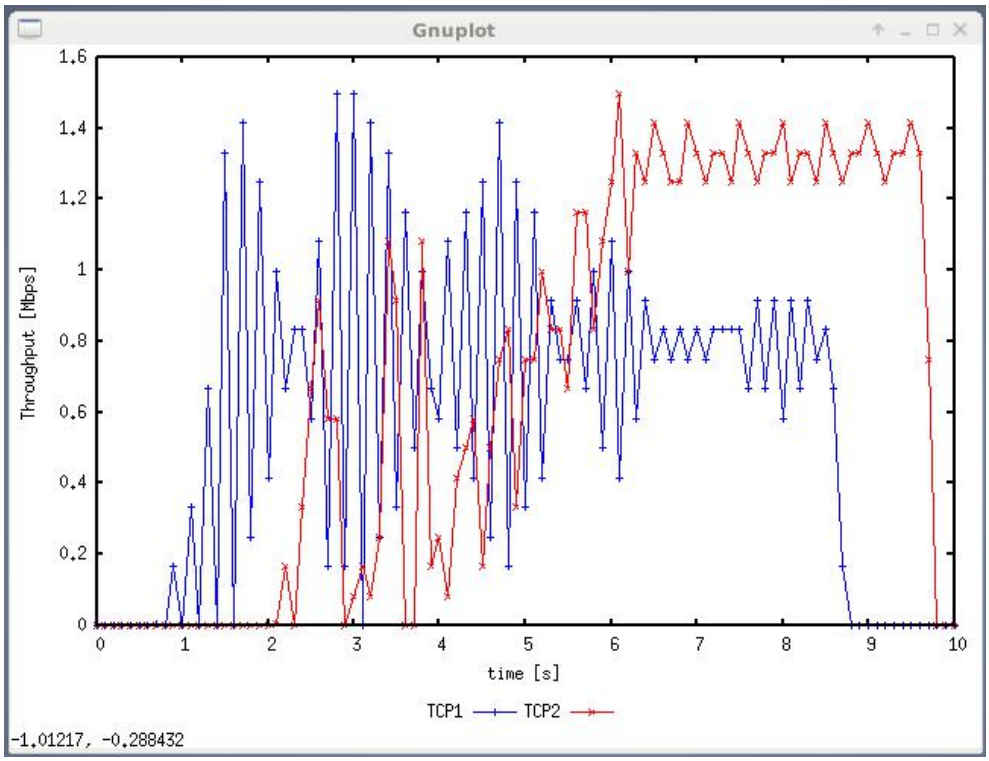
Student ID:z5195715 Name:Junyu Ren

Lab6

Exercise 1: Setting up NS2 simulation for measuring TCP throughput

Question 1: Why the throughput achieved by flow tcp2 is higher than tcp1 between time span 6 sec to 8 sec?



Because on link n1-n2,tcp1 need to compete with tcp4 and on link n2-n4, it need to compete with tcp2. Tcp2 has shorter RTT than tcp1,which can be determined by link RTTs the 2 flows go through.So,tcp2 is more quickly arrive at n2-n4 and use more link capacity. Finally, higher throughput is recorded at n5.

Question 2: Why the throughput for flow tcp1 is fluctuating between time span 0.5 sec to 2 sec?

Because tcp1 has a slow start during 0.5-2 sec.

Question 3: Why is the maximum throughput achieved by any one flow capped at around 1.5Mbps?

At 0.5--2.0 sec,although tcp1 is the unique flow in this network, it is in slow start phrase.After 2 sec,tcp2 joins and tcp1 needs to compete with it for bandwidth resources.So,both tcp1 and tcp2 can not use all the bandwidth(2.5Mbps) exclusively .

