50.012 Networks Mid-Term Fall 2016

Date of examination: 21.10.2016
Time: 9:30 am
Duration: 80 min
Name :
Student ID:

General Remarks

- This is a closed book exam. Do not use any digital or external material.
- This exam consists of 5 questions on 8 printed pages.
- The last 1 page is empty, and can be used for (ungraded) notes.
- Each question has an assigned weight in points. There are 100 points in total.
- Write your answer below the questions, into the boxes.
- Answer all questions as thoroughly as you can.
- Please acknowledge the SUTD Honour Code by signing it on the handout.

Question	Points	Score
Basic operations	20	
Network Address Translation/IP	20	
Switch Operations	20	
CIDR	20	
Congestion Control in TCP	20	
Total:	100	

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

Established in collaboration with MIT

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN
HONOUR CODE

"As a member of the SUTD community, I pledge to always uphold honourable conduct. I will be accountable for my words and actions, and be respectful to those around me."

Introduction to the SUTD Honour Code

What is the SUTD Honour Code?

The SUTD Honour Code was established in conjunction with the school's values and beliefs, in good faith that students are able to discern right from wrong, and to uphold honourable conduct. It is an agreement of trust between the students and the staff and faculty of SUTD, and serves as a moral compass for students to align themselves to. Being in a university that aspires to nurture the leaders of tomorrow, it calls for students to behave honourably, not just solely in their academic endeavours, but also in everyday life.

What the Honour Code encompasses

Integrity & Accountability

To be honourable is to do what is right even when nobody is watching, and to be accountable for the things one does. One should always be accountable for one's words and actions, ensuring that they do not cause harm to others. Putting oneself in a favourable position at the expense of others is a compromise of integrity. We seek to create a community whereby we succeed together, and not at the expense of one another.

Respect

Part of being honourable is also respecting the beliefs and feelings of others, and to never demean or insult them. Should conflicts arise, the aim should always be to settle them in a manner that is non-confrontational, and try to reach a compromise. We will meet people of differing beliefs, backgrounds, opinions, and working styles. Understand that nobody is perfect, learn to accept others for who they are, and learn to appreciate diversity.

Community Responsibility

In addition to that, being honourable also involves showing care and concern for the community. Every individual has a duty to uphold honourable conduct, and to ensure that others in the community do likewise. The actions of others that display immoral or unethical conduct should not be condoned nor ignored. We should encourage each other to behave honourably, so as to build a community where we can trust one another to do what is right.

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Student's signature

Question 1: Basic operations

Host A uses a variety of protocols to discover information about the network it is connected to. For each of the statements, briefly explain if it is generally correct.

(a) (4 points) In a home network, host A typically discovers the IP address of its local DNS server using DHCP.

> **Solution:** That is true. The DHCP offer contains information about the IP of the local DNS server.

(b) (4 points) To transmit a packet outside host A's subnet, host A needed to initially obtain the MAC address of host A's gateway using DHCP.

> **Solution:** This is false. DHCP is not used to obtain MAC addresses.

(c) (4 points) To send a packet to host B (outside host A's subnet), host A must first discover the route using eBGP.

> **Solution:** That is false. eBGP is not used for end hosts.

(d) (4 points) To get an IP address assigned, host A must first discover the IP address of host A's DHCP server using DNS.

> **Solution:** This is definitely not true. DHCP server is discovered via broadcasted DISCOVER messages.

(e) (4 points) To send a packet to another host C in the same subnet, host A must first discover the MAC address of host C using ARP.

> **Solution:** This is correct. An ARP request is used to translated the IP to MAC.

Question 2: Network Address Translation/IP

Host A is connected to a home router R through a switch. The router R runs NAT. A has IP address 10.0.0.2 and MAC address AA:AA:AA:AA:AA:AA. Router R has two interfaces. The one connecting to A has an IP address of 10.0.0.1 and MAC address C1:C1:C1:C1:C1:C1, and the one connected to the public Internet has an IP address of 17.17.0.1 and MAC address C2:C2:C2:C2:C2:C2.

A initiates a connection to a web server with IP address of 74.125.68.94 and MAC address DD:DD:DD:DD:DD:DD at port 80 by sending a TCP SYN segment.

Consider the Ethernet frame and IP datagram that encapsulates this TCP SYN segment.

(a) (8 points) When the packet leaves A, what is the source IP and MAC address? what is the destination IP and MAC address? 2 points per address.

