

## ITS323 – Assignment 2 Answers

The answers assume Group 1 is used. See the Assignment2-GroupAnswers.pdf to see specific answers for each group.

### Question 1 Answers

For Group 1, the value of G is: 00000001

The Class B network addresses available are:

```
1 0 0 0   0 0 0 0 0 0 0 1   0 0 0 0   x x x x x x x x   x x x x x x x x
1 0 0 0   0 0 0 0 0 0 0 1   1 1 1 1   x x x x x x x x   x x x x x x x x
```

In dotted decimal notation: 128.16.0.0 through to 128.31.0.0. That is, there are 16 network addresses available. Within each network address, any combination of the last 16 bits may be used for hosts (except special addresses).

The Class C network addresses available are:

```
1 1 0 0 1   0 0 0 0 0 0 0 1   0 0 0 0 0 0 0 1   0 0 0   x x x x x x x x
1 1 0 0 1   0 0 0 0 0 0 0 1   0 0 0 0 0 0 0 1   1 1 1   x x x x x x x x
```

In dotted decimal notation: 200.8.8.0 through to 200.8.15.0. That is, there are 8 network addresses available. Within each network address, any combination of the last 8 bits may be used for hosts (except special addresses).

Using the above ranges of network addresses, IP addresses can be assigned to interfaces (of hosts and routers) in any order, so long as:

- Each interface attached on the same link (or Ethernet network) has the same network address,
- Each interface with the same network address has a unique host address,
- Two links use different network addresses,
- No special addresses are used.

A possible assignment is shown in the table below.

<b>Device</b>	<b>Interface</b>	<b>IP Address</b>
Host 1	1	200.8.8.1
Host 2	1	200.8.8.2
Router A	4	200.8.8.3
Host 3	1	200.8.9.1
Host 4	1	200.8.9.2
Router A	3	200.8.9.3
Router A	1	128.16.0.1
Router C	3	128.16.0.2
Router A	2	128.17.0.1
Router D	2	128.17.0.2
Router C	1	128.18.0.1
Router F	3	128.18.0.2
Router C	2	128.19.0.1
Router E	1	128.19.0.2
Router D	3	128.20.0.1
Router E	4	128.20.0.2
Router D	1	128.21.0.1
Router G	2	128.21.0.2
Router E	2	128.22.0.1
Router F	2	128.22.0.2
Router E	3	128.23.0.1
Router G	3	128.23.0.2
Router F	1	128.24.0.1
Router B	1	128.24.0.2
Router G	1	128.25.0.1
Router B	2	128.26.0.2
Router B	3	200.8.10.1
Host 5	1	200.8.10.2
Host 6	1	200.8.10.3

Re-arranged into order of device and interfaces, this would be:

<b>Device</b>	<b>Interface</b>	<b>IP Address</b>
Host 1	1	200.8.8.1
Host 2	1	200.8.8.2
Host 3	1	200.8.9.1
Host 4	1	200.8.9.2
Host 5	1	200.8.10.2
Host 6	1	200.8.10.3
Router A	1	128.16.0.1
Router A	2	128.17.0.1
Router A	3	200.8.9.3
Router A	4	200.8.8.3
Router B	1	128.24.0.2
Router B	2	128.26.0.2
Router B	3	200.8.10.1
Router C	1	128.18.0.1
Router C	2	128.19.0.1
Router C	3	128.16.0.2
Router D	1	128.21.0.1
Router D	2	128.17.0.2
Router D	3	128.20.0.1
Router E	1	128.19.0.2
Router E	2	128.22.0.1
Router E	3	128.23.0.1
Router E	4	128.20.0.2
Router F	1	128.24.0.1
Router F	2	128.22.0.2
Router F	3	128.18.0.2
Router G	1	128.25.0.1
Router G	2	128.21.0.2
Router G	3	128.23.0.2

## Question 2 Answers

The link costs can be calculated directly using the equation:

$$\text{cost} = (120/\text{rate}) + 2 * \text{delay}$$

For example, with a data rate of 30Mb/s and propagation delay of 10ms, the cost is

$$\begin{aligned} \text{cost} &= (120/30) + 2 * 10 \\ &= 4 + 20 \\ &= 24 \end{aligned}$$

Link	Data Rate [Mb/s]	Prop. Delay [ms]	Cost
1	30	10	24
2	10	1	14
3	30	9	22
4	40	9	21
5	30	1	6
6	20	2	10
7	30	9	22
8	30	1	6
9	10	3	18
10	30	7	18

