COMP436 HW2

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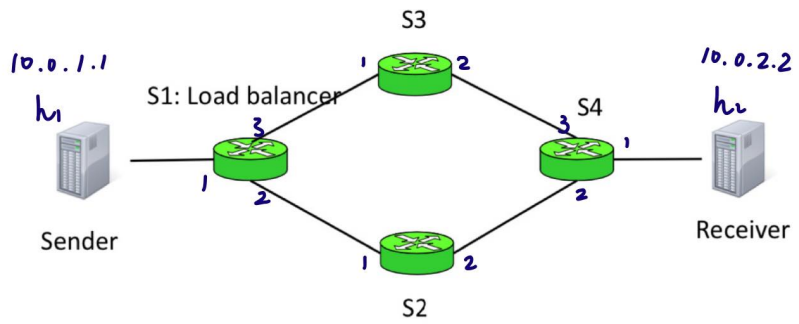
File descriptions and instructions to run the program can be found in README.

Milestone 1

Task 1



This is the topology graph for my network. We have 2 hosts and 4 switches. Sender host is h1 (10.0.1.1). Receiver host is h2 (10.0.2.2). Switches and their ports are shown in the graph as well.

Task 2

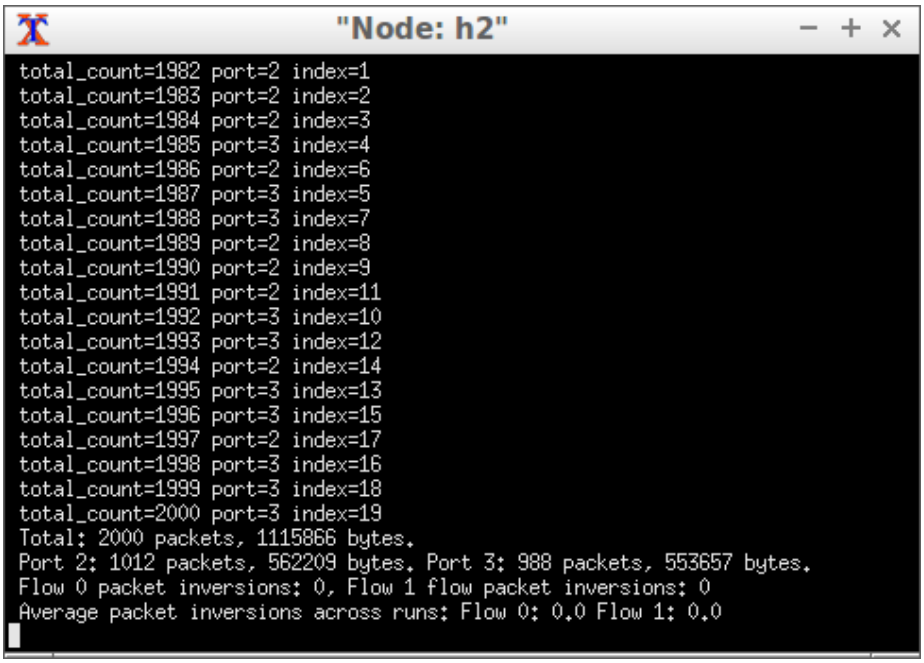
Applying ECMP load balancing results in the packets to be sent out through port 2 or 3 of Switch 1. A packet is tagged with a special IP destination 0.0.0.0 to notify the switch that it is on the first hop. Then, the switch set the destination to 10.0.2.2 and send it to the rest of the switches to do destination-based forwarding.

Task 3

I added a new 'query' protocol, which is send after all of the packets are processed and collects statistics from S1. The statistics are stored in registers in the switch.