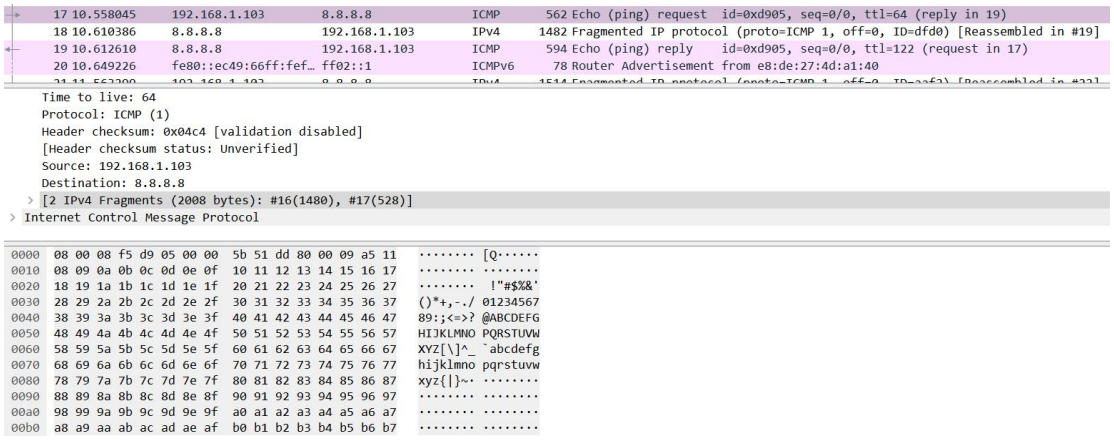
Exercise 2: Understanding IP Fragmentation

Question 1: Which data size has caused fragmentation and why? Which host/ router has fragmented the original datagram? How many fragments have been created when data size is specified as 2000?

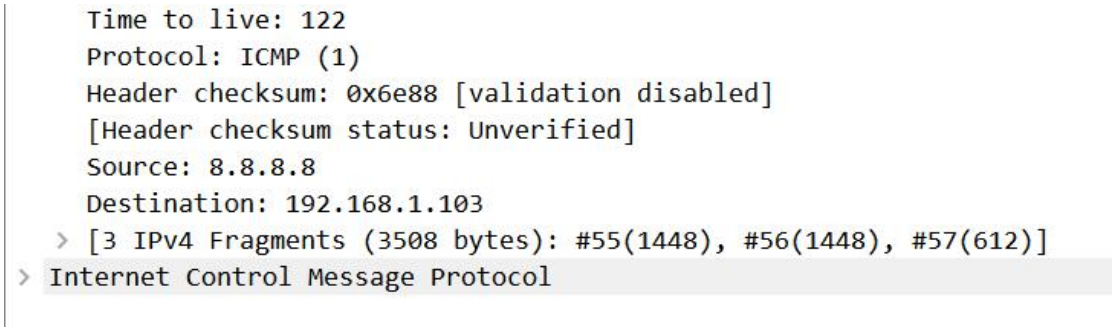
Data size 2000 and 3500 bytes will cause fragmentation.Because MTU of Ethernet is 1500 Bytes.That means a link layer frame can carry at most 1500 bytes.Any bigger packet should be divided into smaller ones to send.

Both 192.168.1.103 and 8.8.8.8 will fragment datagram when they are senders.

When data size is 2000, 2 fragments are created.They are row no.16 and 17 in trace file with header-included length 1500 bytes and 548 bytes respectively.



Question 2: Did the reply from the destination 8.8.8.8. for 3500-byte data size also get fragmented? Why and why not?



Yes, it get fragmented.

The reply is divided into 3 ipv4 fragments.One of the examples is row no.55,56 and 57.Because it has to travel the last link to the sender, it is certain to be fragmented to satisfy MTU limitation.

