ITS 323 – ASSIGNMENT 2 ANSWERS

The following answers are based on the example ID of 4912345670.

Question 0 - Preliminaries

Step 1: If your ID contains any 0's, then replace each zero (0) with a one (1). **4912345671**

Step 2: Write your ID in reverse order. The result is referred to RID.   **1765432194**

The following variables will be used in the assignment:

- A = first 8 digits of RID   **17654321**
- B = all 10 digits of RID   **1765432194**
- C = first 2 digits of RID   **17**

Question 1 [14 marks: 0, 2, 2, 2, 2, 2, 2, 2]

Using A from Question 0, take every two digits to form a dotted decimal IP address. For example, if my ID is 4912345670 then the IP address is: 17.65.43.21.

<div align="center">IP Address: 17.65.43.21</div>

Assuming your computer is using this calculated IP address, answer the following questions:

a) If classful addressing is used:

   i. What is the class of the IP address?   Class: **A**

   Explanation: 17 converted to binary is 00010001. With classful addressing, if the first bit is a 0, then the IP address is class A. Alternatively, if the first component of the dotted decimal IP address is between 1 and 126, then it is a class A address. Since the IP of all students contains only 2 digits in the first component, the class for all students (independent of their ID) will be class A.

   ii. How many computers, other than yours, can be located on the same network as yours?

<div align="center">Number of computers: 2^{24}-3</div>

   Explanation: with a Class A address there are 24 bits in the host portion, meaning 2^{24} possible host address values. However, two of those are reserved values (all 0's and all 1's) and the third is your current IP address. Therefore 2^{24} -3 other computers are possible.

   iii. What IP address would your computer send to in order to reach all other computers on your network?

<div align="right">IP Address: 255.255.255.255 or

17.255.255.255</div>

   Explanation. 255.255.255.255 is the local broadcast address. If you send a packet to this address, the packet will be delivered to all computers on your network. Alternatively you could use the directed broadcast address for your network, e.g. 17.255.255.255.

b) If classless addressing is used:

   i. What is the network address with subnet mask /21?

<div align="right">IP Address: **17.65.42.0**</div>

Explanation: With subnet mask /21, the first 21 bits of the IP address are the network portion – the remaining host bits must be set to 0 to find the network address. Hence the first 16 bits will be the same (17.65 in dotted decimal). The value 43 = 00101001 and the first 5 bits are the same and the last 3 bits set to 0: 00101 000 = 42.

   ii. How many computers, other than yours, can be located on the same network as yours?

<div align="center">Number of computers: $2^{11} - 3 = 2045$</div>

Explanation: There are 11 bits in the host portion, and using the same argument as part (a)ii we get 2^{11}-3 other computers

   iii. What IP address would your computer send to in order to reach all other computers on your network?

<div align="right">IP Address: **255.255.255.255** o**r**

17.65.49.255</div>

Explanation: same argument as part (a)iii. However, with the directed broadcast address the last 11 bits are set to 1.

   iv. What subnet mask would you use if you want to have a maximum of (C x 100) computers on your network (where C is from Question 0)?

<div align="right">Subnet mask: **/21**</div>

Explanation: C = 17 therefore there are 1700 hosts. With 11 bits in the host portion, 2^{11} = 2048, allowing for 2046 hosts. If 10 bits were used, then only 1022 hosts would be possible (not enough). Hence we need 11 bits in the host portion, or subnet mask of /21.

Question 2 [15 marks: 2, 1, 12]

In this question you will generate a network of 8 nodes. Your network can be defined in a 8x8 matrix, where the elements in the matrix identify the link cost from one node (row) to another (column). A value of "–" means there is no link from the node in the row to the node in the column (obviously, there is no link from node 1 to node 1, and so on). To generate your matrix, write your value of B from Question 0 into the *empty* boxes in the matrix below, row by row (that is, left to right in the first row, then continue left to right in the second row, and so on). Repeat the 10 digits as needed.

For example, if B is 1765432194, then the first empty entry (column 2, row 1) would be 1, the second empty entry (column 3, row 1) would be 7, and the third empty entry (column 1, row 2) would be 6. The last empty entry (column 7, row 8) would be 3.

a) Complete your network connectivity matrix.

