COMP 561: Computer Networks

FINAL EXAMINATION

Fall, 2010

Q1. [16 Points] True or false

Determine whether the following statements are true or false. **Circle** the answer. You do NOT need to describe the reasons for your choice.

i. Suppose a network protocol uses variable-length packets and the payload in the packet can be arbitrarily long. If the protocol includes a message checksum for the payload in each packet, the length of the checksum is at least O(log N) where N is the length of the payload.

True (False)

ii. It is possible to use 600 switches to construct a large network with 512 connected computers and let the switches learn the unicast path from one computer to another automatically.

(True) False

iii. B-MAC supports end-to-end acknowledgement in a multi-hop network.

True (False)

iv. A GBN (Go-Back-N) protocol often need more buffer space than a selective repeat protocol.

True (False)

v. RM (Resource Management) cells in an ATM network with ABR (Available Bit Rate) service are created by a sender and will be received by the sender itself.

(True) False

vi. If all Web browsing used persistent HTTP, we would not need cookies.

True (False)

vii. One computer can belong to two IP subnets.

(True) False

viii. PIM (Protocol Independent Multicast) uses an RPF approach in dense mode.

(True) False

Q2. [16 Points] Multiple choices

Choose the BEST answer and write the corresponding letter in the blank space at the beginning of the question.

i. _D_ A leaky bucket is specified as (r, b) where r is the rate tokens are added to the bucket and b is the capacity of the bucket. Consider two leaky buckets B1 and B2 with specifications (r, b) and (R, 1), respectively. Suppose R>r, and we can use B1, B2, or a combination of B1 and B2 to regulate the network traffic. Which of the following statements is NOT true?

A. We can regulate the average rate to be R
B. We can regulate the average rate to be r
C. We can regulate the peak rate to be R
D. We can regulate the peak rate to be r
E. We can regulate the burst size to be 1

ii. _B_ In the early days, emails are all in the text format, and both the email clients (user agents) and the SMTP protocol process only text encoded in ASCII. Which of the following technical components is necessarily changed if we want to support binary attachments in emails?

A. The SMTP protocol
B. The User agent software
C. The mail server software
D. The definition of ASCII code
E. The Telnet commands used for sending emails

iii. _B_ Which of the following changes in the Internet technology is the LEAST likely to reduce the functionality of the Internet and MOST likely to improve its performance?

A. Remove the hop count limit (TTL) field in the IPv4 datagram
B. Remove the header checksum field in the IPv4 datagram
C. Remove the DNS service everywhere and use per-system “hosts” files
D. Let each computer generate a random IPv4 address for itself so that IPv4 addresses can be reused.

iv. _C_ Which of the following components is supposed to understand Internet checksum?

A. A hub
B. A switch
C. A DHCP server
D. A file server in a local area network

v. _B_ Which of the following formula describes the average throughput of TCP? Suppose W is the windows size when loss occurs, RTT is the round-trip time, L is the loss rate, MSS is the maximum segment size, t_{prop} is the maximum propagation delay between 2 nodes, and t_{trans} is the transmission time of the maximum-size packet.

A. $\frac{1.22 \cdot MSS}{RTT \cdot L}$

B. $\frac{0.75 \cdot W}{RTT}$

C. $\frac{L \cdot W}{RTT}$

D. $\frac{1}{1+\frac{5t_{prop}}{t_{trans}}}$

vi. _D_ A mobile host running mobile IP can use the same IP address to communicate with another host in the Internet when

A. the mobile host moves from one BSS to another and establish association with the new AP.
B. the mobile host moves to a new IP network operated by a different ISP.
C. the mobile host replaces its NIC (Network Interface Card).
D. any of the above situation occurs.

vii. _B_ Which of the following is the best description of the RFID Class 1 Generation 2 (C1G2) MAC protocol?

A. A CSMA protocol
B. A slotted ALOHA protocol
C. A center-based multicast protocol
D. A token-ring protocol
E. A Wi-Fi protocol

viii. _E_ Which of the following network or network protocol is likely to have the shortest communication distance?