### Question 3 Answers

Given the link costs and considering the WAN topology, the least cost paths from any router to any other router can be calculated. However, if we only consider possible destinations at Router A (LAN1 and LAN2) and Router B (LAN3), we only need to calculate paths from any router to router A and B. Either manual calculation (by inspecting the paths) or automatic calculation (using software or algorithm) can be applied. The resulting paths for Group 1 are (note that paths to LAN1 and LAN2 are always the same):

<b>From</b>	<b>To</b>	<b>Path</b>	<b>Cost</b>
Router A	LAN1	direct	0
Router A	LAN2	direct	0
Router A	LAN3	A-D-G-B	42
Router B	LAN1	B-G-D-A	42
Router B	LAN2	B-G-D-A	42
Router B	LAN3	direct	0
Router C	LAN1	C-A	24
Router C	LAN2	C-A	24
Router C	LAN3	C-F-B	24
Router D	LAN1	D-A	14
Router D	LAN2	D-A	14
Router D	LAN3	D-G-B	28
Router E	LAN1	E-G-D-A	30
Router E	LAN2	E-G-D-A	30
Router E	LAN3	E-G-B	24
Router F	LAN1	F-C-A	30
Router F	LAN2	F-C-A	30
Router F	LAN3	F-B	18
Router G	LAN1	G-D-A	24
Router G	LAN2	G-D-A	24
Router G	LAN3	G-B	18

The routing tables for the routers can be generated directly from the above information, by taking the next router in the path to the destination.

***Routing Table for Router A***

Destination		Next Router	
Name	IP	Name	IP
LAN1	200.8.8.0	direct	direct
LAN2	200.8.9.0	direct	direct
LAN3	200.8.10.0	D2	128.17.0.2

***Routing Table for Router B***

Destination		Next Router	
Name	IP	Name	IP
LAN1	200.8.8.0	G1	128.25.0.1
LAN2	200.8.9.0	G1	128.25.0.1
LAN3	200.8.10.0	direct	direct

***Routing Table for Router C***

Destination		Next Router	
Name	IP	Name	IP
LAN1	200.8.8.0	A1	128.16.0.1
LAN2	200.8.9.0	A1	128.16.0.1
LAN3	200.8.10.0	F3	128.18.0.2

***Routing Table for Router D***

Destination		Next Router	
Name	IP	Name	IP
LAN1	200.8.8.0	A2	128.17.0.1
LAN2	200.8.9.0	A2	128.17.0.1
LAN3	200.8.10.0	G2	128.21.0.2

**Routing Table for Router E**

Destination		Next Router	
Name	IP	Name	IP
LAN1	200.8.8.0	G3	128.23.0.2
LAN2	200.8.9.0	G3	128.23.0.2
LAN3	200.8.10.0	G3	128.23.0.2