Network Connectivity Matrix

		To node …							
		1	2	3	4	5	6	7	8
From Node …	1	-	1	7	-	-	-	-	-
	2	6	-	-	5	4	-	3	-
	3	2	-	-	-	1	9	-	-
	4	-	4	-	-	1	7	6	-
	5	-	5	4	3	-	2	-	-
	6	-	-	1	9	4	-	-	1
	7	-	7	-	6	-	-	-	5
	8	-	-	-	-	-	4	3	-

b) Draw your network, indicating the direction of links and costs, on the figure below.
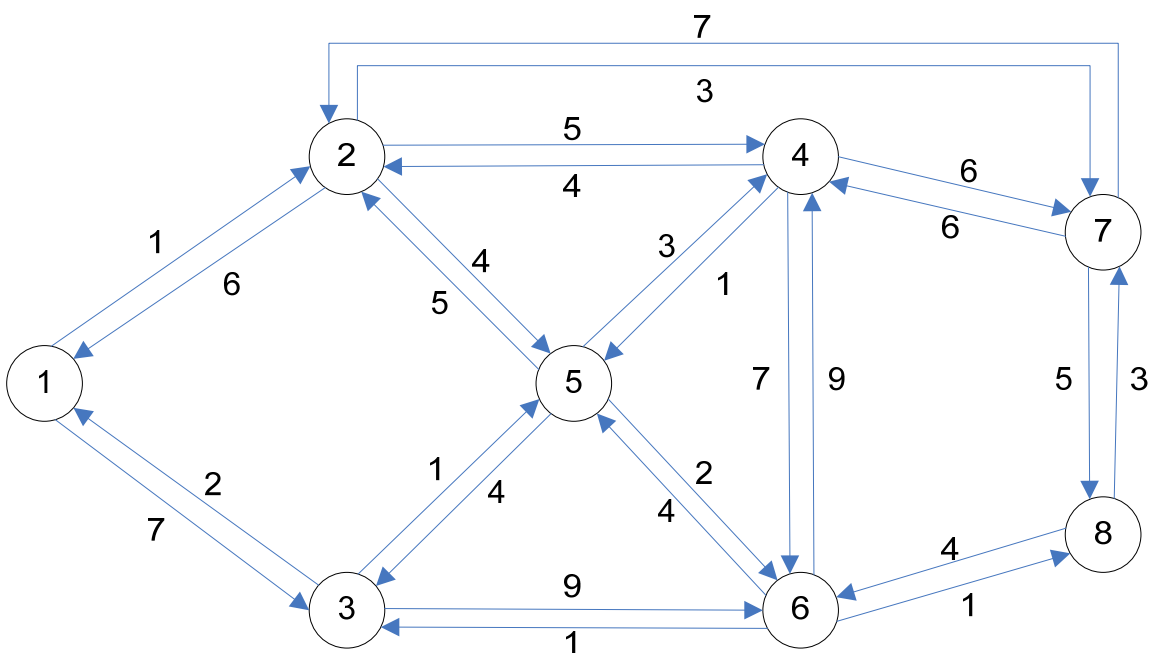
c) Assuming least-cost routing is used, complete the routing tables for nodes 1 and 5. (You may use any approach to determine the routing tables, however you should describe the approach you use, and any calculations if used). You will lose 2 marks for each incorrect value – so be careful, and make sure you check the least-cost routes.

Node 1		
Destination	**Next Node**	**Cost to Destination**
2	2	1
3	3	7
4	2	6
5	2	5
6	2	7
7	2	4
8	2	8

Node 5		
Destination	**Next Node**	**Cost to Destination**
1	6	5
2	2	5
3	6	3
4	4	3
6	6	2
7	6	6
8	6	3

Include any relevant calculations or explanation of the approach you used.

Explanation: There are many approaches to calculate: manually (by inspecting the graph), using one of the shortest past algorithms like Dijsktra, or using software. I used a Scilab (http://www.scilab.org/) function (shortest_path()) to calculate the shortest paths. Once the shortest paths are known, the routing tables are generated by using the cost and the next node in the shortest path.

Question 3 [15 marks]

In your network from Question 2, assume an application on node 1 has *C* x 2000 bytes of data to send to an application on node 8.

You should make the following assumptions:

- IP is the internetworking protocol used, and the routing protocol used selects the least cost path for all packets.