A. Wi-Fi
B. UMTS (3G GSM network)
C. WiMAX
D. LTE
E. B-MAC

Q3. [10 Points] Queueing Theory

This question assumes an M/M/1 model. A network bridge receives packets at a mean rate of 400 packets per second (pps) and the bridge takes 2ms to process and forward a packet.

Hint: M/M1 queueing

Probability of 0 jobs in the system $P_0 = 1-\rho$

Probability of n jobs in the system $P_n = \rho^n(1-\rho)$

Mean number of items in system $L = \frac{\rho}{(1-\rho)}$

i. What is the bridge's utilization?

0.8

ii. What is the average number of packets in the system (the bridge)?

4

iii. What is the average waiting time for packets in the queue (the bridge's buffer)?

4=400*W

W=0.01 seconds

Wq=0.01-0.002=0.008 seconds

iv. What is the probability that there are 3 or more packets in the system (the bridge)?

0.8*0.8*0.8=0.512

Q4. [6 points] Peer-to-peer networking

Consider distributing a file of F bits to N peers using a P2P architecture. The upload bandwidths of the source host and peers are u_s, u_1, u_2, ... u_N, respectively. Assume a fluid model where the source or a peer can simultaneously transmit to multiple peers, transmitting to these peer at different rates, as long as the combined rate does not exceed the upload bandwidth. For simplicity, assume that d_{min}, the minimum downloading bandwidth of all hosts, including the source and the peers, is very large and thus peer download bandwidth is never a bottleneck.

a. (3 points) Suppose $u_s <= (u_s + u_{1 + ... +} u_N)/N$. Specify the minimum distribution time of the file.

F/u_s

b. (3 points) Suppose $u_s >= (u_s + u_{1 + ... +} u_N)/N$. Specify the minimum distribution time of the file.

$NF/(u_s + u_{1 + ... +} u_N)$

Q4. [10 points] RTT

Suppose we design a new method to estimate the round-trip time (RTT) of TCP segments. Let A_i be the i^{th} distinct acknowledgment received. Let r_i be the time at which A_i is received, and let t_i be the time at which the most recently acknowledged byte (the highest-sequence-number byte that has been acknowledged) is sent. Let RTT_i be our estimate of the RTT after receiving A_i. After the first packet is received, we set the delay estimate equal to $RTT_1 = r_1-t_1$.

i. (4 points) After A_n is received, the new RTT estimation procedure specifies that $RTT_n=(r_1-t_1+r_2-t_2+\ldots+r_n-t_n)/n$. Give a *recursive* formula for RTT_n in terms of n, RTT_{n-1}, r_n, and t_n.

$RTT_n=(RTT_{n-1}*(n-1)+r_n-t_n)/n$

ii. (6 points) What problem we may have with the new procedure for estimating RTT? How to fix it?

Because the old RTTs and recent RTTs have the same weights in the calculation, the RTT estimate adapts to changes of RTTs very slowly.

Also, an outlier (a value significantly deviating from the average) may have significant impact on the calculation and it may take long time for this outlier's impact to diminish.

To solve this problem, we can use a moving average to calculate the delay estimate as follows.

$RTT_n=RTT_{n-1}*(1-u)+(r_n-t_n)*u \quad (0<u<1)$

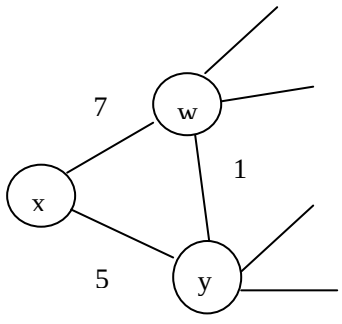
The formula above ensures that old RTTs' weights decay at exponential rate in the calculation so that the RTT estimate adapts to recent values of the RTTs quickly.

iii. (6 points) Would inaccurate RTT estimates affect the functionality of fast retransmit mechanism in TCP? Why?

No. Fast retransmit is activated by 3 duplicate acknowledgments and it does not rely on expiration time which depends on the estimation of the current RTT. Hence, RTT has no effect on fast retransmit.

Q5. [10 points] Distance-vector routing

Consider the network fragment shown below. x has only two attached neighbors, w and y. w has a minimum-cost path to destination u (not shown) of 15, and y has a minimum-cost path to u of 6. The complete paths from w and y to u are not shown. All link costs in the network are strictly positive integer values.



