EEE116 – Multimedia Systems 2007/08
Solutions to tutorial problems 9 (Week 11)

(Q17)

- Use *ping* record the RTTs for a local address (e.g., www.sheffield.ac.uk), then a UK address (e.g., www.bbc.co.uk), and finally a distant address (e.g., www.usyd.edu.au). Explain the differences in RTTs. What effect is there on RTTs if you carry out this small experiment at different times of the day?

Here are some example times for RTT and TTL obtained using the PING command. These times were recorded at 7.00 am (BST) on a Wednesday.

Address	IP address	Average RTT	TTL
www.sheffield.ac.uk	143.167.2.73	1 ms	254
www.bbc.co.uk	212.58.224.114	6 ms	246
www.usyd.edu.au	129.78.64.24	310 ms	236
www.princeton.edu	128.112.130.211	78ms	50

The RTT is the round trip time to send a packet from the source to the destination and its return.

Therefore RTT is a function of transmit time + propagation time + queuing delays.

Transmission time= data size / data throughput

We used the same packet size for all 4 cases. Therefore, transmit time is the same.

Propagation time = distance/speed of light

Therefore the distance to travel is a major contributor to the RTT. Depending on the network utilization (resulting in congestion and other network delays), the RTT recorded at the different times of day can vary a lot.

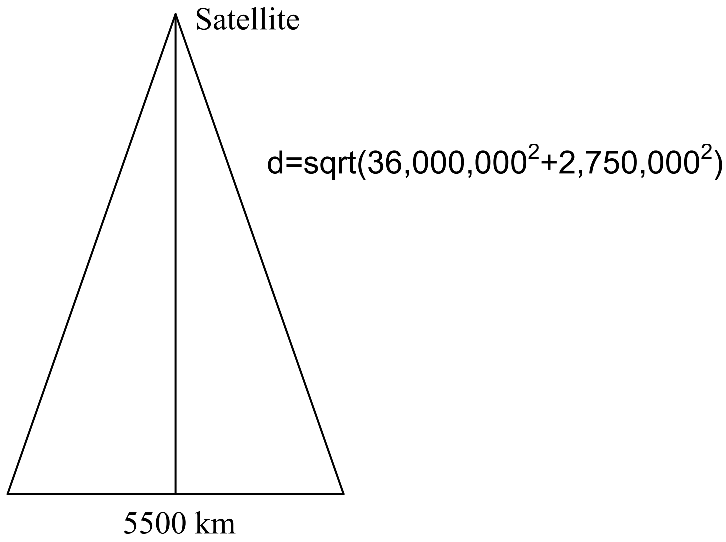
TTL is the time-to-live field in IP datagram. There are 8 bits allocated for this field. Before a packet is sent all 8 bits are set to 1. Therefore the TTL value at the beginning is 255. Every time the IP datagram passed through a router (one hop) TTL is decremented by 1. When the TTL becomes 0, the IPdatagram (packet) is discarded. This mechanism avoids a packet traversing throughr routers forever (Remember the packet switching demo in the class (2 CDs sent from Boro to Joseph)?)

What does (255 – (current TTL value)) give?

- For a USA address (e.g., www.princeton.edu) find the RTTs and then estimate the minimum theoretical RTT. Assume that the RTT is dominated by the time to send a signal over the Atlantic via a geostationary satellite. How does this compare with practical values?

  For this calculation, you will need to know that geostationary satellites are about 36,000 km above the earth's surface, width of the Atlantic is some 5,500 km and speed of light is 3×10^{8} ms^{-1}.

Theoretical time



As described in the solution to previous part, the chief contributor to RTT value is the propagation delay.

RTT= (Total distance travelled) / (speed of light)
$= 2 \times 2 \times d / (3 \times 10^8)$
= 481.4 ms

Much higher than the measured value. Obviously, this is due to your lecturer's wrong assumption.

Now make a different assumption, e.g., using a transatlantic fibre optic cable

Now RTT = (Total distance travelled) / (speed of light)
$= 2 \times 5500 \times 10^3 / (3 \times 10^8)$
= 36.7 ms

This value is more realistic. What factors determine the difference between the theoretical value and the recorded value?

The TTL field (originally stood for *time-to-live*) tells you how many hops (routing nodes) the message has passed through. It starts at 255 and is decremented by 1 at every hop. What does this tell you about the Internet?

Refer to the solution to the first part of this question and discuss with your colleagues ☺

Hint: Maximum number of hops

(Q18)

Calculate the total time required to transfer a 1000 Kbyte file in the following three cases: Assume in all three cases that the Round Trip Time (RTT) is 100 ms, the packet size is 1 Kbyte and that initial handshaking takes place before the data is sent (This handshaking takes the equivalent of 2 x RTT).

i) A link bandwidth of 1.5 Mbps and data packets can be sent continuously

RTT = 100 ms; Initial Handshake = 2 x RTT = 200 ms;
Data size =1000 Kbyte; Packet size = 1Kbyte;
Packets= (Data size)/(packet size) =1000 /1 = 1000;

Total time = Handshake + transmission time for 1 packet x 1000 + propagation time;

