CMPUT 313 - Practice Questions: Hints and Solutions

1. Introduction

1.1 N/A

1.2 (a) True. Routers in a packet-switched datagram network are not required to implement the transport layer or the application layer.

(b) False. A router in a packet-switched datagram network does not maintain state information for each connection passing through it (i.e., the router does not keep statistics about packets that belong to a TCP connection).

(c) False, `traceroute` may generate such output. The measured RTT to router 12 can be larger than the measured RTT to router 13 due to fluctuation in queuing delays over time.

1.3 Let d_{prop} be the propagation delay over a 5000-km link then $d_{prop} = d/s = \frac{5000}{2\times 10^5} = 25$ msec. Also, let d_{trans} be the time required to transmit one 10-Mbit packet over one link then $d_{trans} = L'/R = \frac{10 \text{ Mbits}}{10 \text{ Mbps}} = 1$ sec.

(a) Assuming the file is sent as one message, the end-to-end delay $= 2(3d_{trans} + d_{prop}) = 2 \times 3.025 = 6.05$ sec.

(b) Assuming the file is broken into 3 packets, the end-to-end delay $= 4d_{trans} + 2d_{prop} = 4 \times 1.0 + 2 \times 0.025 = 4.05$ sec.

1.4 Let $T_{pkt} = \frac{L}{R}$. At time NT_{pkt} the first packet has reached the destination, the second packet is stored in the last router, the third packet is stored in the next-to-last router, etc. At time $NT_{pkt} + T_{pkt}$, the second packet has reached the destination, the third packet is stored in the last router, etc. Continuing with this logic, we see that $d_{end\_to\_end} = NT_{pkt} + (P-1)T_{pkt} = (N+P-1)T_{pkt}$.

1.5 VoIP Packetization Delay. Consider the *first* bit in a packet:

$$\begin{aligned} T_{packetization} &= \text{delay encountered in constructing a packet that includes the bit} \\ &= \frac{56 \text{ byte}}{8 \text{ KBps}} = 7 \text{ msec} \end{aligned}$$

$$T_{pkt} = \text{time required to transmit a voice packet} = 0.224 \text{ msec}$$

$$T_{propagation} = 10 \text{ msec}$$

So, the delay until decoding the bit $= 17.224$ msec. A similar analysis shows that any other bit experiences a similar delay until decoded at host B.

2. Performance Analysis

2.1 See the course slides.

2.2 (a) X is a Geometric random variable with probability p.

(b) Check 0.0387 and 0.3487.

(c) Y is a Binomial random variable with $n = 100$, and probability p.

(d) Check 0.1849 and 0.9207.

2.3 $D(t)$ is a Poisson random variable with parameter $\alpha = \lambda T = 0.1\, t$.

2.4 Chapter 1, P13 part(a) (5/E: P13): Note that the buffer is empty when a new batch of N packets arrive (since it takes LN/R sec. to transmit the N packets). The average delay is

$$\frac{1}{N}\sum_{i=0}^{N-1}\frac{iL}{R} = \frac{(N-1)L}{2R}.$$

2.5 (a) Using $I = \frac{\lambda}{\mu}$, note that

$$\frac{IL}{R(1-I)} = \frac{\lambda}{\mu(\mu-\lambda)} = \frac{1}{\mu-\lambda} - \frac{1}{\mu}$$

as required.

(b) The average total packet delay is the sum of the average queueing only delay plus the average service (i.e., transmission) delay. The above part then implies that the total delay derived from the problem's assumption is the same as the total delay given by the M/M/1 result.