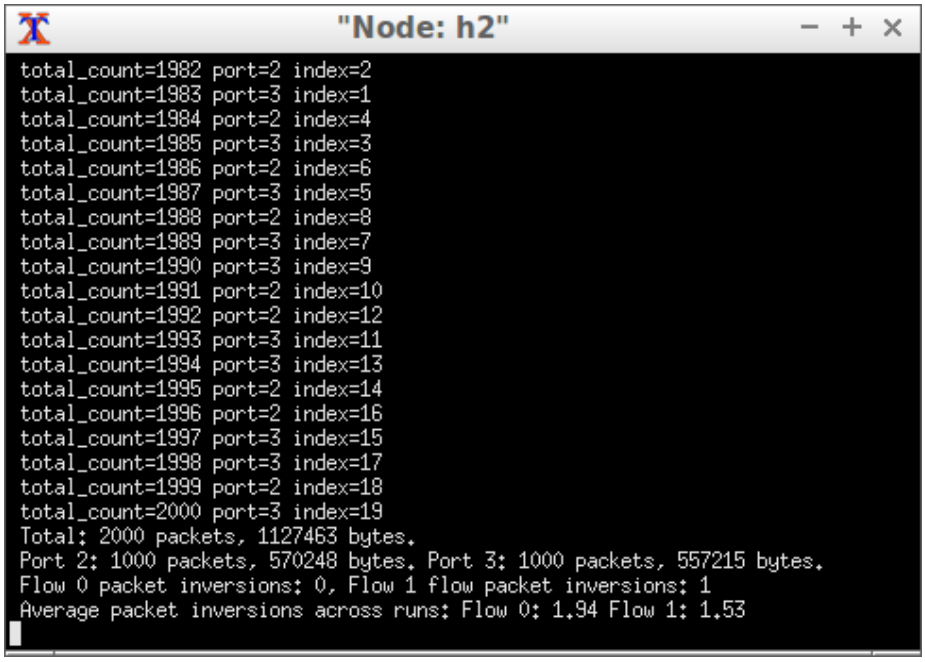
Milestone 2

Task 1



I generated random flows as defined by the five tuples, with different sizes (random sized string from length 1 to 1000 in load). I sent 100 flows with 20 packets for each flow, which adds up to 2000 packets in total. ECMP load balancing produces the result above. "Port 2" and "Port 3" are port 2 and 3 of Switch 1. We can see that the packets numbers are pretty balanced between the two ports, though the the packets being random sized means the traffic are not necessarily balanced as good.

