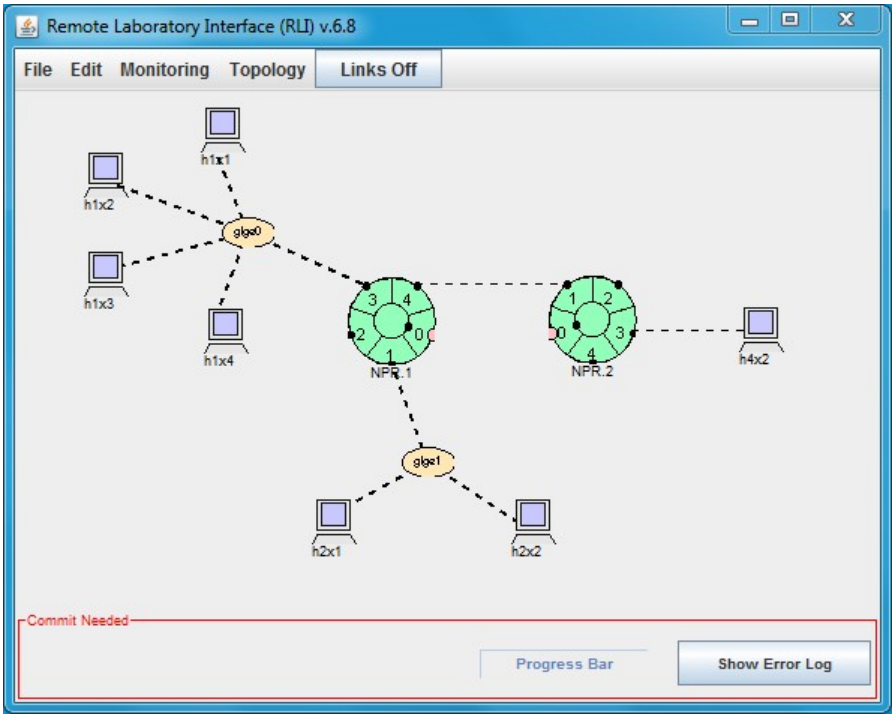
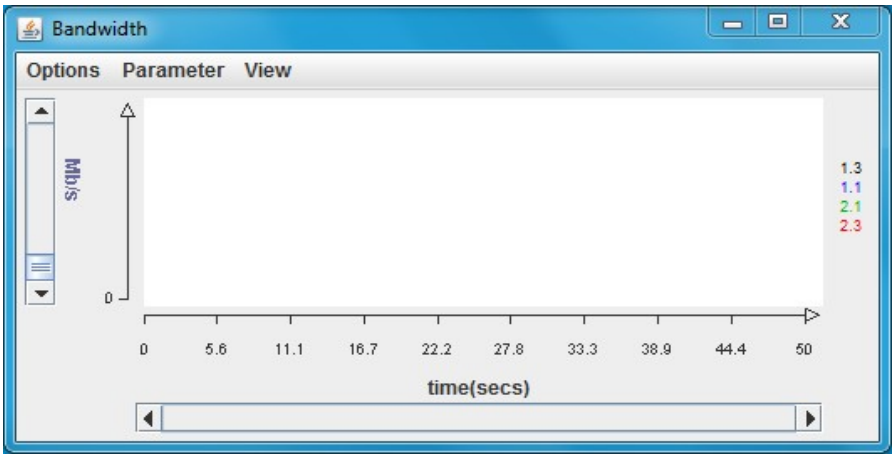
ECE 671 – Computer Networks
Fall 2011 – Lab 1-Solution

Topology





Part 1: Set IP Address in the Routing Table

Table1. Routing table of NPR1 and NPR2

NPR1					
Port 1		Port 3		Port 4	
Prefix/ mask	Next port	Prefix/ mask	Next port	Prefix/ mask	Next port
192.168.1.0/24	3:0.0.0.0	192.168.1.0/24	3:0.0.0.0	192.168.1.0/24	3:0.0.0.0
192.168.2.0/24	1:0.0.0.0	192.168.2.0/24	1:0.0.0.0	192.168.2.0/24	1:0.0.0.0
192.168.4.0/24	4:192.168.3.2	192.168.4.0/24	4:192.168.3.2	192.168.4.0/24	4:192.168.3.2

NPR2			
Port 1		Port 3	
Prefix/ mask	Next port	Prefix/ mask	Next port
192.168.1.0/24	1:192.168.3.1	192.168.1.0/24	1:192.168.3.1
192.168.2.0/24	1:192.168.3.1	192.168.2.0/24	1:192.168.3.1
192.168.4.0/24	3:0.0.0.0	192.168.4.0/24	3:0.0.0.0