**Routing Table for Router F**

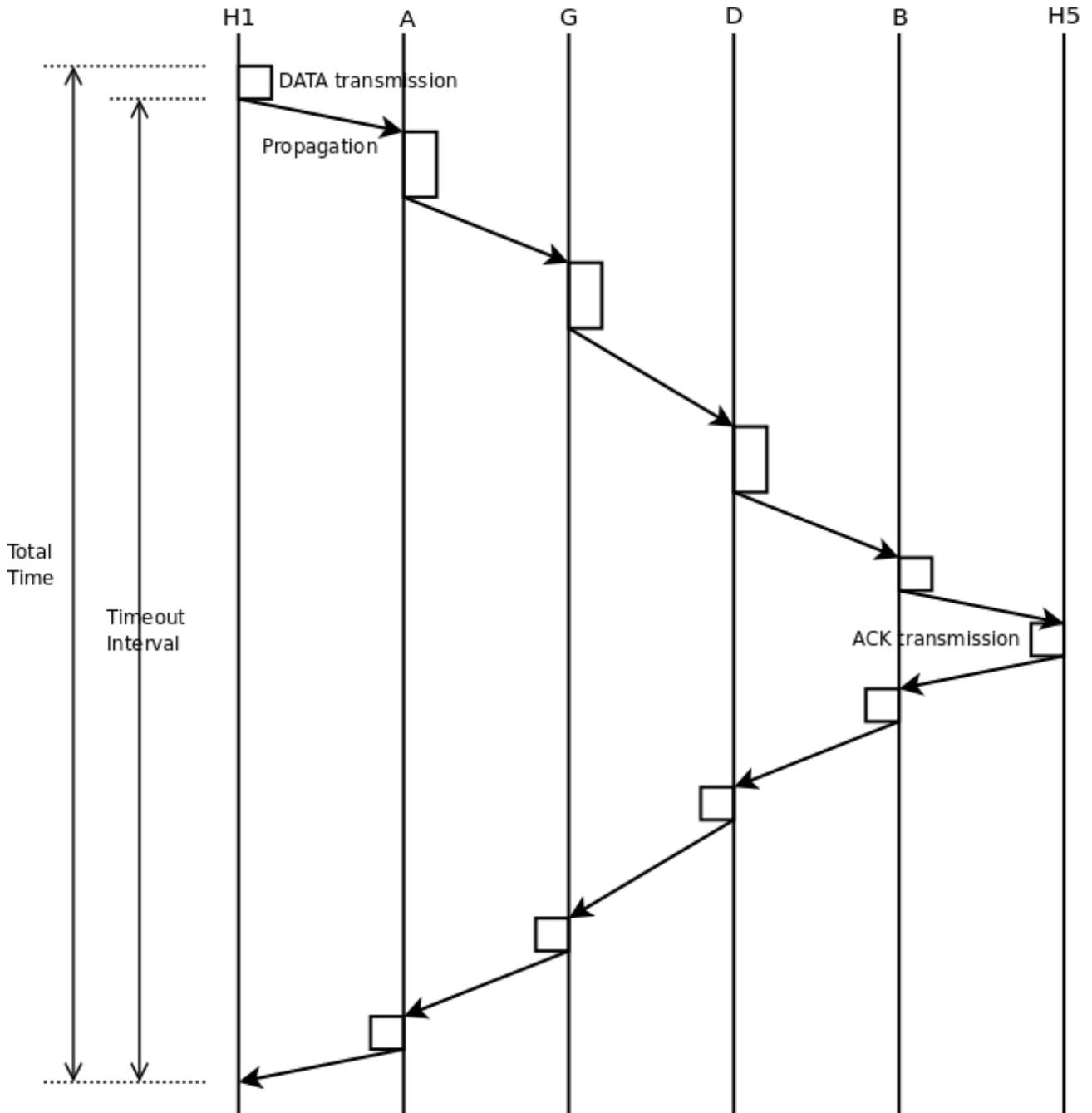
Destination		Next Router	
Name	IP	Name	IP
LAN1	200.8.8.0	C1	128.18.0.1
LAN2	200.8.9.0	C1	128.18.0.1
LAN3	200.8.10.0	B1	128.24.0.2

**Routing Table for Router G**

Destination		Next Router	
Name	IP	Name	IP
LAN1	200.8.8.0	D1	128.21.0.1
LAN2	200.8.9.0	D1	128.21.0.1
LAN3	200.8.10.0	B2	128.26.0.2

### Question 4 Answers

Each DATA packet must be switched via the routers. Therefore you must calculate the transmission time over each link, as well as the propagation time. The diagram below illustrates the main concept.



Payload size: 1000 Bytes

DATA packet contains 25 byte Stop-and-Wait header plus 20 byte IP header:

$$\text{DATA size: } 1000 + 25 + 20 = 1045 \text{ Bytes}$$

ACK packet contains 25 byte Stop-and-Wait header plus 20 byte IP header (no data):

$$\text{ACK size: } 25 + 20 = 45 \text{ Bytes}$$

Consider the least-cost path from host in LAN1 to host in LAN3.

$$\text{Total propagation delay: } 0.001 + 1 + 2 + 7 + 0.001 = 10.002\text{ms}$$

$$\text{Transmission time at } 100\text{Mb/s: } \quad 0.0836\text{ms} \quad 0.0036\text{ms}$$

$$\quad 10\text{Mb/s: } \quad 0.836\text{ms} \quad 0.0360\text{ms}$$

$$\quad 20\text{Mb/s: } \quad 0.418\text{ms} \quad 0.0180\text{ms}$$

$$\quad 30\text{Mb/s: } \quad 0.278\text{ms} \quad 0.0120\text{ms}$$

$$\text{Total DATA transmission time: } \quad 1.6992$$

$$\text{Total ACK transmission time: } \quad 0.0732$$

$$\text{Total time: } \quad 21.7764\text{ms}$$

$$\text{Throughput: } 1000\text{B} / 21.7764\text{ms} = 367\text{kb/s}$$

The timer starts after the source host has fully transmitted the DATA packet.

$$\text{Timeout} = (\text{Total time} - \text{Data trans on } 1^{\text{st}} \text{ link}) * 1.2$$

$$= (21.7764 - 0.0836) * 1.2$$

$$= 26\text{ms}$$

If 1 error packet in 10 packet sent, then we can consider the first 9 packets arrive at the destination, and then the 10<sup>th</sup> packet is lost. After a timeout, the source retransmits the 10<sup>th</sup> packet. The 10<sup>th</sup> packet and the next 8 packets (total of 9 packets) arrive at the destination and then the next packet is lost. The procedure repeats. From the perspective of the source, it transmits 10 packets. The total time before it can transmit the 11<sup>th</sup> packet is:

$$9 \text{ successfully packets take } 21.7764\text{ms}$$

$$1 \text{ lost packet takes data transmission time plus timeout of } 26\text{ms}$$