- Switched 100Mb/s Fast Ethernet is used on each subnet. In addition to the standard IEEE 802.3 MAC frame, the IEEE 802.3 Physical layer adds an 8 byte header to the MAC frame. Also, although CSMA/CD is not used, there is an Inter Frame Gap (IFG) between each frame sent (that is, after completing transmission of one frame, the transmitter must wait for IFG before starting transmission of the next frame). The IFG is the time to send 96 bits.

- The application at node 1 fragments the data into messages such that IP Fragmentation will not be needed, and (where possible) the maximum sized MAC frame will be used.

- Propagation delay of each link is the link cost, given in 10's of microseconds. For example, if the link cost from node 1 to node 2 is 5, then the propagation delay for that link is 50μs (microseconds).

- Queuing delays and processing delays are 0.

- No errors occur over the links or at nodes.

- You can ignore any overheads introduced by transport or application layer protocols.

- You can ignore the time needed in discovering the route (only consider data transfer).

a) Calculate the total time it takes to transfer the data.   **3272 μs**

b) Calculate the throughput achieved with the data transfer.   **83129584 b/s**

Clearly show your calculations and state any additional assumptions you make.

Explanation:

To understand the headers (and overheads) introduced in this question, it is useful to draw the packet as it is generated at the source node (Node 1). The information about the data and headers at each layer is shown in the following figure. C x 2000 Bytes of data is generated by the application. The application layer protocol segments into pieces such that two conditions are met:

1. The size of the pieces is such that IP fragmentation will not be performed by the source host. IP will fragment a datagram if the datagram will be larger than the maximum size supported by the DLL of the next subnet. In our case, the DLL is IEEE 802.3, which we know supports 1518 bytes (18 header plus 1500 bytes of payload). Therefore the IP datagram must be 1500 bytes or less. Since the IP header is 20 bytes (assuming no IP options), then the Data size must be 1480 bytes or less.

2. The size of the pieces is such that the DLL of the next subnet will send maximum size MAC frames. From the previous condition we decided the Data size must be 1480 Bytes or less. For example, 1000 Bytes is possible. However, the second condition says to use

the maximum possible size (presumably to increase efficiency). Hence the Data size should be 1480 Bytes. The one exception is the last Data segment: if the amount of Oriiginal Data is not an integral number of 1480 Bytes, then the last Data segment will be smaller than 1480 Bytes.
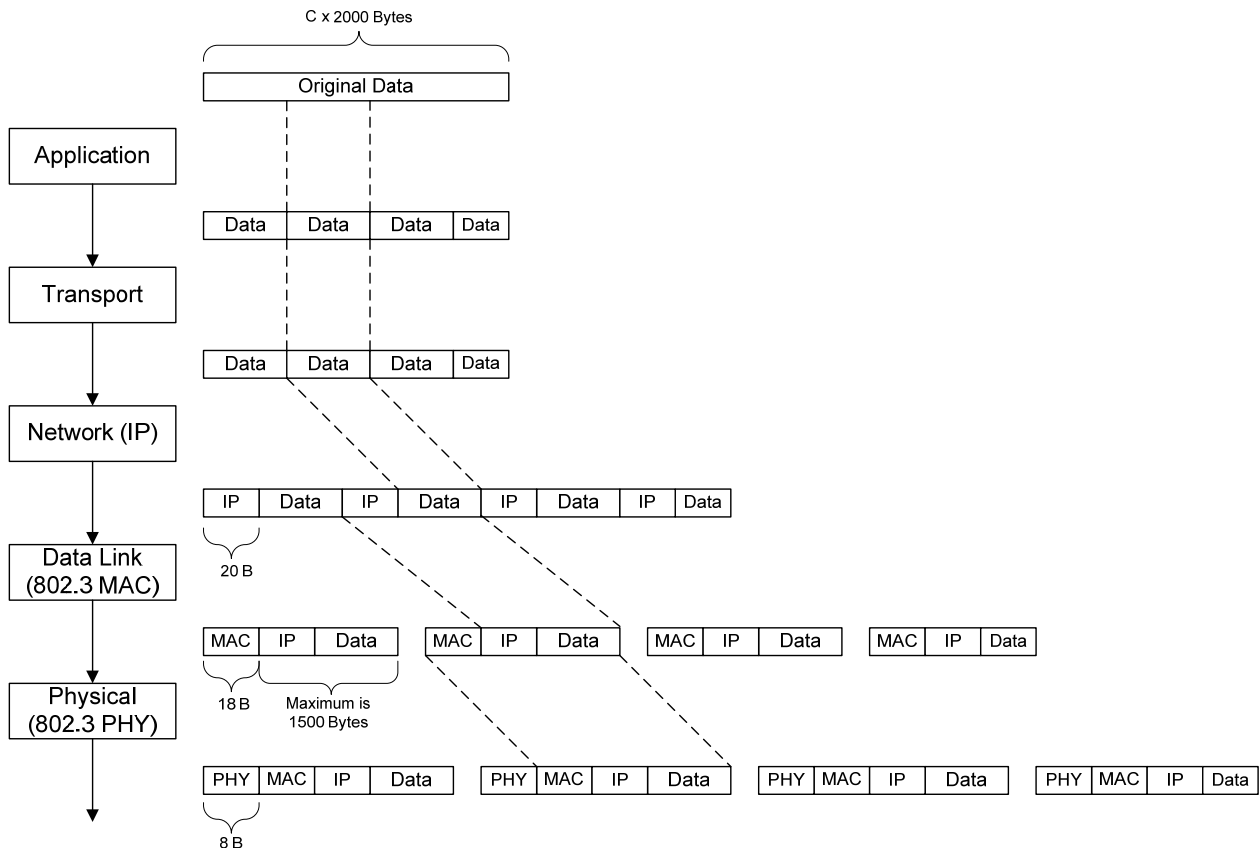
In our example, C = 17, and hence the Original Data is 34000 Bytes. This gives 22 Data pieces of 1480 Bytes and the last Data piece of 1440 Bytes. The total number of Data pieces is 23.

