

HW-3 part-3 Report

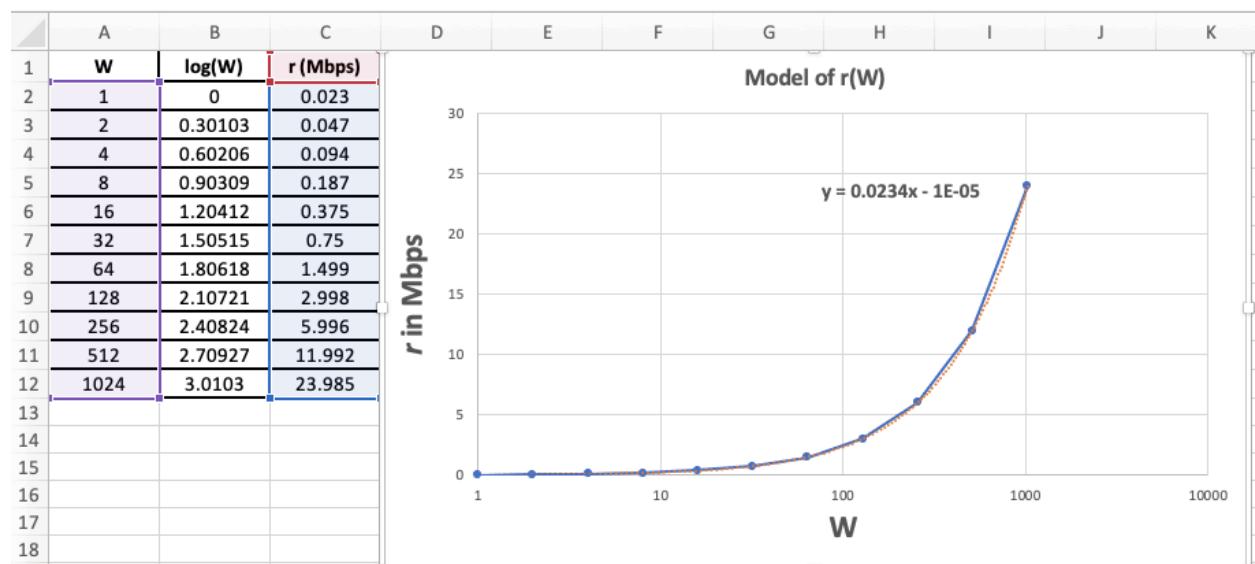
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Q1. Examine how your goodput scales with window size W.

I obtained the data on ts machine with the receiver as s3.irl.cs.tamu.edu.

Configuration: loss p=0 both sides, link speed=1 Gbps, RTT=0.5s.

The curve obtained using Excel is shown below [blue is the scatter plot and orange is the trendline].



Discussion: We see that we obtain a linear model for $r(W)$. This **matches** the theory discussed in