= 0.2 + (1 Kbyte / 1.5 Mbps)*1000 + RTT/2

= 0.2 + (8x1024)/(1.5x1024x1024)x1000 + 0.05

= 5.46 s

We assumed propagation time = RTT/2 because the other delays compared to the propagation time are quite small.

ii) A bandwidth of 1.5 Mbps but after sending each packet wait one RTT before sending the next

The total time constitute of following components:

- Initial handshake (same as in (i))
- Transmit time for 1000 packets (same as in (i))
- 999*RTT waiting time for the first 999
- ½ RTT propagation time for the last packet (same as in (i))

Total time = time for (i) + 999*RTT
= 105.36 s

iii) The bandwidth is infinite (i.e., transmit time is zero) and up to 20 packets can be sent per RTT.

Up to 20 packets can be sent per RTT
For 1000 packets 50 times required

This means 49xRTT waiting time for the first 49 sets and ½ RTT propagation time for the 50th set of total propagation time is required.

Total time = Handshake + transmit time + Total RTT

= 0.2 + 0 + (49*0.1 + 0.1/2)

= 5.15 s

(Q19) Visit http://www.net.cmu.edu/cgi-bin/netops.cgi and run traceroute command for www.shef.ac.uk. This command will trace the route from www.cmu.edu to www.shef.ac.uk and will display all the hops involved in reaching the destination. An example route when I ran the experiment is show below.

```
traceroute to garuda.shef.ac.uk (143.167.2.73), 30 hops max, 38 byte packets
 1  POD-C-VL4.GW.CMU.NET (128.2.4.1)  0.246 ms  0.203 ms  0.186 ms
 2  CORE255-VL907.GW.CMU.NET (128.2.255.186)  0.277 ms  0.191 ms  0.185 ms
 3  POD-I-CYH-VL942.GW.CMU.NET (128.2.255.205)  0.211 ms  0.200 ms  0.193 ms
 4  bar-cmu-ge-4-0-0-2.3rox.net (192.88.115.185)  0.291 ms  0.273 ms  0.266 ms
 5  beast-bar-pc1-1.3rox.net (192.88.115.77)  0.229 ms  0.164 ms  0.168 ms
 6  abilene-psc.abilene.ucaid.edu (192.88.115.124)  10.079 ms  9.921 ms  9.816 ms
 7  abilene-wash.rt1.fra.de.geant2.net (62.40.125.17)  115.565 ms  115.561 ms  115.565 ms
 8  so-5-0-0.rt1.ams.nl.geant2.net (62.40.112.58)  139.054 ms  122.897 ms  122.920 ms
 9  so-1-0-0.rt1.lon.uk.geant2.net (62.40.112.138)  130.981 ms  130.987 ms  130.998 ms
10  po2-0-0.gn2-gw1.ja.net (62.40.124.198)  131.124 ms  130.882 ms  130.871 ms
11  po1-1.lond-scr3.ja.net (146.97.35.97)  130.902 ms  130.941 ms  130.916 ms
12  po1-0.lond-scr.ja.net (146.97.33.29)  131.145 ms  131.147 ms  131.169 ms
13  po3-0.leed-scr.ja.net (146.97.33.69)  135.590 ms  135.536 ms  136.019 ms
14  po1-0.leeds-bar.ja.net (146.97.35.74)  135.495 ms  135.503 ms  135.511 ms
15  146.97.41.150 (146.97.41.150)  135.727 ms  135.589 ms  135.707 ms
16  garuda.shef.ac.uk (143.167.2.73)  137.238 ms  137.919 ms  137.639 ms
17  garuda.shef.ac.uk (143.167.2.73)  137.242 ms  136.929 ms  137.065 ms
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Using the above trace,

a) Find the IP address class in the cmu.net network and the maximum number of hosts connected to this network at any given time.

From the first hop, we know an IP address of a host connected to CMU net is 128.2.4.1.
To determine the class of IP address we first write the binary form of the first octet, i.e., 128 in this case.
1 0 0 0 0 0 0 0
And now we examine the most significant three bits. From the lectures we know,
If the most significant (first) 3 bits are 0 x x the IP address is class A.
1 0 x the IP address is class B
1 1 0 the IP address is class C
(x can be either 1 or 0)
In this example the first three bits are 1 0 0.
Therefore, the IP address is class B.

b) How many hops are required to reach the www.shef.ac.uk from the source?

There are 17 entries.
Therefore, 17 hops required.

c) What is the value of the TTL field in the IP datagram, when it reached the destination?

At the beginning the TTL field is set to 255 and decremented by 1 at each hop. Therefore the final value should be,
255-17= 238.

d) What is the average RTT?

The average of (137.242 ms 136.929 ms 137.065 ms)
= 137.08 ms

e) Why there are 3 time measurements shown for each measurement?

Traceroute command sends 3 packets and the time for each packet is recorded.

f) What is the IP address of the European gateway?

It is evident that the hop 7 is concerned with crossing the Atlantic, as it records the largest time (around 110ms) between routers. Therefore the IP address is taken from the 7th hop entry -- 62.40.125.17.