The Application Layer takes the Original Data, segments into 23 pieces, and each piece is sent, one at a time, to the Transport layer. The Transport layer (which performs no processing) sends the Data directly to IP, which adds an IP header (20 bytes) and sends to the DLL (MAC). IEEE 802.3 MAC adds a header (in fact it is a header and trailer, however the above diagram shows only the header) and:

1. Sends a MAC frame to the Physical layer

2. Waits for an Inter Frame Gap (IFG)

3. Repeats from step 1.

When the Physical layer receives a frame, it adds the Physical layer header and transmits the bits over the link (to the next router).

Now, to calculate the total transfer delay over a datagram packet switching network, we can first calculate:

- Total size per packet:
  - 1480 Byte Data: 1480 + 20 (IP) + 18 (MAC) + 8 (PHY) = 1526 Bytes
  - 1440 Byte Data: 1440 + 20 + 18 + 8 = 1486 Bytes
- Transmission time:
  - 1526 Byte packet @ 100Mb/s = 122.08μs

- 1486 Byte packet @ 100Mb/s = 118.88μs

- Inter Frame Gap:
  - 96 bits @ 100Mb/s = 0.96μs

From Question 2, from Node 1 to Node 8, the shortest path is 1-2-5-6-8. Hence there are 4 links with a cost of 8 (respective costs are 1, 4, 2 and 1). The link propagation times are:

- Link 1-2: 10μs

- Link 2-5: 40μs

- Link 5-6: 20μs

- Link 6-8: 10μs

The transmission and propagation of packets across the network can be shown as follows (not to scale):
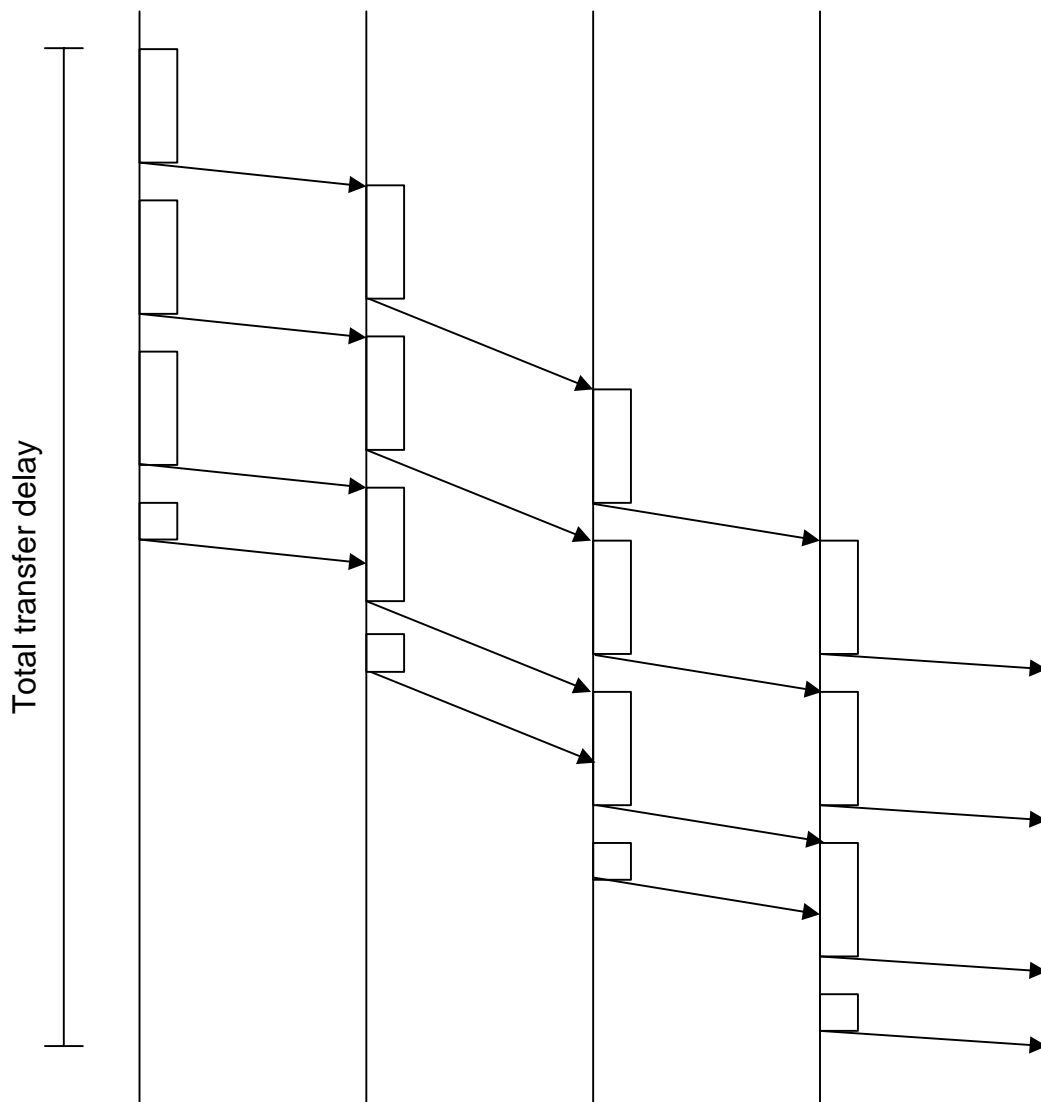
We need to calculate the total time from when the first bit is transmit at Node 1, until when the last bit is received at Node 8. By following the diagram (see figure below), we see the time consists of:
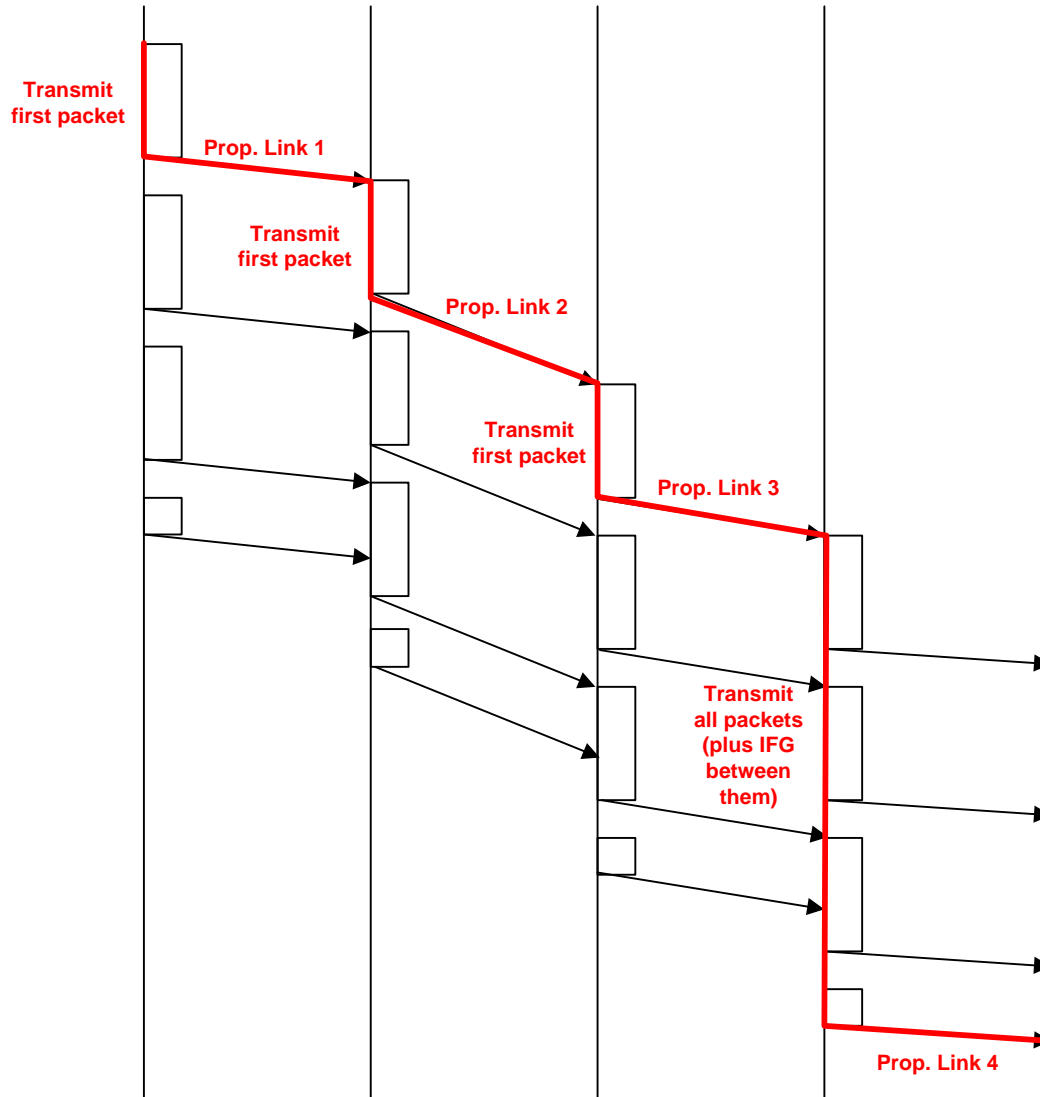
Time to transmit first packet over first 3 links