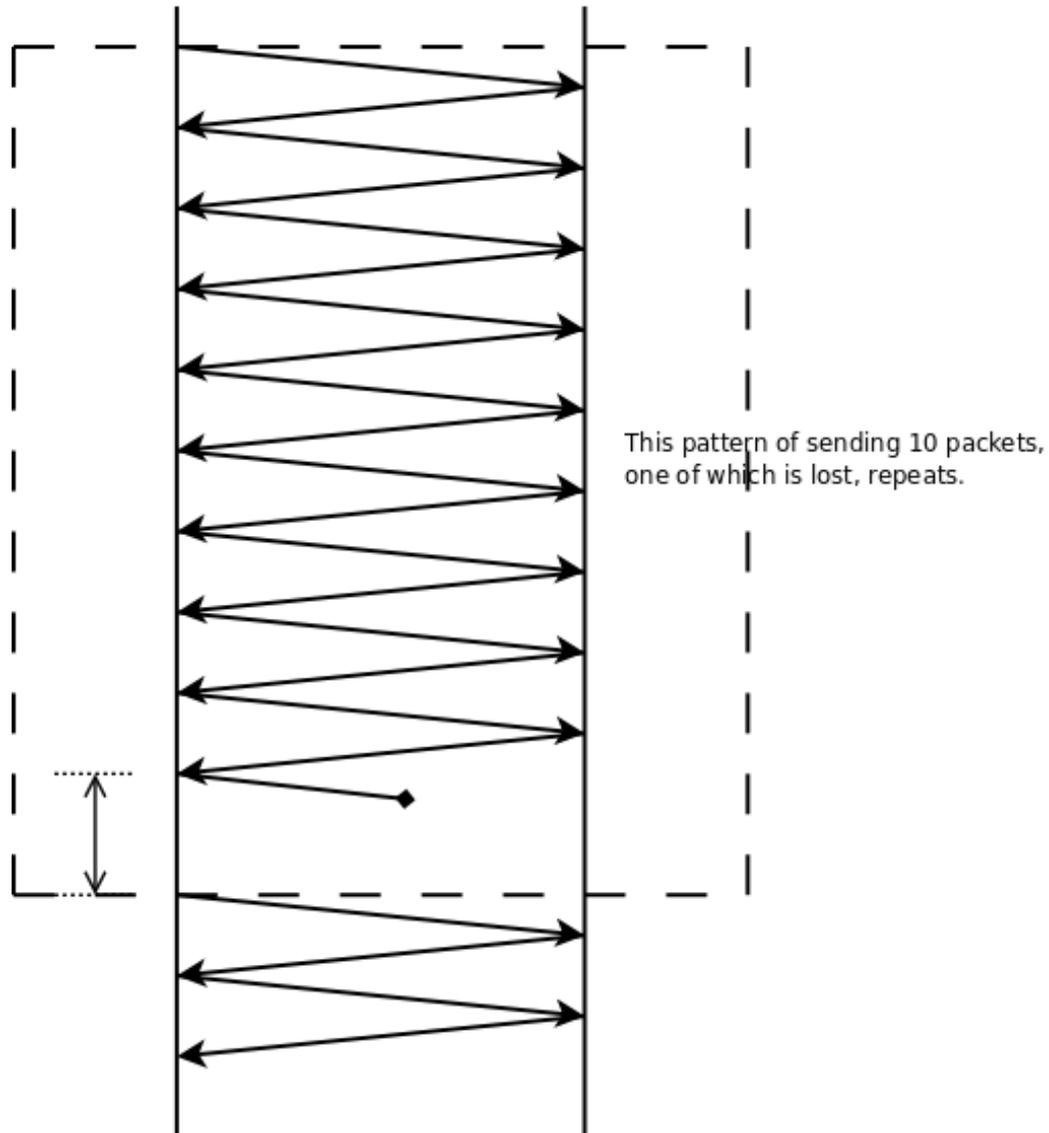
resulting in total time of: 222.0712ms

From the perspective of the receiver it receives 9x1000 Bytes of data every 222.0712ms, giving a throughput of 324kb/s.