3. The Application Layer

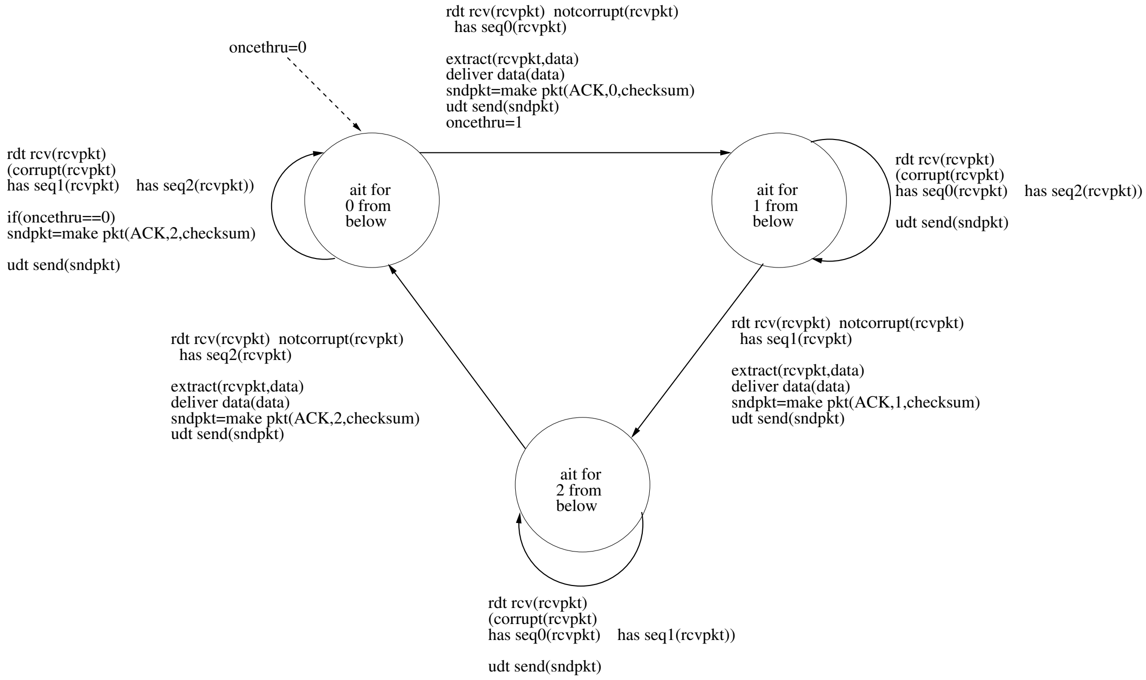
3.1 N/A

4. The Transport Layer

4.1 N/A

4.2 Chapter 3, R7 (UDP demultiplexing): Yes, both UDP segments from hosts A and B will be directed to the same socket. The Socket API provides functions that enable an application to determine the source IP number, and the source port number.

4.3 Note that the rdt2.2 receiver in Figure 3.14 works also as a receiver of the rdt3.0 protocol.



FSM of a receiver that works with the modified sender

4.4
- For the (A, B) link we have:
  $T_{pkt} = 10$ msec, $T_{prop} = 20$ msec, $a = 2$, $Thr_{norm} = \frac{N}{1+2a} = \frac{3}{5}$, $Thr_{AB} = \frac{Thr_{norm}}{T_{pkt}} = \frac{3}{50}$ pkt/msec.
- For the (B, C) link we have:
  $T_{pkt} = 1000/R$ msec (where R is in Kbps), $T_{prop} = 5$ msec, $a = \frac{R}{200}$, $Thr_{norm} = \frac{1}{1+2a}$, $Thr_{BC} = \frac{1}{T_{pkt}(1+2a)}$.
- Choose R for the (B, C) link such that $Thr_{AB} \leq Thr_{BC}$. Verify that $R \geq 150$ Kbps satisfies the condition.

4.5 (a) For GBN, the following events occur:

- $t_9 = 3T_{pkt} + T_{timeout}$: retransmission of $pkt[1]$ is completed
- $t_{15} = 4T_{pkt} + T_{timeout} + RTT$: first transmission of $pkt[5]$ is completed
- $t_{22} = 5T_{pkt} + 2T_{timeout} + RTT$: retransmission of $pkt[5]$ is completed
- $t_{29} = 7T_{pkt} + 2T_{timeout} + 2RTT$: $ACK[7]$ arrives (and the sender concludes that all packets have been delivered).

(b) FOR SR, the following events occur:

- t_9, t_{15}, and t_{22}: same as above
- $t_{27} = t_{22} + RTT$: $ACK[5]$ arrives (and the sender concludes that all packets have been delivered).

