Department of Computer Science and Engineering, National Sun Yat-Sen University
First Semester of 2006 PhD Qualifying Exam
Computer Networks

Problem 1. (Totally, 20 points)

(1) Explain the additive-increase, multiplicative-decrease (AIMD) algorithm used in TCP congestion control.

(2) Explain how the fast recovery (fast retransmission) in TCP works. Why fast recovery is better than simply waiting for retransmission timeout in terms of throughput?

(3) Draw a figure that shows the typical evolution of TCP's congestion control window size. You can select either TCP-Tahoe or TCP-Reno.

(4) What are the major differences between TCP and UDP?

Problem 2. (Totally, 20 points)

(1) What is multicast? Explain how multicast is used to reduce bandwidth consumption in the Internet backbone and the Ethernet-based local area networks.

(2) List the advantages and the disadvantages of layer-3 multicast and layer-7 multicast.

(3) What is the main function of the IGMP (Internet Group Management Protocol)? Is it necessary for a multicast router to know which hosts in a Ethernet local area network are in a multicast group? Please justify your answer.

(4) Explain the major difference between inter-AS routing and intra-AS routing. (AS stands for autonomous system) List one popular inter-AS routing protocol and one popular intra-AS routing protocol.

Problem 3. (Totally, 10 points)

(1) What are the major differences between the symmetric key encryption scheme and the public key encryption scheme?

(2) Use public key encryptions to design a scheme that assures privacy and integrity for a communication session from Jane to Michael over an insecure Internet.

Problem 4. (Totally, 10 points)

Let G be the total network traffic load. Typically, the network throughput is a function of G.

(1) When the ALOHA is used, the network throughput equals $f_1(G) = G \cdot e^{-2G}$. Draw the function $f_1(G)$ and use Calculus to find the maximum value of $f_1(G)$.

(2) When the slotted ALOHA is used, the network throughput equals $f_2(G) = G \cdot e^{-G}$. Draw the function $f_2(G)$ and use Calculus to find the maximum value of $f_2(G)$.

Problem 5. (Totally, 10 points)

Consider a M/M/1 queueing system. Let $a(t) = \lambda e^{-\lambda t}$ be the probability density function for the inter-arrival times and $b(t) = \mu e^{-\mu t}$ be the probability density function of the service times. Let $X(t)$ be the system size of the queueing system at time t. In addition, $X(0) = 0$.

(1) Let $p_n = \lim_{t\to\infty} P\{X(t) = n\}, \forall n \geq 0$. Derive p_n's, where $n \geq 0$.

(2) Derive the average system delay W and the average queueing delay W_q.

Problem 6. (20 points)

In addition to IPv6, CIDR (Classless Interdomain Routing) and NAT (Network Address Translation) are two methods to combat the shortage of IP addresses.

(1) What is the major difference between IPv6 and IPv4?

(2) Use an example to briefly explain CIDR.

(3) Use an example to briefly explain NAT.

(4) What is the the longest prefix matching rule? Use an example to explain your answer.

Problem 7. (10 points)

It is not unusual that you simultaneously run a number of network applications, such as web browsing, email, MSN, Skype, and etc, on your computer. Therefore, a mechanism is required for the network sub-system of the operating system to forward received packets to the right application. For example, a packet containing the content of a website should be forwarded to browser rather than Outlook, MSN or Skype.

Draw the protocol stack and show how packets are processed when a HTTP GET request is first sent from host A (with IP address 140.117.169.206) to host B (with IP address 140.117.168.106) and then a HTTP response is sent back from host B to host A. In particular, you should show the values of the most important header fields (such as port numbers, IP addresses, and upper-layer-protocol) at different layers.