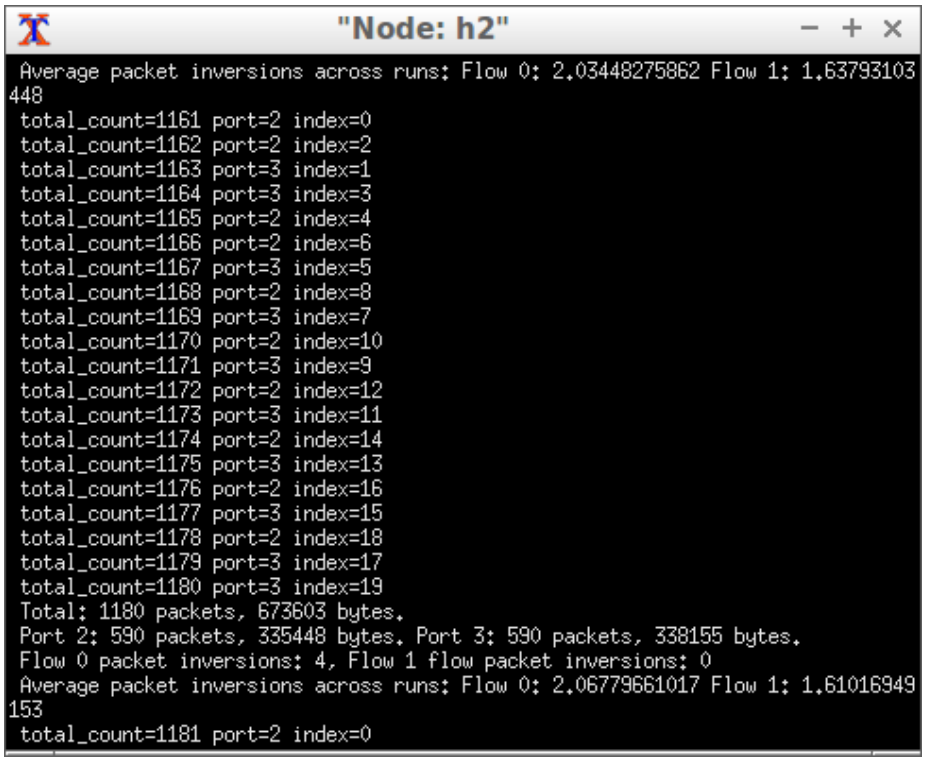
Task 2

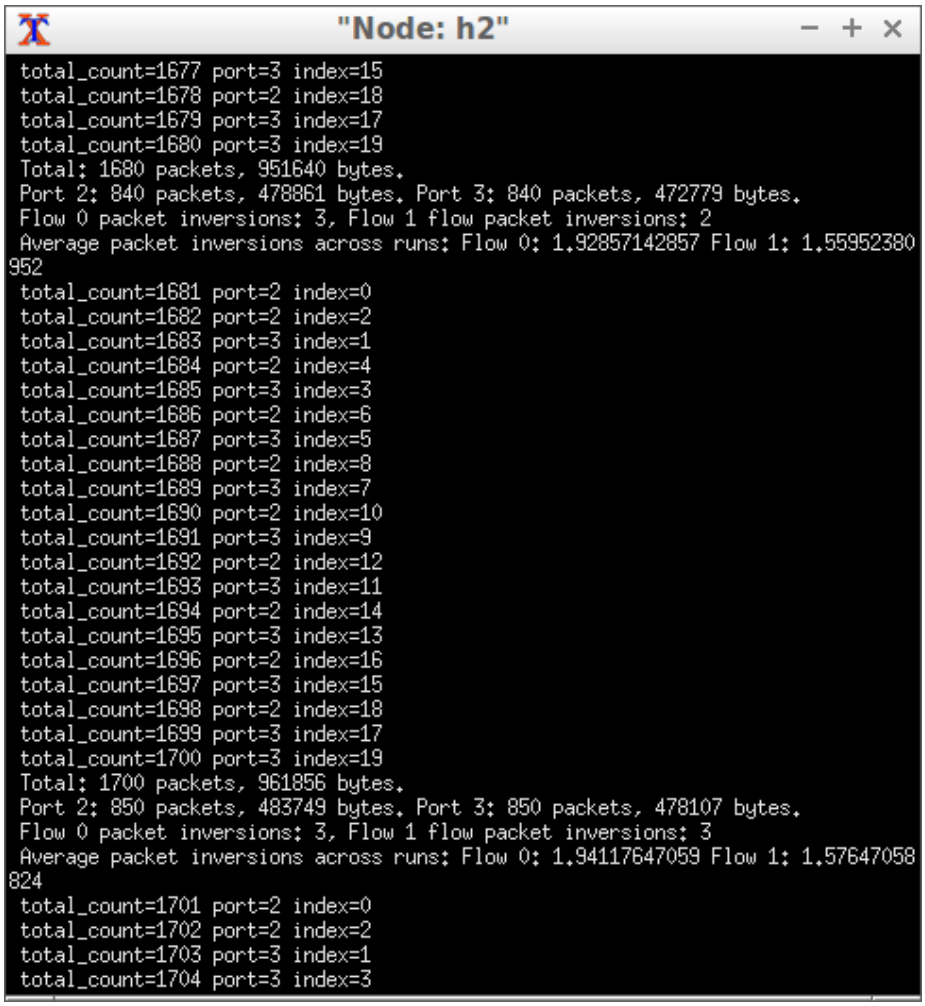


I sent 100 flows with 20 packets for each flow again, but with per-packet load balancing (according to packet numbers per port). It produces the result above. We can see that the packets are evenly distributed between the two ports.

Task 3

I used inversions to quantify the out-of-order packets. In a list of packets a, $a[i]$ and $a[j]$ form an inversion if $a[i] > a[j]$ and $i < j$. From the result image in Task 2, we can also see the average packet inversions per flow across runs. I also configured the link latencies to observe the inversions. Specifically, S1-S2 has a latency of 1ms, and S1-S3 has a latency of 50ms. Below are a couple of sneak peaks of the packet inversion counts from some runs.


"Node: h2"
Average packet inversions across runs: Flow 0: 2.03448275862 Flow 1: 1.63793103448
total_count=1161 port=2 index=0
total_count=1162 port=2 index=2
total_count=1163 port=3 index=1
total_count=1164 port=3 index=3
total_count=1165 port=2 index=4
total_count=1166 port=2 index=6
total_count=1167 port=3 index=5
total_count=1168 port=2 index=8
total_count=1169 port=3 index=7
total_count=1170 port=2 index=10
total_count=1171 port=3 index=9
total_count=1172 port=2 index=12
total_count=1173 port=3 index=11
total_count=1174 port=2 index=14
total_count=1175 port=3 index=13
total_count=1176 port=2 index=16
total_count=1177 port=3 index=15
total_count=1178 port=2 index=18
total_count=1179 port=3 index=17
total_count=1180 port=3 index=19
Total: 1180 packets, 673603 bytes.
Port 2: 590 packets, 335448 bytes. Port 3: 590 packets, 338155 bytes.
Flow 0 packet inversions: 4, Flow 1 flow packet inversions: 0
Average packet inversions across runs: Flow 0: 2.06779661017 Flow 1: 1.61016949153
total_count=1181 port=2 index=0


"Node: h2"
total_count=1677 port=3 index=15
total_count=1678 port=2 index=18
total_count=1679 port=3 index=17
total_count=1680 port=3 index=19
Total: 1680 packets, 951640 bytes.
Port 2: 840 packets, 478861 bytes. Port 3: 840 packets, 472779 bytes.
Flow 0 packet inversions: 3, Flow 1 flow packet inversions: 2
Average packet inversions across runs: Flow 0: 1.92857142857 Flow 1: 1.55952380
952
total_count=1681 port=2 index=0
total_count=1682 port=2 index=2
total_count=1683 port=3 index=1
total_count=1684 port=2 index=4
total_count=1685 port=3 index=3
total_count=1686 port=2 index=6
total_count=1687 port=3 index=5
total_count=1688 port=2 index=8
total_count=1689 port=3 index=7
total_count=1690 port=2 index=10
total_count=1691 port=3 index=9
total_count=1692 port=2 index=12
total_count=1693 port=3 index=11
total_count=1694 port=2 index=14
total_count=1695 port=3 index=13
total_count=1696 port=2 index=16
total_count=1697 port=3 index=15
total_count=1698 port=2 index=18
total_count=1699 port=3 index=17
total_count=1700 port=3 index=19
Total: 1700 packets, 961856 bytes.
Port 2: 850 packets, 483749 bytes. Port 3: 850 packets, 478107 bytes.
Flow 0 packet inversions: 3, Flow 1 flow packet inversions: 3
Average packet inversions across runs: Flow 0: 1.94117647059 Flow 1: 1.57647058
824
total_count=1701 port=2 index=0
total_count=1702 port=2 index=2
total_count=1703 port=3 index=1
total_count=1704 port=3 index=3