Question 3: Give the ID, length, flag and offset values for all the fragments of the first packet sent by 192.168.1.103 with data size of 3500 bytes?

```
> Frame 39: 1514 bytes on wire (12112 bits), 1514 bytes captured (12112 bits) on interface 0
> Ethernet II, Src: Apple_64:20:54 (e0:ac:cb:64:20:54), Dst: Tp-LinkT_4d:a1:40 (e8:de:27:4d:a1:40)
v Internet Protocol Version 4, Src: 192.168.1.103, Dst: 8.8.8.8
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 1500
    Identification: 0x7a7b (31355)
  v Flags: 0x2000, More fragments
      0... .... .... .... = Reserved bit: Not set
      .0.. .... .... .... = Don't fragment: Not set
      ..1. .... .... .... = More fragments: Set
      ...0 0000 0000 0000 = Fragment offset: 0
    Time to live: 64
    Protocol: ICMP (1)
    Header checksum: 0x0887 [validation disabled]
    [Header checksum status: Unverified]
    Source: 192.168.1.103
    Destination: 8.8.8.8
    Reassembled IPv4 in frame: 41
```

```
> Frame 40: 1514 bytes on wire (12112 bits), 1514 bytes captured (12112 bits) on interface 0
> Ethernet II, Src: Apple_64:20:54 (e0:ac:cb:64:20:54), Dst: Tp-LinkT_4d:a1:40 (e8:de:27:4d:a1:40)
v Internet Protocol Version 4, Src: 192.168.1.103, Dst: 8.8.8.8
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 1500
    Identification: 0x7a7b (31355)
  v Flags: 0x20b9, More fragments
      0... .... .... .... = Reserved bit: Not set
      .0.. .... .... .... = Don't fragment: Not set
      ..1. .... .... .... = More fragments: Set
      ...0 0000 1011 1001 = Fragment offset: 185
    Time to live: 64
    Protocol: ICMP (1)
    Header checksum: 0x07ce [validation disabled]
    [Header checksum status: Unverified]
    Source: 192.168.1.103
    Destination: 8.8.8.8
    Reassembled IPv4 in frame: 41
```

```
> Frame 41: 582 bytes on wire (4656 bits), 582 bytes captured (4656 bits) on interface 0
> Ethernet II, Src: Apple_64:20:54 (e0:ac:cb:64:20:54), Dst: Tp-LinkT_4d:a1:40 (e8:de:27:4d:a1:40)
v Internet Protocol Version 4, Src: 192.168.1.103, Dst: 8.8.8.8
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 568
    Identification: 0x7a7b (31355)
  v Flags: 0x0172
      0... .... .... .... = Reserved bit: Not set
      .0.. .... .... .... = Don't fragment: Not set
      ..0. .... .... .... = More fragments: Not set
      ...0 0001 0111 0010 = Fragment offset: 370
    Time to live: 64
    Protocol: ICMP (1)
    Header checksum: 0x2ab9 [validation disabled]
    [Header checksum status: Unverified]
    Source: 192.168.1.103
    Destination: 8.8.8.8
  > [3 IPv4 Fragments (3508 bytes): #39(1480), #40(1480), #41(548)]
```

Packet	ID	length	flag	offset
39	0x7a7b(31355)	1500	1	0
40	0x7a7b(31355)	1500	1	185 * 8 = 1480
41	0x7a7b(31355)	568	0	370 * 8 = 2960

Question 4: Has fragmentation of fragments occurred when data of size 3500 bytes has been used? Why and why not?

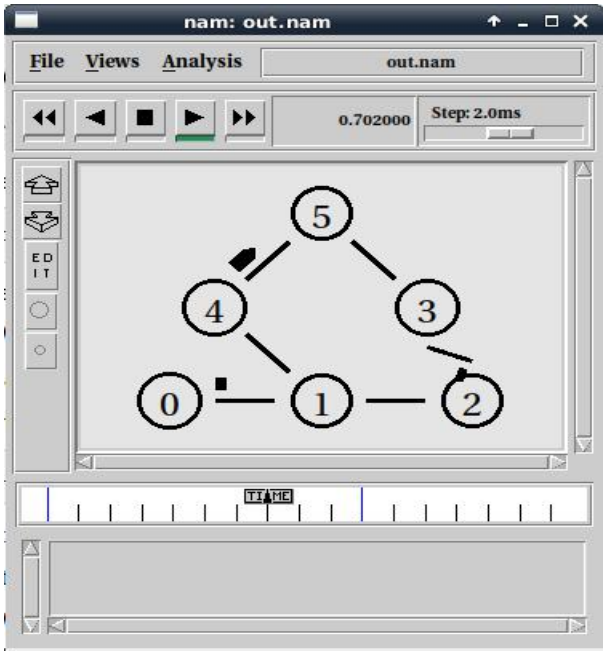
No, it hasn't.Every request correspond to one reply.Since 192.168.1.103 is the destination of reply and exactly 3 fragments are received.So, no fragmentation of fragment happens when data size is 3500.