Table 2 Routing table of Hosts

Hosts	Prefix/Mask	Next hop
h1x1, h1x2 h1x3, h1x4	192.168.1.0/24	0:0.0.0.0
	192.168.2.0/24	0:192.168.1.5
	192.168.4.0/24	0:192.168.1.5
h2x1, h2x2	192.168.2.0/24	0:0.0.0.0
	192.168.1.0/24	0:192.168.2.3
	192.168.4.0/24	0:192.168.2.3
h4x2	192.168.4.0/24	0:192.168.4.1
	192.168.2.0/24	0:192.168.4.1
	192.168.1.0/24	0:192.168.4.1

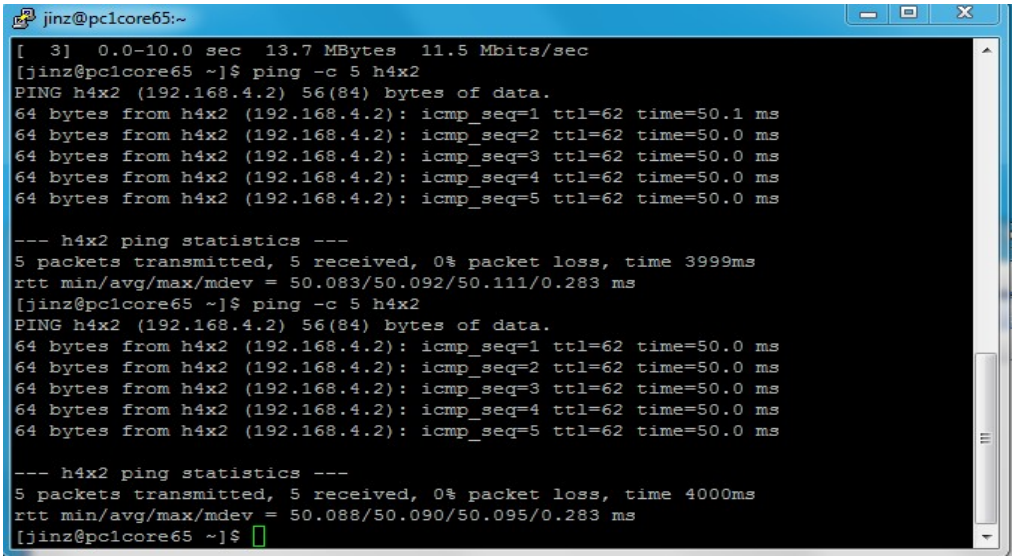
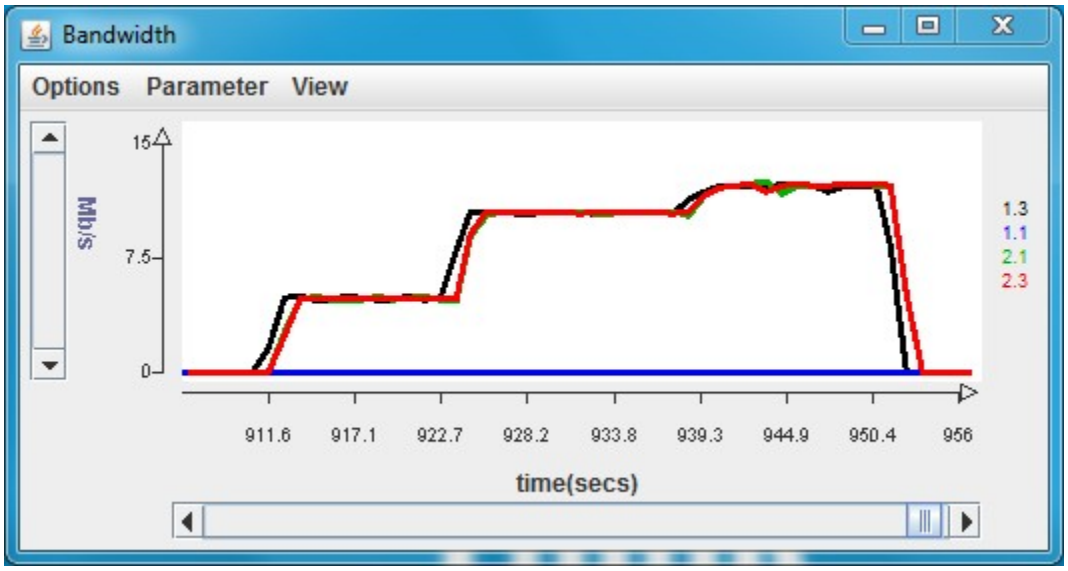


