Exercise 1: 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?

- Node 0 sends packets to node 5 which route is 0-1-4-5, node 2 sends packets to node 5 which route is 2-3-5. The route does not 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?

- At time 1.0, link 1-4 goes down, but node 0 and node 5 does not change, so node 0 unable to reach node 5. At time 1.2, link 1-4 goes up again, and the packets that waiting at node 1 are now forward to node 4 and then node 5. Traffic between node 2 and node 5 are not affected.

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?

- I observe additional control traffic whereby DV protocol is exchanging information to build its forwarding table. Now, when link 1-4 goes down, the DV routing protocol discovers a different route(0-1-2-3-5) and uses it. Once link 1-4 becomes available again, the routing protocol reverts to the original route(0-1-4-5), since it has a lower cost(in terms of number of hops to destination).

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

- This changes the cost of link 1-4 to 3. We can find that the flow between node 0 and node 5 becomes route 0-1-2-3-5 which total cost is 4, because this route cost lower than route 0-1-4-5 which total cost is 5.

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

- The routes between nodes 0-5 have 2 conditions. One route is 0-1-4-5 which total cost is 4 and another route is 0-1-2-3-5 which total cost is 6. Flow follows the least cost path(0-1-4-5).
- The routes between nodes 2-5 also have 2 conditions. Route 2-3-5 and 2-1-4-5, and both have equal cost of 4. Since the network is using multipath routing, node 2 will split traffic equally on both paths.

Exercise 2: 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?

- Flow tcp1 is competing with flow tcp4 on link n1-n2. And flow tcp1 again competing with tcp2 on link n2-n4. Flow tcp2 has less RTT than tcp1, so TCP2 gets higher share of the bandwidth on link n2-n4 and eventually throughout is recorded at n5.

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

- Because flow tcp2 is probing for available bandwidth using Slow Start mechanism.

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

- It is not permitted for sole use of the Bandwidth for any flow. During time 0.5 - 2.0 sec, tcp1 is the only flow active but it is still in the Slow Start phase. And it have to complete with other flows starting at 2.0 sec before it can discover the maximum bandwidth.

Exercise 3: 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 of 2000 and 3500 bytes for ICMP has caused fragmentation. Because MTU for Ethernet is 1500 bytes, large packets need to be divided into smaller packets to be transferred.
- When transferring datagrams, sender fragments datagram into several fragments, then the receiver reassemble the arrived fragments into complete datagram. Both of 192.168.1.103 and 8.8.8.8 will fragment datagram when they act as sender.
- For data size of 2000, IP gets a total payload of 2008 bytes(1992 bytes data + 8 bytes ICMP time stamp + 8 bytes ICMP header). It creates 2 fragments which length are 1500 bytes and 548 bytes.

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. The reply also get fragmented in three IPv4 datagrams. Because it has to travel the last link to sender, it is bound to be fragmented as the MTU for the last mile link is 1500 bytes.

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?

- Packet 39: ID=0x7a7b(31355), length= 1500, flag=0x01, offset = 0
- Packet 40: ID=0x7a7b(31355), length= 1500, flag=0x01, offset = 1480
- Packet 41: ID=0x7a7b(31355), length= 568, flag=0x00, offset = 2960

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

- No, the fragmentation of fragments has not occurred. Every request correspond to exactly one explicit reply. When the fragmentation of fragments occurred, there will be more than 3 fragments received.

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

- The sender has to eventually retransmit all the fragments again.