Solution: Source IP 10.0.0.2 and MAC address AA:AA:AA:AA:AA:AA. Destination IP 74.125.68.94 and MAC C1:C1:C1:C1:C1:C1.

(b) (4 points) When the packet leaves R, what is the source IP address? what is the destination IP address? 2 points per address.

Solution: Source IP 17.17.0.1, destination IP 74.125.68.94.

(c) (8 points) The TCP SYN packet has a source port number p when it leaves A, and source port number q when it leaves R. Show the entry in the NAT table that corresponds to this connection between A and the server at 74.125.68.94. Up to 8 points total for all required values.

Solution: 2 points per correct port or IP. No points were deducted if too many values were given.

source port	source IP	dest port	dest IP
p	10.0.0.2	80	74.125.68.94

Or, alternatively,

source port	source IP	dest IP	outg. port number
p	10.0.0.2	74.125.68.94	q

Question 3: Switch Operations

A switch has three interfaces, labelled 1 to 3, and an empty CAM table (initially). The switch receives four frames consecutively in the order listed in the table below. The source, destination, and the interface in which each frame is received is summarized in the table below. MAC addresses are shortened to save space.

Incoming Interf.	Source MAC	Destination MAC	Action taken
1	AA:AA:AA	DD:DD:DD	Broadcast
1	AA:AA:AA	BB:BB:BB	Broadcast
2	BB:BB:BB	AA:AA:AA	Forward to 1
3	DD:DD:DD	BB:BB:BB	Forward to 2

(a) (8 points) The action column in the table above refers to the action that the switch takes on each frame. Complete the table by filling the action column. An action can be either “forward to x” (x is one interface), or “broadcast”.

2 points for each correct action (8 max total).

(b) (4 points) Assume the next frame received is the following

Incoming Interf.	Source MAC	Destination MAC	Action taken
1	CC:CC:CC	AA:AA:AA	

By default, the switch will drop that frame. Please comment on why that is reasonable (or not). 2 points for correct classification, 2 points for explanation.

Solution: This is reasonable, as CC:CC:CC and AA:AA:AA seem to be on the same port. The previous switch should have forwarded this packet directly, or a hub was used. Sending the packet back might lead to infinite loops.

Note: it is perfectly normal to have two hosts on the same port—e.g., if that port connects to another switch. But they should never send packages addressed to other hosts on same port.

(c) (8 points) Assume that the switch mentioned above is now configured with two VLANs. Port 1 is configured as Trunk port for VLAN1 and VLAN2, while port 2 is an Access port for VLAN1, and port 3 is an Access port for VLAN2. For each of the incoming and outgoing frames in the following table, please state what the VLAN ID (VID) in the header should be to ensure that frame 3 and 4 can reach their destination. If the frame should not contain an 802.1q header, please put VID as “None”. 1 point per correct VID.

Inc. Interf.	Source MAC	Destination MAC	Incoming VID	Outgoing VID
1	AA:AA:AA	DD:DD:DD	2	None
1	AA:AA:AA	BB:BB:BB	1	None
2	BB:BB:BB	AA:AA:AA	None	1
3	DD:DD:DD	AA:AA:AA	None	2

Question 4: CIDR

The following shows a routing table for IPv4. For all answers, up to 5 points are awarded if a correct explanation is provided.

Prefix	Output interface:
128.0.10.0/28	A
128.0.10.0/25	B
x	C
default	D

(a) (5 points) Suppose that a packet with address 128.0.10.15 is forwarded to output interface C. What are the possible values of x?

Solution:

- 128.0.10.8/29
- 128.0.10.12/30
- 128.0.10.14/31
- 128.0.10.15/32

(b) (5 points) What is the maximal number of hosts that can be reached via interface B? Up to 5 points for solution with explanation.

Solution: $2^7 - 1 = 127$ because all are reachable (except .0). If answer is removing other routes, e.g. $2^7 - 1 - (2^4 - 1) = 112$, deduct 1 point.
Deduct 1 point for counting .0 in.

(c) (5 points) From now on, assume x is 128.0.0.0/1 (which is NOT an answer to a). How many hosts are reached through the default route? A closed form expression is enough.

Solution: If we ignore private IP addresses and other reserved ranges: 2^{31} (4 points). If we deduct network and broadcast addresses: $128 * 256^2 * 254 = 2,130,706,432$ (5 points). If we want to deduct the 10.0.0.0/8 private network and subtract network and broadcast addresses: $127 * 256^2 * 254 = 2,114,060,288$ (also 5 points).