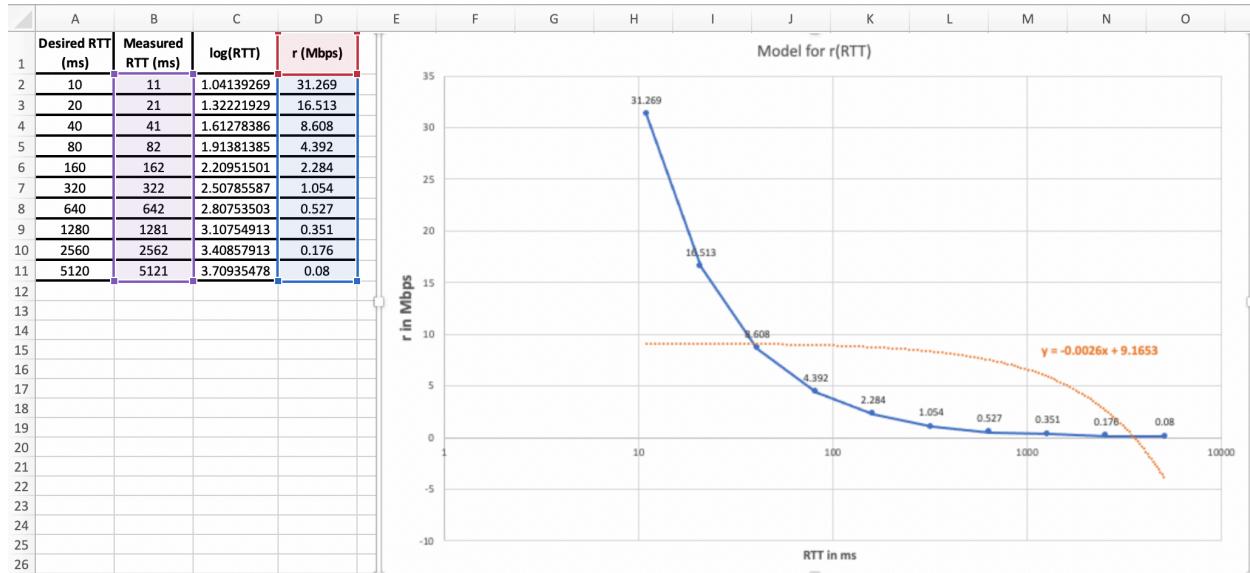
$$U_{\text{sender}} = \frac{3 * L / R}{RTT + L / R}$$

class. Specifically, in slide 4 of lecture 3/11/202, we see that

Assuming $RTT \gg L/R$, we can ignore it in the denominator.

Then, we see that in RTT time we send $W*L$ bytes. So the rate is $(W*L)/RTT$. Therefore, the relationship is indeed linear with respect to W as observed empirically through the experiment reported above.

Q2. Plot stable rate $r(RTT)$, again placing the x-axis on a logscale.



Discussion: This again matches theory discussed in class.

$$U_{\text{sender}} = \frac{3 * L / R}{RTT + L / R}$$

As the utilization is given by $U_{\text{sender}} = \frac{3 * L / R}{RTT + L / R}$, and again assuming $RTT \gg L/R$, we can see that the rate $= (W*L)/RTT$. So the rate is inversely proportional to the RTT which means that as the RTT goes up the rate will decay. We observe this from the plot above.

Q3. Run the dummy receiver on your localhost and produce a trace using W = 8K

I ran the code on ts machine which has the following CPU configuration:
X64, Six-Core AMD Processor 2200 Mhz, 16 GB RAM

I was able to obtain nearly **450 Mbps** with the dummy receiver.