Figure 1 check the connection establishment by ping command

Part 2: TCP Congestion Control

Delay: 50ms



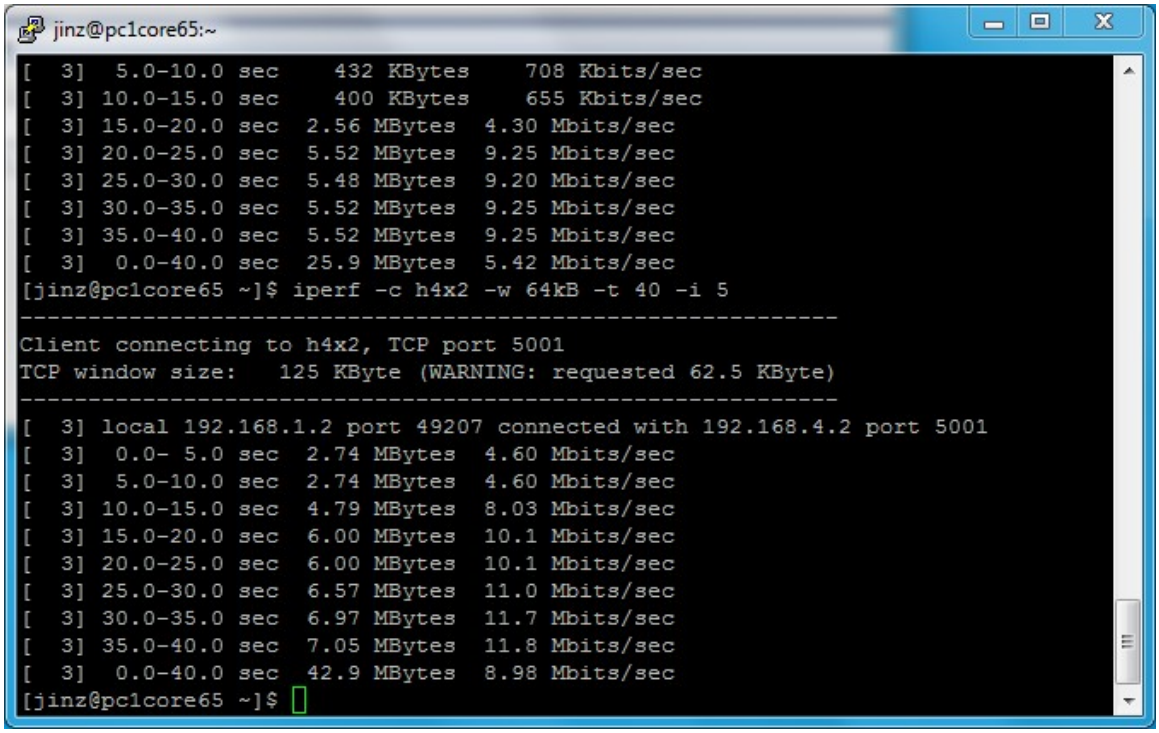
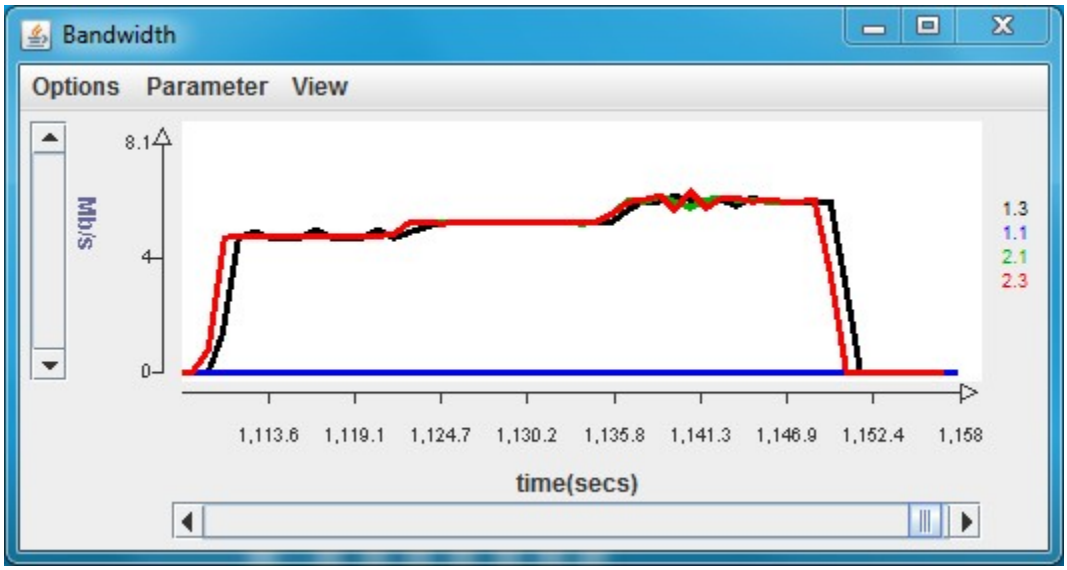


Figure 2 change of bandwidth when link rate is 5Mbps, 20Mbps, 1Mbps, delay=50ms

Delay 100ms:



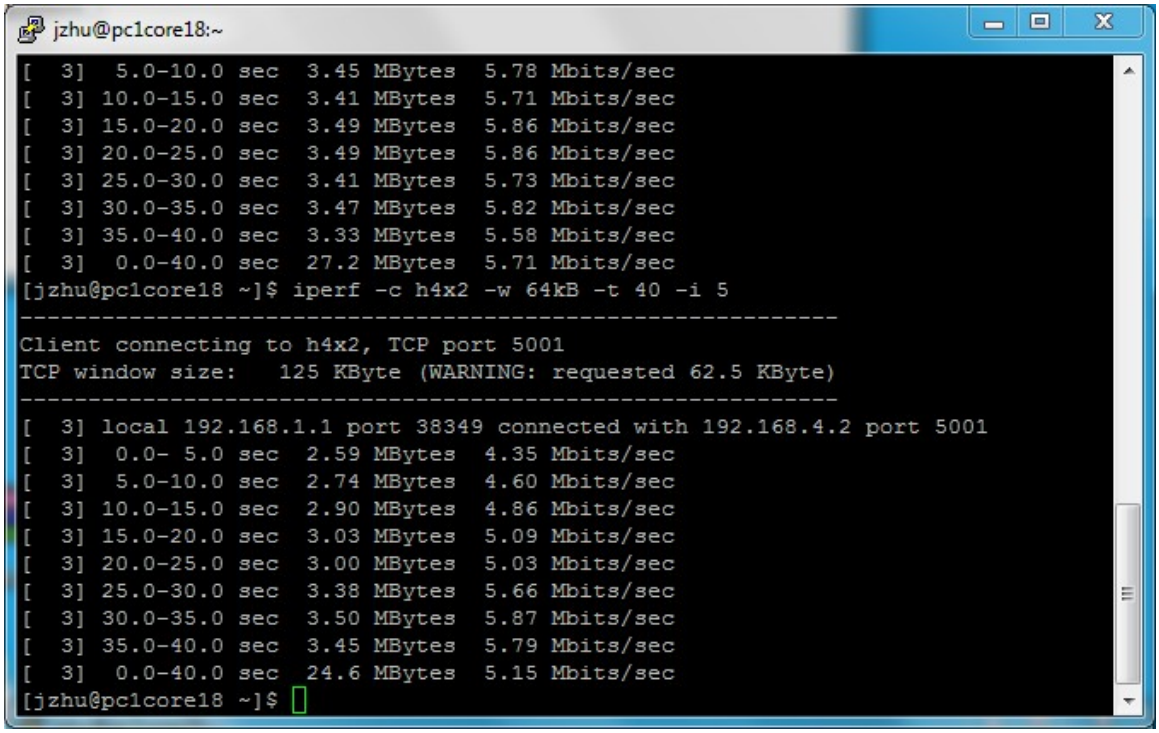


Figure 3 change of bandwidth when link rate is 5Mbps, 20Mbps, 1Mbps, delay=100ms

Table 3 result of throughput in different link rate

Link Rate			5Mbps	20Mbps	1Gbps
Throughput	Delay 50ms	Theoretical result	5Mbps	10.24Mbps	10.24Mbps
		Experiment result	4.61Mbps	10.10Mbps	11.70Mbps
	Delay100ms	Theoretical result	5Mbps	5.12Mbps	5.12Mbps
		Experiment result	4.61Mbps	5.03Mbps	5.77Mbps

The key point of explanation

- When link rate is 5Mbps, the time need to send 64KB data is

$$t = \frac{64KB}{5Mbps} = \frac{64 * 1000 * 8bits}{5Mbps} = 102.4ms$$

which is larger than the RTT (50ms or 100ms)
So when the link rate is 5Mbps, the throughput is the same as the link rate

- When link rate is 20Mbps or 1Gbps, the time need to send 64KB data is

$$t = \frac{64KB}{20Mbps} = \frac{64 * 1000 * 8bits}{20Mbps} = 25.6ms$$

$$t = \frac{64KB}{1Gbps} = \frac{64 * 1000 * 8bits}{1Gbps} = 0.512ms$$

which is much smaller than the RTT (50ms or 100ms)
So when the link rate is 20Mbps or 1Gbps, the throughput is

$$throughput = \frac{window\ size\ 64kB}{RTT}$$

the results are showed in the table

- The server(reveiver) received packets at a rate (4.61Mbps) lower than the capacity of the bottleneck (5Mbps), because there is additional bytes of IP header (20-byte) and TCP header (20-byte to 60-byte) that accounts for an additional 7% in the packet length. This difference means that 7% of the 5Mbps bottleneck capacity is consumed by packet headers and therefore, the receiver will see only about 4.61Mbps at the application level.