Lab 1 Report

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Equations and Variables
L = packet size
R = bandwidth
Dtrans = L/R
Delay = Dtrans + Dprop + Dq
Dtrans = L bits / Rate of transfer
Dprop is given
Dq = Dtrans * number of packets that were queued before this one
Note: if there the first packet in queue arrived before the packet in question then we subtract Dtrans * (1 - difference in arrival time).

1 Two Node Networks

#
n1 — n2
#
n1 n2
n2 n1

Scenario One
L = 8,000 bits
R = 1 Mbps

Simulation Output

Dprop	Dtrans	Dq	Delay
1 s	.008 s	0 s	1.008 s

Calculated Delays

Dtrans = 8,000 bits/1,000,000 bps = .008 s
Dprop = 1 s
Dq = 0 s (only packet in queue)
Delay = .008 s + 1 s + 0 s = 1.008 s

Scenario Two
L = 8,000 bits
R = 100 bps

Simulation Output

Dprop	Dtrans	Dq	Delay
.01 s	80 s	0 s	80.01 s

Calculated Delays

Dtrans = 8,000 bits/100 bps
Dprop = 10 ms
Dq = 0 s (only packet in queue)
Delay = 80 s + 10 ms + 0 s = 80.01 s

<u>Scenario Three</u>
L = 8,000 bits
R = 1 Mbps

Simulation Output

Packet	Dprop	Dtrans	Dq	Delay
1	.01 s	.008 s	0 s	.018 s
2	.01 s	.008 s	.008 s	.026 s
3	.01 s	.008 s	.016 s	.034 s
4	.01 s	.008 s	0 s	.018 s

Calculated Delays

Dtrans = 8,000 bits/1,000,000 bps
Dprop = 3 * 10 ms
Dq1 = 0 s
Dq2 = .008 s
Dq3 = .016 s
Dq4 = 0 s (queue is empty after two seconds–the three previous packets transmit in less than a second–leaving this packet alone)
Delay1 = .008 s + .01 s + 0 s = .018 s
Delay2 = .008 s + .01 s + .008 s = .026 s
Delay3 = .008 s + .01 s + .016 s = .034 s
Delay4 = .008 s + .01 s + 0 s = .018 s

2 Three Node Network

```
#
# n1 — n2 — n3
#
n1 n2
n2 n1 n3
n3 n2
```

Scenario One
L = 1,000 bits
R1 = 1 Mbps
R2 = 1 Mbps

Simulation Output

Packet	Dprop	Dtrans	Dq	Delay
95	.2 s	.016 s	6.2E-15 s	.216 s
96	.2 s	.016 s	6.2E-15 s	.216 s
97	.2 s	.016 s	6.2E-15 s	.216 s
98	.2 s	.016 s	6.2E-15 s	.216 s
99	.2 s	.016 s	6.2E-15 s	.216 s

Calculated Delays

Dtrans = 8,000 bits/1,000,000 bps * 2 links * 1,000 packets = 16 s
Dprop = .1 s * 2 links * 1,000 packets = 200 s
Dq = 0
Delay = 216 s

Scenario Two
L = 1,000 bits
R1 = 1 Gbps
R2 = 1 Gbps

Simulation Output

Packet	Dprop	Dtrans	Dq	Delay
95	.2 s	0.000128 s	0.05572 s	0.255848 s
96	.2 s	0.000128 s	0.055776 s	0.255904 s
97	.2 s	0.000128 s	0.055832 s	0.25596 s
98	.2 s	0.000128 s	0.055888 s	0.256016 s
99	.2 s	0.000128 s	0.055944 s	0.256072 s

Calculated/Experimental Delays

Dtrans = 8,000 bits/1,000,000,000 bps * 2 links * 1,000 packets = .000128 s
Dprop = .1 s * 2 links * 1,000 packets = 200 s
Dq = 27.972 s
Delay = 228.1 s

Scenario Three
L = 1,000 bits
R1 = 1 Mbps
R2 = 256 Kbps

Simulation Output

Packet	Dprop	Dtrans	Dq	Delay
95	.2 s	.314 s	240.79 s	249.264 s
96	.2 s	.314 s	241.032 s	249.514 s
97	.2 s	.314 s	241.274 s	249.764 s
98	.2 s	.314 s	241.516 s	250.014 s
99	.2 s	.314 s	241.758 s	250.264 s

Calculated Delays

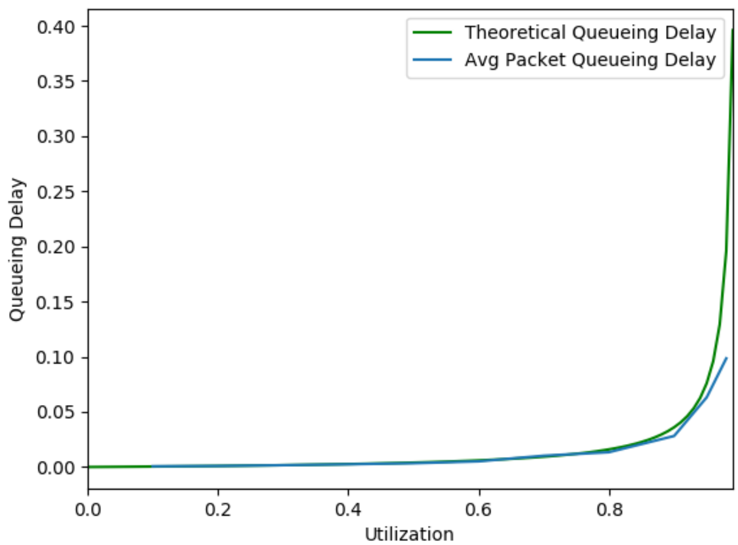
Dtrans = 8,000 bits/1,000,000 bps * 1,000 packets + 8,000 bits/ 256,000 bps * 1,000 packets = 39.25 s
Dprop = .1 s * 2 links * 1,000 packets = 200 s
Dq = 120879 s
Delay = 121393 s

3 Queueing Theory

#
n1 — n2
#
n1 n2
n2 n1

link configuration
n1 n2 1Mbps 1000ms
n2 n1 1Mbps 1000ms

For this final part of the lab we tested the simple network described above with 11 different loads: 10, 20, 30, 40, 50, 60, 70, 80, 90, 95, 98 percent. When we graphed our data, it was slightly less than the theoretical values, but was otherwise faithful to the near constant rate below 80 percent, the inflection point a little above 80 percent, the subsequent exponential increase, and the vertical asymptote. Given this close relationship to the theoretical curve, we are confident that our network was setup correctly and our tests were well-designed and effective.


Theoretical Queueing Delay
Avg Packet Queueing Delay
Queueing Delay
Utilization
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.0
0.2
0.4
0.6
0.8