Trace:

```
Microsoft Visual Studio Debug Console
Main:    sender W = 8000, RTT 0.100 sec, loss 0 / 0, link 1000 Mbps
Main:    initializing DWORD array with 2^30 elements...done in 3370 ms
Main:    connected to 127.0.0.1 in 3.381 sec, pkt size 1472 bytes
[ 1] B 73524 ( 108.3 MB) N 73525 T 0 F 0 W 8000 S 430.563 Mbps RTT 0.210
[ 4] B 144161 ( 211.8 MB) N 144163 T 0 F 0 W 8000 S 413.630 Mbps RTT 0.225
[ 6] B 219180 ( 321.7 MB) N 219182 T 0 F 0 W 8000 S 439.286 Mbps RTT 0.209
[ 8] B 294887 ( 432.6 MB) N 294888 T 0 F 0 W 8000 S 443.316 Mbps RTT 0.215
[10] B 369391 ( 541.8 MB) N 369394 T 0 F 0 W 8000 S 436.268 Mbps RTT 0.213
[12] B 443624 ( 650.5 MB) N 443627 T 0 F 0 W 8000 S 434.688 Mbps RTT 0.217
[14] B 518914 ( 760.8 MB) N 518916 T 0 F 0 W 8000 S 440.871 Mbps RTT 0.209
[16] B 594606 ( 871.7 MB) N 594607 T 0 F 0 W 8000 S 443.232 Mbps RTT 0.208
[18] B 670416 ( 982.7 MB) N 670418 T 0 F 0 W 8000 S 443.915 Mbps RTT 0.219
[20] B 746856 ( 1094.7 MB) N 746859 T 0 F 0 W 8000 S 447.612 Mbps RTT 0.209
[22] B 822553 ( 1205.6 MB) N 822555 T 0 F 0 W 8000 S 443.259 Mbps RTT 0.218
[24] B 899119 ( 1317.7 MB) N 899120 T 0 F 0 W 8000 S 448.345 Mbps RTT 0.209
[26] B 974216 ( 1427.7 MB) N 974217 T 0 F 0 W 8000 S 439.744 Mbps RTT 0.213
[28] B 1047534 ( 1535.1 MB) N 1047537 T 0 F 0 W 8000 S 429.328 Mbps RTT 0.217
[30] B 1123301 ( 1646.1 MB) N 1123302 T 0 F 0 W 8000 S 443.666 Mbps RTT 0.211
[32] B 1198783 ( 1756.7 MB) N 1198784 T 0 F 0 W 8000 S 441.999 Mbps RTT 0.209
[34] B 1273741 ( 1866.5 MB) N 1273742 T 0 F 0 W 8000 S 438.929 Mbps RTT 0.218
[36] B 1349201 ( 1977.0 MB) N 1349204 T 0 F 0 W 8000 S 441.872 Mbps RTT 0.211
[38] B 1425254 ( 2088.4 MB) N 1425256 T 0 F 0 W 8000 S 445.340 Mbps RTT 0.211
[40] B 1501321 ( 2199.9 MB) N 1501323 T 0 F 0 W 8000 S 445.422 Mbps RTT 0.210
[42] B 1576687 ( 2310.3 MB) N 1576688 T 0 F 0 W 8000 S 441.322 Mbps RTT 0.223
[44] B 1649329 ( 2416.7 MB) N 1649331 T 0 F 0 W 8000 S 425.364 Mbps RTT 0.221
[46] B 1724606 ( 2526.9 MB) N 1724609 T 0 F 0 W 8000 S 440.789 Mbps RTT 0.206
[48] B 1801266 ( 2639.2 MB) N 1801270 T 0 F 0 W 8000 S 448.907 Mbps RTT 0.210
[50] B 1877181 ( 2750.4 MB) N 1877183 T 0 F 0 W 8000 S 444.534 Mbps RTT 0.210
[52] B 1953085 ( 2861.6 MB) N 1953087 T 0 F 0 W 8000 S 444.471 Mbps RTT 0.225
[54] B 2027795 ( 2971.1 MB) N 2027797 T 0 F 0 W 8000 S 437.477 Mbps RTT 0.208
[56] B 2104736 ( 3083.8 MB) N 2104736 T 0 F 0 W 8000 S 450.541 Mbps RTT 0.207
[58] B 2181705 ( 3196.5 MB) N 2181706 T 0 F 0 W 8000 S 450.706 Mbps RTT 0.208
[60] B 2256276 ( 3305.8 MB) N 2256278 T 0 F 0 W 8000 S 436.664 Mbps RTT 0.208
[62] B 2331284 ( 3415.6 MB) N 2331286 T 0 F 0 W 8000 S 439.224 Mbps RTT 0.209
[64] B 2403897 ( 3522.0 MB) N 2403900 T 0 F 0 W 8000 S 425.194 Mbps RTT 0.223
[66] B 2480562 ( 3634.3 MB) N 2480563 T 0 F 0 W 8000 S 448.930 Mbps RTT 0.219
[68] B 2554946 ( 3743.3 MB) N 2554947 T 0 F 0 W 8000 S 435.570 Mbps RTT 0.225
[70] B 2629121 ( 3851.9 MB) N 2629123 T 0 F 0 W 8000 S 434.345 Mbps RTT 0.217
[72] B 2705234 ( 3963.4 MB) N 2705235 T 0 F 0 W 8000 S 445.693 Mbps RTT 0.208
[74] B 2780674 ( 4073.9 MB) N 2780677 T 0 F 0 W 8000 S 441.753 Mbps RTT 0.210
[76] B 2857681 ( 4186.6 MB) N 2857602 T 0 F 0 W 8000 S 450.459 Mbps RTT 0.208
[78] B 2932572 ( 4296.4 MB) N 2932573 T 0 F 0 W 8000 S 439.007 Mbps RTT 0.215
[78.82] <-- FIN-ACK 2933721 0
Main:    transfer finished in 77.810 sec, 441583.66 Kbps, checksum 39F2A0E6
Main:    estRTT 0.213, ideal rate 440054.91 Kbps

C:\Users\raj_vardhan\Documents\github\csce612\hw3\x64\Release\hw3.exe (process 10936) exited with code 0.
Press any key to close this window . . .
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With packet size of 9000 bytes, the trace is as follows.
Here, I was able to obtain nearly 1.7 Gbps.

Trace:

```
 [Select Microsoft Visual Studio Debug Console]
Main:    sender W = 8000, RTT 0.100 sec, loss 0 / 0, link 1000 Mbps
Main:    initializing DWORD array with 2^30 elements...done in 3324 ms
Main:    connected to 127.0.0.1 in 3.345 sec, pkt size 8972 bytes
[ 2] B 49343 ( 442.7 MB) N 49344 T 0 F 0 W 8000 S 1769.223 Mbps RTT 0.318
[ 4] B 96602 ( 866.7 MB) N 96603 T 0 F 0 W 8000 S 1694.432 Mbps RTT 0.349
[ 6] B 146078 ( 1308.7 MB) N 146079 T 0 F 0 W 8000 S 1773.913 Mbps RTT 0.319
[ 8] B 194864 ( 1743.4 MB) N 194865 T 0 F 0 W 8000 S 1749.184 Mbps RTT 0.335
[10] B 242343 ( 2168.1 MB) N 242344 T 0 F 0 W 8000 S 1702.310 Mbps RTT 0.325
[12] B 289925 ( 2598.0 MB) N 289926 T 0 F 0 W 8000 S 1705.976 Mbps RTT 0.336
[14] B 339522 ( 3046.0 MB) N 339523 T 0 F 0 W 8000 S 1778.274 Mbps RTT 0.320
[16] B 389280 ( 3495.5 MB) N 389281 T 0 F 0 W 8000 S 1784.031 Mbps RTT 0.326
[18] B 437814 ( 3933.9 MB) N 437816 T 0 F 0 W 8000 S 1740.128 Mbps RTT 0.338
[20] B 479136 ( 4301.4 MB) N 479136 T 0 F 0 W 8000 S 1481.559 Mbps RTT 0.298
[20.36] <-- FIN-ACK 479136 0
Main:    transfer finished in 19.340 sec, 1776576.50 Kbps, checksum 39F2A0E6
Main:    estRTT 0.298, ideal rate 1924846.25 Kbps

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Press any key to close this window . . .
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Q4.

Buffer size 2^{23} DWORDs, RTT = 200ms, W = 300 packets, link capacity S = 10 Mbps, and loss only in the reverse direction equal to p = 0.1.