Question 5: What will happen if for our example one fragment of the original datagram from 192.168.1.103 is lost?

The packet with any missing fragments will be dropped. 192.168.1.103 needs to retransmit all the fragments again.

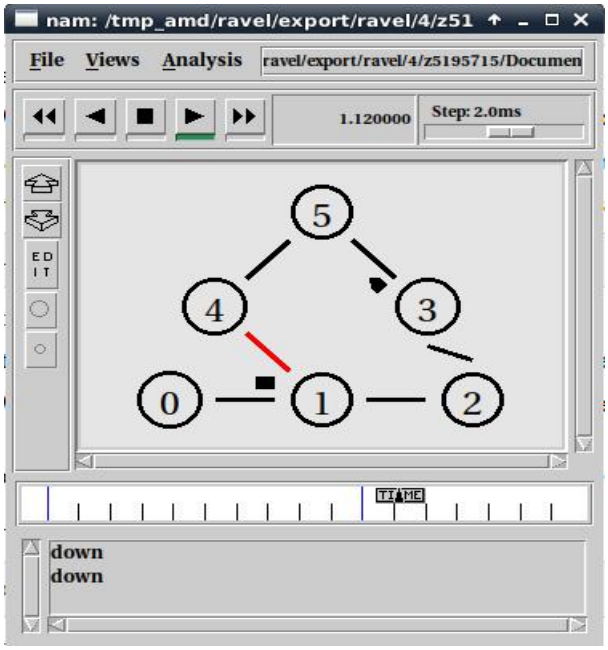
Exercise 3: Understanding the Impact of Network Dynamics on Routing

Question 1: Which nodes communicate with which other nodes? Which route do the packets follow? Does it change over time?



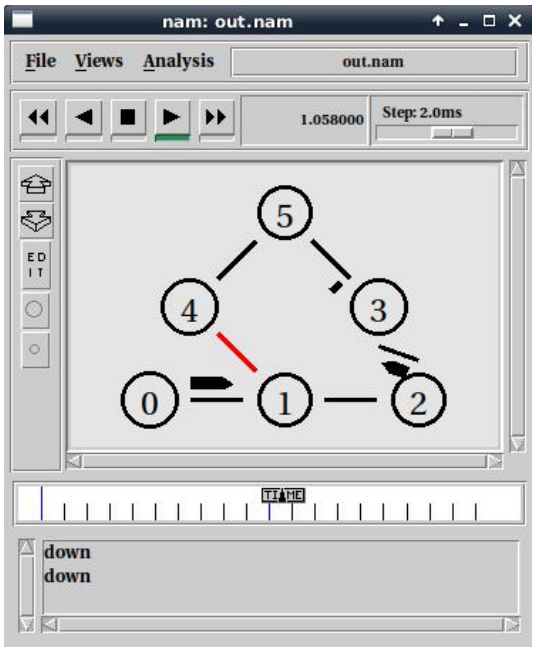
n0 communicate with n5 by path 0-1-4-5
n2 communicate with n5 by path 2-3-5
It doesn't change over time.

Question 2: What happens at time 1.0 and at time 1.2? Does the route between the communicating nodes change as a result of that?



Link between n1 and n4 doesn't work at time 1.0. The route between n0 and n5 does not change.So,the whole path 0-1-4-5 break down.
Link between n1 and n4 recover to work at time 1.2,which makes path 0-1-4-5 work again.
Moreover, communication between n2 and n5 is not affected, still by path 2-3-5.