+

Propagation time across each of the 4 links

+

Time to transmit all packets over the last link (including IFGs)

For our example:

Delay =   122.08 x 3

          +   10 + 40 + 20 + 10

          +   122.08 x 22 + 118.88 x 1 + 0.96 x 22

      =   366.24 + 80 + 2825.76

      =   3272 µs

Throughput   =   34000 Bytes / 3272 µs

          =   83129584 bits / second

Question 4 [16 marks: 0, 0, 2, 1, 3, 4, 2, 1, 1, 2; Bonus 6]

On your PC you can use programs and commands to view and edit the details of your computers interfaces and connections. In this question you will use some simple commands on your own computer.

Perform the following tasks either on:

1. Your personal PC or laptop while connected to the Internet (that is, if you are using your laptop, make sure you have an active Internet connection when performing the tasks).

2. An SIIT lab computer.

Do not use your friends computer – that is, make sure you perform the tasks yourself on your own computer. The intention is that everyone performs the tasks on their own.

In Microsoft Windows XP, the following tasks can be performed by opening a Command prompt (e.g. go to "Start" menu, select "Run…" and enter the program "cmd").

In Linux (such as Ubuntu) you can perform the tasks in a shell.

a) What computer did you use for the tests? (circle only one)

    a. **Home**/Dormitory desktop computer

    b. Personal Laptop

    c. SIIT Lab computer in Room _____ (enter the room number)

    d. Other (describe) _____

b) What operating system did you use during the test? (circle only one)

WindowsVista   **WindowsXP**   Ubuntu   MacOSX   Other: _____

c) Look at the interfaces of your computer and record the details in the tables below.

    • Windows XP: `ipconfig /all`

    • Ubuntu Linux: `ifconfig`

In Windows, each interface may be called an *adapter*. In Linux, the output will normally also include the *loopback* interface (Windows normally does not show this).

