigeon exhaustion increases exponentially (as $2^{\text{length}}$) with the length of the message it carries. If the message size is tripled to 3000 words, how does their mail throughput (in words per day) change? (7)

End of Problem 3.
Problem 4 (Reliable transport FSM, 25 points): Suppose we have two network entities, A and B. B has a supply of data messages that will be sent to A according to the following conventions. When A gets a request from the layer above to the next data (D) message from B, A must send a request (R) message to B on the A-to-B channel. Only when B receives an R message can it send a data (D) message back to A on the B-to-A channel. A should deliver exactly one copy of each D message to the layer above. R messages can be lost (but not corrupted) in the A-to-B channel; D messages, once sent, are always delivered correctly. The delay along both channels is unknown and variable.

Design (give an FSM description of) a protocol that only incorporates the appropriate mechanisms to compensate for the loss-prone A-to-B channel and implements message passing to the layer above at entity A, as discussed above. Use only those mechanisms that are absolutely necessary.

End of Problem 4.