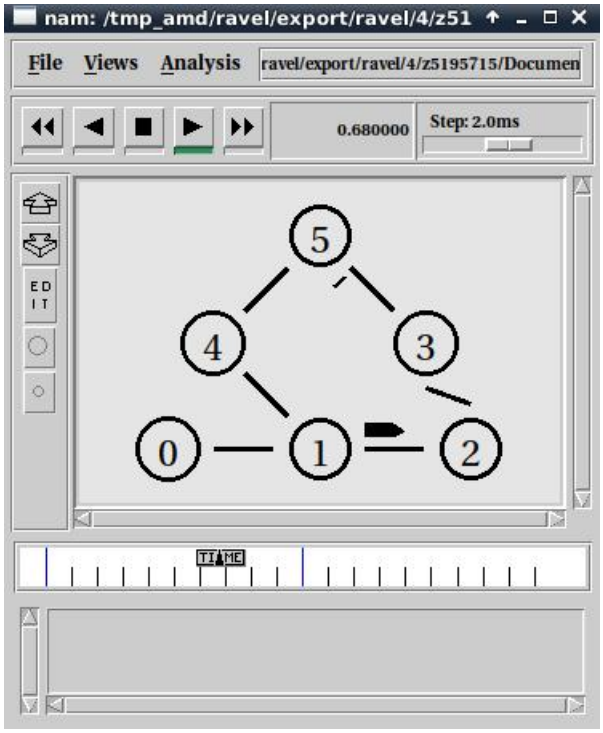
Question 3: Did you observe any additional traffic as compared to Step 3 above? How does the network react to the changes that take place at time 1.0 and time 1.2 now?



Yes, there's an additional traffic path 0-1-2-3-5.
When link between n1 and n4 doesn't work at time 1,traffic follow an alternative path 0-1-2-3-5 based on DV routing protocol.When link between n1 and n4 recover to work at time 1.2,traffic follow path 0-1-4-5.This is because path 0-1-2-3-5 has cost 4 and 0-1-4-5 has cost 3.Path with

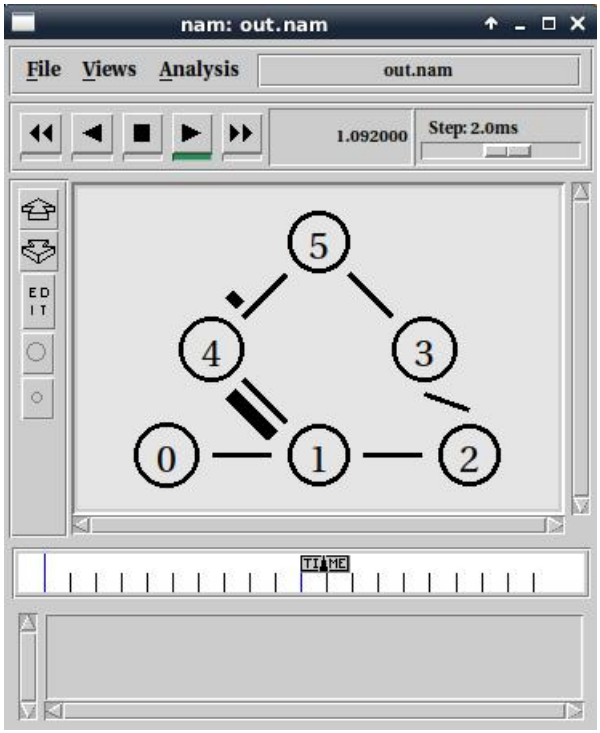
lower cost will be selected.(Suppose the cost of each link is 1 if not specially declared,same for Q4 and Q5)

Question 4: How does this change affect the routing? Explain why.



'$ns cost $n1 $n4 3' change the cost between n1 and n4 into 3.Thus, path 0-1-4-5 has total cost 5.Traffic now will follow path 0-1-2-3-5 because the cost of this path is 4, which is smaller than 5.

Question 5: Describe what happens and deduce the effect of the line you just uncommented.



‘$ns cost $n1 $n4 2 $ns cost $n3 $n5 3’ changes cost between n1 and n4 into 2 and changes cost between n3 and n5 into 3.

For n0 communicate with n5,there are 2 alternative paths:0-1-4-5 and 0-1-2-3-5,with total cost 4 and 6 respectively.So,traffic will always follow path 0-1-4-5 because of smaller cost.

For n2 communicate with n5,there are also 2 alternative paths:2-3-5 and 2-1-4-5.Both of them have total cost 4. ’Node set multiPath_ 1’ means multipath routing is used.Thus, n2 will allocate packets to travel averagely along this two paths.