Case: loss only in the reverse direction (p=0.1)

```
Microsoft Visual Studio Debug Console

Main: sender W = 300, RTT 0.200 sec, loss 0 / 0.1, link 10 Mbps
Main: initializing DWORD array with 2^23 elements...done in 27 ms
Main: connected to s3.irl.cs.tamu.edu in 0.238 sec, pkt size 1472 bytes
[ 1] B    127 ( 0.2 MB) N    254 T    0 F    0 W    127 S 0.744 Mbps RTT 0.234
[ 3] B   1755 ( 2.3 MB) N   2055 T    0 F    0 W    300 S 9.533 Mbps RTT 0.353
[ 5] B   3453 ( 4.6 MB) N   3753 T    0 F    0 W    300 S 9.943 Mbps RTT 0.353
[ 8] B   5151 ( 6.8 MB) N   5451 T    0 F    0 W    300 S 9.943 Mbps RTT 0.353
[10] B   6849 ( 9.1 MB) N   7149 T    0 F    0 W    300 S 9.943 Mbps RTT 0.353
[12] B   8548 ( 11.3 MB) N  8848 T    0 F    0 W    300 S 9.949 Mbps RTT 0.353
[14] B  10246 ( 13.6 MB) N 10546 T    0 F    0 W    300 S 9.943 Mbps RTT 0.353
[16] B  11944 ( 15.8 MB) N 12244 T    0 F    0 W    300 S 9.943 Mbps RTT 0.353
[18] B  13643 ( 18.1 MB) N 13943 T    0 F    0 W    300 S 9.949 Mbps RTT 0.353
[20] B  15343 ( 20.3 MB) N 15643 T    0 F    0 W    300 S 9.955 Mbps RTT 0.352
[22] B  17042 ( 22.6 MB) N 17342 T    0 F    0 W    300 S 9.949 Mbps RTT 0.353
[24] B  18741 ( 24.8 MB) N 19041 T    0 F    0 W    300 S 9.949 Mbps RTT 0.353
[26] B  20442 ( 27.1 MB) N 20742 T    0 F    0 W    300 S 9.961 Mbps RTT 0.353
[28] B  22141 ( 29.3 MB) N 22441 T    0 F    0 W    300 S 9.949 Mbps RTT 0.353
[29.77] <-- FIN-ACK 22920 D70096AB
Main: transfer finished in 28.353 sec, 9467.76 Kbps, checksum D70096AB
Main: estRTT 0.353, ideal rate 9944.54 Kbps

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Case: no loss in either direction

```
Microsoft Visual Studio Debug Console

Main: sender W = 300, RTT 0.200 sec, loss 0 / 0, link 10 Mbps
Main: initializing DWORD array with 2^23 elements...done in 25 ms
Main: connected to s3.irl.cs.tamu.edu in 0.262 sec, pkt size 1472 bytes
[ 2] B    128 ( 0.2 MB) N    256 T    0 F    0 W    128 S 0.741 Mbps RTT 0.236
[ 4] B   1755 ( 2.6 MB) N   2055 T    0 F    0 W    300 S 9.527 Mbps RTT 0.353
[ 6] B   3453 ( 5.1 MB) N   3753 T    0 F    0 W    300 S 9.943 Mbps RTT 0.353
[ 8] B   5151 ( 7.6 MB) N   5451 T    0 F    0 W    300 S 9.943 Mbps RTT 0.353
[10] B   6849 ( 10.1 MB) N  7149 T    0 F    0 W    300 S 9.943 Mbps RTT 0.353
[12] B   8547 ( 12.6 MB) N  8847 T    0 F    0 W    300 S 9.943 Mbps RTT 0.353
[14] B  10246 ( 15.1 MB) N 10546 T    0 F    0 W    300 S 9.949 Mbps RTT 0.353
[16] B  11944 ( 17.6 MB) N 12244 T    0 F    0 W    300 S 9.943 Mbps RTT 0.353
[18] B  13643 ( 20.1 MB) N 13943 T    0 F    0 W    300 S 9.949 Mbps RTT 0.353
[20] B  15343 ( 22.6 MB) N 15643 T    0 F    0 W    300 S 9.955 Mbps RTT 0.353
[22] B  17043 ( 25.1 MB) N 17343 T    0 F    0 W    300 S 9.955 Mbps RTT 0.353
[24] B  18742 ( 27.6 MB) N 19042 T    0 F    0 W    300 S 9.949 Mbps RTT 0.353
[26] B  20442 ( 30.1 MB) N 20742 T    0 F    0 W    300 S 9.955 Mbps RTT 0.353
[28] B  22141 ( 32.6 MB) N 22441 T    0 F    0 W    300 S 9.949 Mbps RTT 0.353
[29.79] <-- FIN-ACK 22920 D70096AB
Main: transfer finished in 28.351 sec, 9468.12 Kbps, checksum D70096AB
Main: estRTT 0.353, ideal rate 9944.10 Kbps