1) Give x's distance vector for destination w, y, and u.

   $D_x(w)=6$; $D_x(y)=5$; $D_x(u)=11$;

2) Give a link-cost change for c(x, w) such that x will inform its neighbors of a new minimum-cost path to u as a result of executing the distance-vector algorithms.

   $D_x(w)=2$;

   x will broadcast updates: $Dx(w)=2$; $D_x(y)=3$; $D_x(u)=9$;

Q7. [10 points] CRC

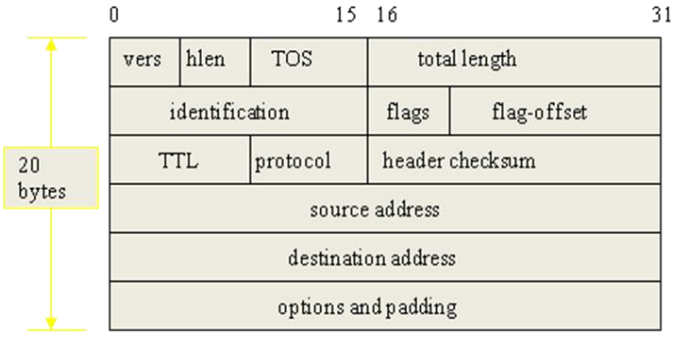
Suppose a network protocol uses CRC with G=1001 (4-bit binary number) to verify the integrity of packets.

i. Computer the CRC bits for data D=1010110 (7-bit binary number).
Since G is 4-bit, r is 3 bits. The CRC bits should be 101.

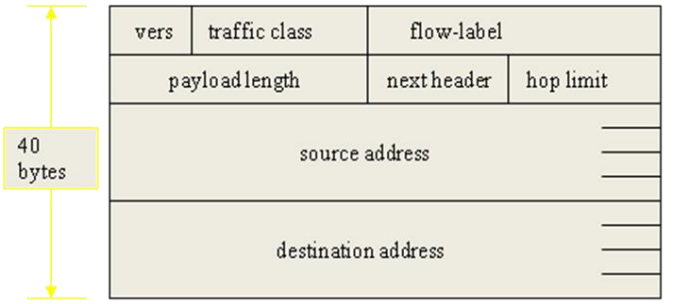
ii. How many erroneous bits can this protocol detect for sure in one packet?
3

Q8 [6 points] IP

The following two diagrams show the packet formats of IPv4 and IPv6 datagrams. Please describe two changes in the packet format from IPv4 to IPv6, and explain the rationale (or motivation) for these changes.



IPv4



IPv6

1) Address space is expanded from 32bit to 128bit. Since the world is running out of IPv4 addresses, we need a much large address space.

2) Header checksum is removed. The reason is that the overhead of computing header checksums on every router is non-negligible. Note that TTL is reduced at each hop. It is also believed that communication error rate is low enough for the protocol to be efficient without a header checksum. Often it is the case that the upper level protocol provides some mechanism to check the integrity of the packets.

Q9. (6 points) CSMA/CD

In the Ethernet, the MAC protocol uses CSMA/CD. When a host on the Ethernet detects collision, it transmits a 48-bit jam signal. Explain why the jam signal is useful. Give an example with timing information to show what problem may occur if there is no jam signal. Use bit-time as the time unit.

The jam signal ensures that all hosts on the Ethernet can detect the collision. Consider the following case where two hosts, host A and B, transmit on an Ethernet without using the jam signal. Suppose the propagation time between the two hosts is 100 bit-times.

0 bit-time: host A starts transmitting
99 bit-times: host B starts transmitting
100 bit-times: host A's frame arrives at host B
101 bit-times: host B detects collision, and stops transmission without sending the jam signal
199 bit-times: host B's frame arrives at host A
201 bit-times: host B's frame disappears at the location of host A (frame aborted at 101 bit-times)
The 2 bits arriving at A may not constitute sufficient energy for host A to detect the collision. Hence, host A may not know the collision and may assume the frame it sent at 0 bit-time was successful.

Q10. (8 points) TCP

Complete the following diagram about TCP congestion control: fill descriptions of events to the blanks with question marks ('?').