If you only have one interface, only complete one table. If you have two (or more) interfaces, complete both tables. Depending on the operating system, not all values in the tables below are shown – if they are not shown, you can calculate them from the other values.

Interface 1:

Interface Type or Name	**Ethernet adapter: Realtek Gigabit Ethernet NIC**
MAC Address	**00-17-31-7E-50-7D**
IP Address	**192.168.1.2**
Subnet Mask	**255.255.255.0**
Broadcast Address	**192.168.1.255**

Interface 2 (if present):

Interface Type or Name	
MAC Address	
IP Address	
Subnet Mask	
Broadcast Address	

d) Using the IEEE address assignment database at http://standards.ieee.org/regauth/oui/, determine the manufacturer of your Ethernet card.

Manufacturer:

ASUSTek COMPUTER INC.

No.5 Shing Yeh Street,Kwei Shan Hsiang,Taoyuan

Taipei 333

TAIWAN, REPUBLIC OF CHINA

e) Look at the routing table for your computer and record the routes (depending on your computer and network, there may be multiple entries).

- Windows XP: `route print`

- Ubuntu Linux: `route`

Note that Gateway refers to the Next Router. To learn what Windows route command shows, simply type `route`. For Linux, try `man route`.

Entry	Destination	Mask	Gateway	Interface	Metric
1	0.0.0.0	0.0.0.0	192.168.1.1	192.168.1.2	20
2	127.0.0.0	255.0.0.0	127.0.0.1	127.0.0.1	1
3	192.168.1.0	255.255.255.0	192.168.1.2	192.168.1.2	20
4	192.168.1.2	255.255.255.255	127.0.0.1	127.0.0.1	20
5	192.168.1.255	255.255.255.255	192.168.1.2	192.168.1.2	20
6	224.0.0.0	240.0.0.0	192.168.1.2	192.168.1.2	20
7	255.255.255.255	255.255.255.255	192.168.1.2	192.168.1.2	1
8					
9					
10					

f) Select at least 4 entries from your routing table (if your table has less than 4, then select all entries). For each entry describe how the entry is used. For example, "Entry 1: if a packet is destined to a computer on network X.Y.Z.0, then the packet is sent to gateway A.B.C.D via interface Q". If there are any special addresses used, make sure you describe how they are used.

Answer

First note that my computer has two interfaces: 192.168.1.2 (my Ethernet interface) and 127.0.0.1 (my loopback interface – Windows XP does not show this in the output of ipconfig).

Entry 1: if a packet is destined to any address, then send via my Ethernet interface to the router (gateway) 192.168.1.1.

Entry 2: if a packet is destined to a special 127.x.x.x address, then send to my loopback interface (that is, send to myself).

Entry 3: if a packet is destined to any computer on the network 192.168.1.0, then send to my Ethernet interface. Ethernet will then deliver to the destination.

Entry 4: if a packet is destined to my own Ethernet interface, then send to the loopback interface.

Entry 5: if a packet is destined to the directed broadcast address for my network then send to my Ethernet interface. Ethernet will then deliver to all destinations.

Entry 6: if a packet is destined to a special multicast address, then send to my Ethernet interface.

Entry 7: if a packet is destined to the local broadcast address, then send to my Ethernet interface. Ethernet will then deliver to all destinations.

Note that the routing table entries are NOT applied in order (if so, every packet would match Entry 1, and Entries 2 to 7 would never be used). IP uses "longest-prefix matching", which means the rule for which the most bits in the packet address match a destination address in the Routing Table will be applied. This is outside the scope of our course.

g) Both Windows and Linux typically report a *default* entry. What is that value in your computer, and explain how/when it is used?

Answer (and explanation):

The default gateway is 192.168.1.1. If a packet address does not match any of the rules, then by default the packet will be sent to the router 192.168.1.1.