(d) (5 points) Which interface would be taken for a packet with destination IP 128.0.10.133?

Solution: This will go to interface C (which is set to route 128.0.0.0/1).

Question 5: Congestion Control in TCP

The Transmission Control Protocol uses congestion control to adapt the traffic volume transmitted to the network. The behavior of TCP congestion control can be represented as a graph in which the x-axis indicates the time, and the y-axis indicates congestion window size. Please use the graph in Figure 1 to the answer the following questions. Assume that all segments are of size MTU, which is also used to label the chart. Infinite data needs to be sent, and all data is sent out as soon as congestion control allows. No segments or ACKs are lost unless explicitly stated, and all ACKs arrive in exactly RTT time. A timeout happens if no ACK was received after RTT. Throughput is unlimited.

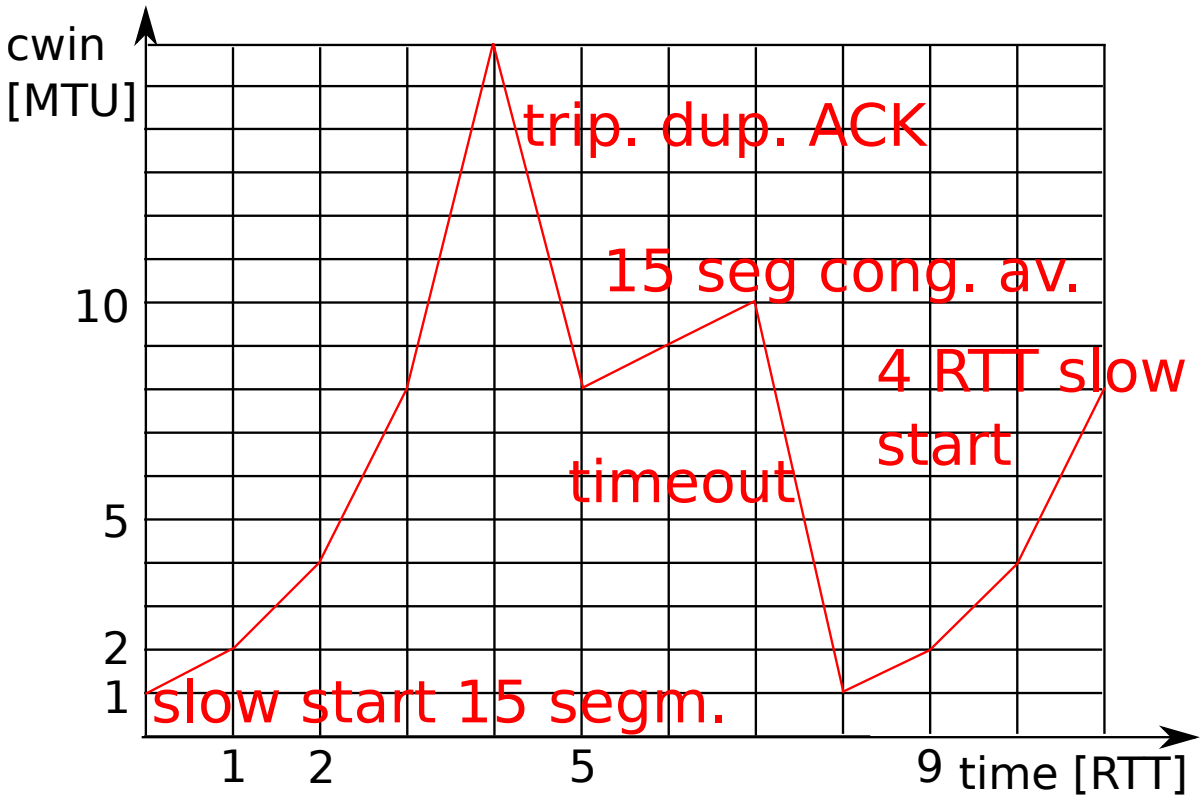

Figure 1: Congestion window development.

(a) (7 points) Assume the congestion window starts with value 1 MTU. Sketch the development of the congestion window over the next 15 segments.

(b) (7 points) Assume that segment 16 is lost in transmission, and triple duplicate ACKs are received for segment 17, 18, and 19. Sketch the congestion window for segments 16-32.

(c) (6 points) Assume that the next 10 segments (33-42) are all lost one time in transmission. Please sketch the congestion window over the following four RTT time units.

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