4.6 Assuming a pkt is first sent at time t, and its last ACK cannot possibly arrive after time t' then:
the smallest possible sequence number space $>$ the number of pkts the source can transmit

during the $[t, t']$ interval
$=$ the number of pkts the source can transmit in the interval $(2MPL + T_{persist} + T_{rcv})$
$= (2MPL + T_{persist} + T_{rcv})R$
where R is in pkts/sec. About 1.9 million pkts can be sent (so, the seq# space requires 21 bits)

4.7 (a) $SendBase - 1 \leq LastByteRcvd$

(b) $y - 1 \leq LastByteRcvd$

5. The Network Layer

5.1 R16: 50% overhead

5.2 R36: In a group-shared tree, one tree carries the multicast traffic from all senders belonging to a given multicast group. In contrast, with source-based trees, the multicast traffic from a given source is routed over a specific routing tree constructed for that source. A router may have to keep track of several source-based trees for a given multicast group.

5.3 P5:

a. Given the requirement of using the same VC number on all links, no new VC can be established.

b. The number of possible combinations $= 2^4 = 16$

5.4 P30 (5/E: P28):

a. $D_x(w) = 2$, $D_x(y) = 4$, $D_x(u) = 7$

b. x will inform its neighbours of a new minimum cost path to u if, for example, $c(x, w)$ becomes 1, or a value larger than 6.

c. x will **not** inform its neighbours of a new minimum cost path to u if $c(x, y)$ changes to any positive integer value (in any such case, $D_x(u)$ will continue to be 7).

5.5

a) Valid IP addresses for 101.101.101.64/26 are in the range between 101.101.101.65 to 101.101.101.126. Note that 101.101.101.127 is not a valid IP address since it is used as a broadcast address in this subnet.

01100101	01100101	01100101	01**000000**	=>	101.101.101.64/26

01100101	01100101	01100101	01**000001**	=>	101.101.101.65/26
01100101	01100101	01100101	01**000010**	=>	101.101.101.66/26
.	.	.	.		.
.	.	.	.		.
.	.	.	.		.
.	.	.	.		.
.	.	.	.		.
01100101	01100101	01100101	01**111110**	=>	101.101.101.126/26
01100101	01100101	01100101	01**111111**	=>	101.101.101.127/26

b) In order to subnet the 101.101.128.0/17 into four equal different blocks, we need to change bits 14 and 15:

01100101	01100101	10000000	00000000	=>	101.101.128.0/17

01100101	01100101	1**00**00000	00000000	=>	101.101.128.0/19
01100101	01100101	1**01**00000	00000000	=>	101.101.160.0/19
01100101	01100101	1**10**00000	00000000	=>	101.101.192.0/19
01100101	01100101	1**11**00000	00000000	=>	101.101.224.0/19

5.6 P55 (5/E: P52):

a. $N = 2^{28}$

b. Prob [k randomly chosen class D addresses don't interfere with each other]=

$$\frac{N.(N-1).(N-2)\cdots(N-k+1)}{N^k} = \left(1-\frac{1}{N}\right)\cdot\left(1-\frac{2}{N}\right)\cdots\left(1-\frac{k-1}{N}\right).$$

Ignoring cross-product terms, one gets $\approx 1 - \frac{(k-1).k}{2N}$.

So, Prob [at least two of the k addresses are identical] $\approx \frac{(k-1).k}{2N}$.

c. For $k = 1000$, the value is less than 0.002.

6. The Link Layer and Medium Access Control

6.1 First, some notation:

* Denote by $x1$ and $x2$ the two network interfaces of the first router where $x1$ is connected to Subnet 1.
* Denote by $y1$ and $y2$ the two network interfaces of the second router where $y2$ is connected to Subnet 3.
* Denote the unique interface of each host by the host's name.

* For a given interface x, let $LAN(x)$ and $IP(x)$ denote x's LAN and IP addresses, respectively.

a.
  - The forwarding table in host A determines that the datagram should be routed to $IP(x1)$.
  - The adapter in host A creates an Ethernet packet with destination address $LAN(x1)$.
  - The first router receives the packet and extracts the datagram. The forwarding table in this router indicates that the datagram should be routed to $IP(y1)$.
  - The first router then sends an Ethernet packet with the source address of $LAN(x2)$ and the destination address of $LAN(y1)$.
  - The process continues until the packet reaches Host F.

b. ARP in host A must determine $LAN(x1)$. Host A sends out an ARP query packet within a broadcast Ethernet frame. The first router receives the query packet and sends to Host A an ARP response packet. This response packet is carried by an Ethernet frame with Ethernet destination address of $LAN(A)$.