A general equation is 1 out of N packets are lost:

$$N \times \text{Data} / ( (N-1) * \text{NormalTotalTransmission} + \text{DataTransmission} + \text{TimeoutInterval} )$$

where Data is the size of the original data, NormalTotalTransmission is the time calculated in part (a) (time to receive an ACK), DataTransmission is time to transmit the DATA packet over the first link, and TimeoutInterval is the time calculated in part (b).



The reason for the lower throughput is the packet is lost, causing time to be wasted: time to transmit the lost packet as well as the time for waiting for timeout. This extra wasted time means the data arrives at the destination at a slower rate (i.e. lower throughput). A factor that impacts on the magnitude of throughput degradation is the timeout interval (how long does the source wait before retransmitting).

A good way to overcome the reduction in throughput is to allow the source to send multiple packets before waiting for an ACK. That is, use Go-Back-N or Selective Reject, which both make use of sliding window mechanisms. The disadvantage of these schemes is that they add extra complexity to the source/destination, and may increased buffer sizes.

## Question 5 Answers

I will use my computer as an example. It is a Intel Dual Core based PC running Ubuntu Linux. It has a IEEE 802.3 Ethernet network interface which allows data rates of 10Mb/s, 100Mb/s and 1Gb/s (e.g. Gigabit Ethernet). Other computers may have IEEE 802.11 Wireless LAN interfaces supporting data rates of 54Mb/s or more, as well as Bluetooth interfaces (e.g. 2Mb/s or 3Mb/s).

The interface information in Ubuntu Linux can be obtained using ifconfig:

```
eth0      Link encap:Ethernet  HWaddr 00:17:31:5a:e5:89
          inet addr:192.168.1.2  Bcast:192.168.1.255  Mask:255.255.255.0
          inet6 addr: fe80::217:31ff:fe5a:e589/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:457613 errors:0 dropped:0 overruns:0 frame:0
          TX packets:448611 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:100
          RX bytes:327885047 (327.8 MB)  TX bytes:158501349 (158.5 MB)
          Memory:cffe0000-d0000000

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:16436  Metric:1
          RX packets:25 errors:0 dropped:0 overruns:0 frame:0
          TX packets:25 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:3187 (3.1 KB)  TX bytes:3187 (3.1 KB)
```

In summary, my Ethernet interface has:

- MAC address of 00:17:31:5a:e5:89
- IP address 192.168.1.2, using subnet mask 255.255.255.0 and therefore a directed broadcast address of 192.168.1.255

In addition I have an loopback interface using IP address 127.0.0.1. This is not a real physical network interface, but instead a software-based virtual interface allowing my computer to send packets to itself.

Using the IEEE website I can find the manufacturer of the Ethernet card:

<b>00-17-31</b>	(hex)	ASUSTek COMPUTER INC.
001731	(base 16)	ASUSTek COMPUTER INC.
		No.5 Shing Yeh Street, Kwei Shan Hsiang, Taoyuan
		Taipei 333
		TAIWAN, REPUBLIC OF CHINA

In Ubuntu Linux I can view the routing table using the route command:

Kernel IP routing table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use	Iface
192.168.1.0	0.0.0.0	255.255.255.0	U	1	0	0	eth0
192.168.27.0	0.0.0.0	255.255.255.0	U	0	0	0	vmnet8
192.168.26.0	0.0.0.0	255.255.255.0	U	0	0	0	vmnet1
169.254.0.0	0.0.0.0	255.255.0.0	U	1000	0	0	eth0
0.0.0.0	192.168.1.1	0.0.0.0	UG	0	0	0	eth0

The 1<sup>st</sup> entry is used if my computer sends an IP datagram destined to any host in the same network as mine (i.e. network 192.168.1.0 with netmask 255.255.255.0). The gateway of 0.0.0.0 indicates there is no gateway but instead my computer will send direct to the destination (using its MAC address).

The 2<sup>nd</sup> and 3<sup>rd</sup> entries are created for the VMWare software running on my computer, and again mean send direct to the destination (not to a gateway) if the destination is on the 192.168.27.0 or 192.168.26.0 network.

The 4<sup>th</sup> entry is again informing my computer to send direct to the destination if the IP destination is on network 169.254.0.0 (netmask 255.255.0.0). This is a special set of addresses used for communication between hosts on a network if the hosts are not assigned IP addresses (i.e. a host chooses a random address within the 169.254.0.0 network).

The 5<sup>th</sup> entry indicates my default gateway. If my computer has a IP datagram with destination address not matching the first four entries, then it will send the datagram to the router 192.168.1.1.

Other operating systems may use different formats, and your computer may have more/different entries. In the Networking Lab next semester you will learn more about the routing tables, and how to manipulate them.