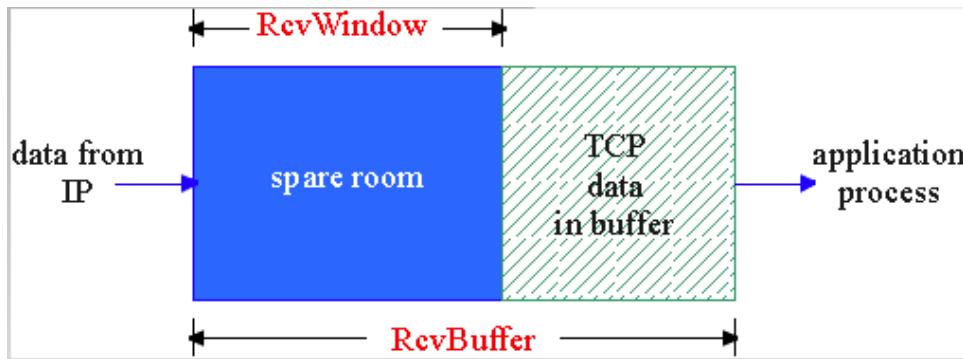
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Press any key to close this window . . .
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Discussion: Yes, the protocol keeps the same rate (around 9.9 Mbps) in both cases. The reason could be that the protocol (TCP) uses cumulative ACKs. With reverse loss of 0.1, 1 in 10 packets or 3 in 300 (window size) get lost. Say, if ACK p-1, p, p+1 are sent by receiver and only ACK p is lost. Then, on receiving ACK p+1 the sender knows that everything up to packet p has been

received by the receiver. Therefore the sender and receiver can continue to make progress and the rate is nearly maintained.

Q5. Determine the algorithm that the receiver uses to change its advertised window. What name does this technique have in TCP?

The receiver uses TCP Flow Control to change its advertised window (RcvWin).
From lecture 3/16/21:



$$\text{RcvWin} = \text{RcvBuffer} - [\text{LastByteReceivedInOrder} - \text{LastByteDelivered}]$$

The receiver window cannot grow till infinite because its upper bound is RcvBuffer i.e. the receiver's buffer as shown in the figure above.