Assume your computer has an additional interface that uses the short range wireless technology called ZigBee (IEEE 802.15). Three mobile devices (such as electronic games, phones and sensors) connect to your computer using ZigBee, and then your computer connects to the Internet via an existing (Ethernet or Wireless LAN) interface as given in part (c). Assume one of the mobile devices using ZigBee has the IP address you used in Question 1. The network would look like the figure below:
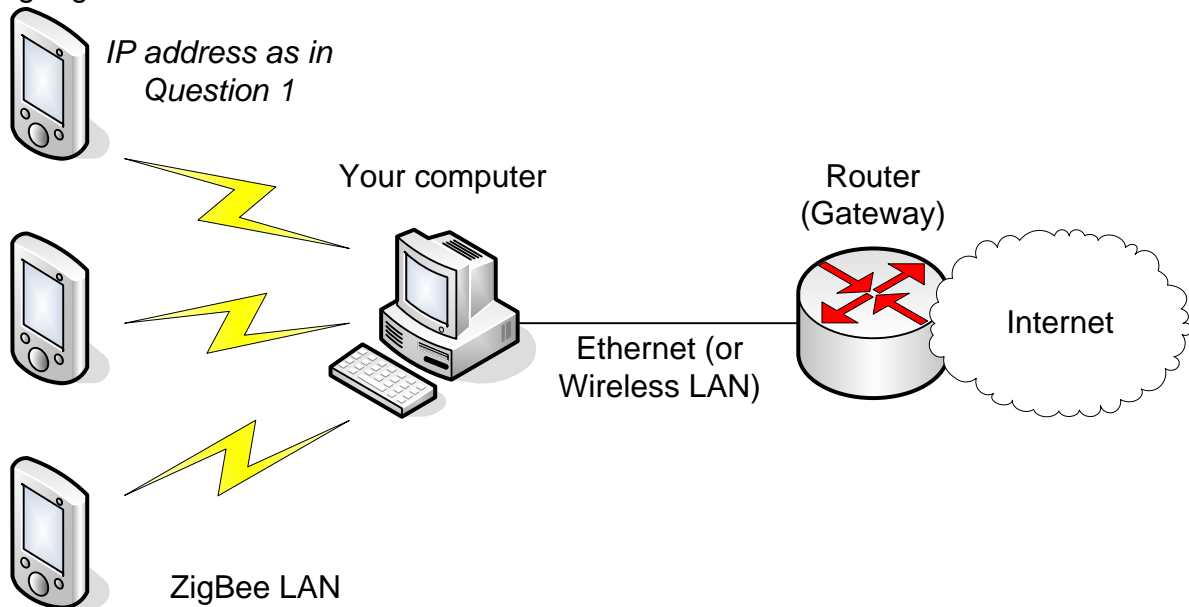
h) Select an IP address for the ZigBee interface on your computer.

IP address of computer ZigBee interface: **17.65.43.1 (assume class A)**

i) Select the IP addresses of the other two ZigBee mobile devices (remember, the first ZigBee device uses the IP address from Question 1)

IP address of ZigBee Mobile Device 2: **17.65.43.2**

IP address of ZigBee Mobile Device 3: **17.65.43.3**

j) Complete a suitable routing table for the first ZigBee mobile device (with IP address as in Question 1). Use a *default* entry if appropriate.

Destination	Mask	Gateway	Interface	Metric
17.0.0.0	255.0.0.0	17.65.43.21	17.65.43.21	1
default	0.0.0.0	17.65.43.1	17.65.43.21	1

Explanation: at minimum you should show the default router/gateway to be 17.65.43.1 (the address of your computer's ZigBee interface) as well as an entry for the local network. The metric is not important – it actually means the cost of the link/path.

k) [Bonus question] With the operating system of your computer, explain what you need to do to enable your computer to forward packets from ZigBee devices to the Internet. You should explain in enough detail such that someone with good knowledge of your operating system (for example, me) could follow the instructions and configure the computer.

Explanation:

There are two main steps that you must take to setup your computer:

1. Configure your computer as a Router. Most PC operating systems automatically are configured as Hosts – they do not forward packets. You must change your computer from a Host to a Router so that it will forward packets.

2. Configure the routing tables on your Router. Now that your computer is a router, the routing tables must be configured so your computer forwards traffic to the correct network.

Destination	Mask	Gateway	Interface	Metric
17.0.0.0	255.0.0.0	17.65.43.21	17.65.43.21	1
192.168.1.0	255.255.255.0	192.168.1.2	192.168.1.2	1
default	0.0.0.0	192.168.1.1	192.168.1.2	1

We will cover how to perform these steps in Windows and Linux in ITS332 Lab. Some details are available at: http://support.microsoft.com/kb/315236 and by looking at the commands route (on Windows and Linux), and the file /proc/sys/net/ipv4/ip_forward in Linux.