Exercise 1

Question 1

Flow tcp1 is competing with flow tcp4 on link n1-n2 and link n2-n4. Flow tcp2 has less RTT and it gets higher share of the bandwidth on link n2-n4, which is recorded at n5.

Question 2

Flow tcp1 is using Slow Start mechanism.

Question 3

Between 0.5 – 2.0 sec, tcp1 is the only flow active, but it is still in the SS phase and must compete with the other flows starting at 2.0 sec before it can discover the maximum bandwidth.

Exercise 2

Question 1

- 2000-bytes and 3500-bytes payload would cause fragmentation, because the MTU is 1500 bytes
- 192.168.1.103 has fragmented the original datagram
- 2 fragments have been created when data size is specified as 2000.

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.1.1	255.255.255.255	UDP	215	36861 → 7437 Len=173
2	1.433512	fe80::ec49:66ff:fe…	ff02::1	ICMPv6	78	Router Advertisement from e8:de:27:4d:a1:40
3	3.071798	192.168.1.1	255.255.255.255	UDP	215	36861 → 7437 Len=173
4	3.262721	192.168.1.103	8.8.8.8	ICMP	98	Echo (ping) request id=0xd805, seq=0/0, ttl=64 (reply in 5)
5	3.287081	8.8.8.8	192.168.1.103	ICMP	98	Echo (ping) reply id=0xd805, seq=0/0, ttl=122 (request in 4)
6	3.993354	192.168.1.106	224.0.0.251	MDNS	108	Standard query 0x0000 PTR _homekit._tcp.local, "QM" question OPT
7	3.993713	fe80::18fe:846:f78…	ff02::fb	MDNS	128	Standard query 0x0000 PTR _homekit._tcp.local, "QM" question OPT
8	4.264498	192.168.1.103	8.8.8.8	ICMP	98	Echo (ping) request id=0xd805, seq=1/256, ttl=64 (reply in 9)
9	4.286191	8.8.8.8	192.168.1.103	ICMP	98	Echo (ping) reply id=0xd805, seq=1/256, ttl=122 (request in 8)
10	5.269254	192.168.1.103	8.8.8.8	ICMP	98	Echo (ping) request id=0xd805, seq=2/512, ttl=64 (reply in 11)
11	5.291311	8.8.8.8	192.168.1.103	ICMP	98	Echo (ping) reply id=0xd805, seq=2/512, ttl=122 (request in 10)
12	6.045195	192.168.1.1	255.255.255.255	UDP	215	36861 → 7437 Len=173
13	9.113418	192.168.1.1	255.255.255.255	UDP	215	36861 → 7437 Len=173
14	9.169162	192.168.1.103	255.255.255.255	DB-LS…	268	Dropbox LAN sync Discovery Protocol, JavaScript Object Notation
15	9.169892	192.168.1.103	192.168.1.255	DB-LS…	268	Dropbox LAN sync Discovery Protocol, JavaScript Object Notation
16	10.558043	192.168.1.103	8.8.8.8	IPv4	1514	Fragmented IP protocol (proto=ICMP 1, off=0, ID=a13d) [Reassembled in #17]
17	10.558045	192.168.1.103	8.8.8.8	ICMP	562	Echo (ping) request id=0xd905, seq=0/0, ttl=64 (reply in 19)
18	10.610386	8.8.8.8	192.168.1.103	IPv4	1482	Fragmented IP protocol (proto=ICMP 1, off=0, ID=dfd0) [Reassembled in #19]
19	10.612610	8.8.8.8	192.168.1.103	ICMP	594	Echo (ping) reply id=0xd905, seq=0/0, ttl=122 (request in 17)
20	10.649226	fe80::ec49:66ff:fe…	ff02::1	ICMPv6	78	Router Advertisement from e8:de:27:4d:a1:40
21	11.563299	192.168.1.103	8.8.8.8	IPv4	1514	Fragmented IP protocol (proto=ICMP 1, off=0, ID=aaf2) [Reassembled in #22]
22	11.563302	192.168.1.103	8.8.8.8	ICMP	562	Echo (ping) request id=0xd905, seq=1/256, ttl=64 (reply in 24)
23	11.609673	8.8.8.8	192.168.1.103	IPv4	1482	Fragmented IP protocol (proto=ICMP 1, off=0, ID=e2e9) [Reassembled in #24]
24	11.609956	8.8.8.8	192.168.1.103	ICMP	594	Echo (ping) reply id=0xd905, seq=1/256, ttl=122 (request in 22)
25	12.082915	192.168.1.1	255.255.255.255	UDP	215	36861 → 7437 Len=173
26	12.568393	192.168.1.103	8.8.8.8	IPv4	1514	Fragmented IP protocol (proto=ICMP 1, off=0, ID=4a07) [Reassembled in #27]
27	12.568394	192.168.1.103	8.8.8.8	ICMP	562	Echo (ping) request id=0xd905, seq=2/512, ttl=64 (reply in 29)

Question 2

Yes, since the MTU for the last link is 1500 bytes, we cannot be sure who fragmented the original 3500 bytes reply.

Question 3

- Packet 39: ID=0x7a7b, length=1500, flag=0x01(MF bit on), offset=0

- Packet 40: ID=0x7a7b, length=1500, flag=0x01(MF bit on), offset=1480
- Packet 41: ID=0x7a7b, length=568, flag=0, offset=2960

Question 4

No fragmentation of fragments has occurred for the reply from 8.8.8.8 for data size of 3500. We cannot be sure the fragmentation from 192.168.1.103 to 8.8.8.8 since the reassembly is only done at the destination.

Question 5

The fragments would be incomplete, and the receiver would discard.

Exercise 3

Question 1

- Node 0 communicates with Node 5 follow route 0 - 1 - 4 - 5
- Node 2 communicates with Node 5 follow route 2 - 3 - 5

It does NOT change over time.

Question 2

- At time t=1.0, link 1-4 goes down, node 0 – node 5 not changed, node 0 cannot reach node 5
- At time t=1.2, link 1-4 goes up, node 0 can reach node 5, node 1 can reach node 4

Traffic between node 2 and node 5 does not affected.

Question 3

The DV routing protocol discovers a different route (0-1-2-3-5) when link 1-4 goes down. When 1-4 goes up, the routing protocol is 0-1-4-5.

Question 4

The cost of link 1-4 increase to 3, the cost of 0-1-4-5 is 4, and the cost of t0-1- 2-3-5 is 4. Therefore, the flow between node 0 and node 5 now uses route 0- 1-2-3-5, because it has the lowest cost.

Question 5

For node 0 and node 5, the total cost does not change. But from node 2 to node 5, there are two routes of equal total cost (2-3-5 and 2-1-4-5). Since the network is using multipath routing, node 2 will split traffic equally on both paths.