Extra Credit

Between ts and s3.irl.cs.tamu.edu, I am able to obtain nearly 659 Mbps.

```
Microsoft Visual Studio Debug Console
Main:    sender W = 3000, RTT 0.010 sec, loss 0 / 0, link 10000 Mbps
Main:    initializing DWORD array with 2^30 elements...done in 3605 ms
Main:    connected to s3.irl.cs.tamu.edu in 3.630 sec, pkt size 1472 bytes
[ 2] B 95223 ( 140.1 MB) N 95877 T 0 F 0 W 3000 S 557.084 Mbps RTT 0.054
[ 4] B 205686 ( 302.0 MB) N 206251 T 0 F 0 W 3000 S 646.842 Mbps RTT 0.056
[ 6] B 316204 ( 463.9 MB) N 316858 T 0 F 0 W 3000 S 647.158 Mbps RTT 0.052
[ 8] B 428055 ( 627.7 MB) N 428749 T 0 F 0 W 3000 S 654.963 Mbps RTT 0.054
[10] B 538009 ( 788.8 MB) N 538576 T 0 F 0 W 3000 S 643.856 Mbps RTT 0.051
[12] B 648821 ( 951.1 MB) N 649413 T 0 F 0 W 3000 S 648.878 Mbps RTT 0.053
[14] B 759233 ( 1112.8 MB) N 759995 T 0 F 0 W 3000 S 646.493 Mbps RTT 0.058
[16] B 869556 ( 1274.4 MB) N 870104 T 0 F 0 W 3000 S 646.061 Mbps RTT 0.052
[18] B 979772 ( 1435.9 MB) N 980383 T 0 F 0 W 3000 S 645.382 Mbps RTT 0.050
[20] B 1092446 ( 1600.9 MB) N 1093105 T 0 F 0 W 3000 S 659.792 Mbps RTT 0.054
[22] B 1203033 ( 1762.9 MB) N 12083675 T 0 F 0 W 3000 S 647.562 Mbps RTT 0.054
[24] B 1313868 ( 1925.3 MB) N 1314495 T 0 F 0 W 3000 S 649.013 Mbps RTT 0.053
[26] B 1424691 ( 2087.6 MB) N 1425432 T 0 F 0 W 3000 S 648.945 Mbps RTT 0.055
[28] B 1535959 ( 2250.6 MB) N 1536510 T 0 F 0 W 3000 S 651.550 Mbps RTT 0.055
[30] B 1646391 ( 2412.4 MB) N 1647031 T 0 F 0 W 3000 S 646.655 Mbps RTT 0.053
[32] B 1757823 ( 2575.6 MB) N 1758480 T 0 F 0 W 3000 S 652.510 Mbps RTT 0.053
[34] B 1866954 ( 2735.5 MB) N 1867630 T 0 F 0 W 3000 S 639.035 Mbps RTT 0.057
[36] B 1976011 ( 2895.2 MB) N 1976714 T 0 F 0 W 3000 S 638.605 Mbps RTT 0.054
[38] B 2086624 ( 3057.2 MB) N 2087239 T 0 F 0 W 3000 S 647.715 Mbps RTT 0.054
[40] B 2199187 ( 3222.1 MB) N 2199727 T 0 F 0 W 3000 S 659.132 Mbps RTT 0.052
[42] B 2310637 ( 3385.4 MB) N 2311162 T 0 F 0 W 3000 S 652.616 Mbps RTT 0.051
[44] B 24221163 ( 3547.3 MB) N 2421731 T 0 F 0 W 3000 S 647.178 Mbps RTT 0.055
[46] B 2530365 ( 3707.3 MB) N 2531084 T 0 F 0 W 3000 S 639.478 Mbps RTT 0.056
[48] B 2639883 ( 3867.7 MB) N 2640515 T 0 F 0 W 3000 S 641.301 Mbps RTT 0.052
[50] B 2725317 ( 3992.8 MB) N 2728317 T 3 F 2 W 3000 S 500.274 Mbps RTT 0.057
[52] B 2726674 ( 3992.9 MB) N 2729674 T 20 F 5 W 3000 S 7.946 Mbps RTT 0.057
[54] B 2726815 ( 3992.9 MB) N 2729815 T 35 F 13 W 3000 S 0.826 Mbps RTT 0.057
[56] B 2726939 ( 3992.9 MB) N 2729939 T 51 F 16 W 3000 S 0.726 Mbps RTT 0.057
[58] B 2727411 ( 3993.0 MB) N 2730411 T 67 F 25 W 3000 S 2.764 Mbps RTT 0.057
[60] B 2805175 ( 4101.2 MB) N 2805663 T 72 F 30 W 3000 S 455.360 Mbps RTT 0.058
[62] B 2917666 ( 4265.9 MB) N 2918272 T 72 F 30 W 3000 S 658.715 Mbps RTT 0.054
[63.25] <-- FIN-ACK 2933721 39F2A0E6
Main:    transfer finished in 62.213 sec, 552287.56 Kbps, checksum 39F2A0E6
Main:    estRTT 0.048, ideal rate 728275.75 Kbps

C:\Users\raj_vardhan\Documents\github\csce612\hw3\x64\Release\hw3.exe (process 11796) exited with code 0
Press any key to close this window . . .
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Between ts2 and s3.irl.cs.tamu.edu:

```
[Select Microsoft Visual Studio Debug Console]
Main:    sender W = 3000, RTT 0.010 sec, loss 0 / 0, link 10000 Mbps
Main:    initializing DWORD array with 2^30 elements...done in 10005 ms
Main:    connected to s3.irl.cs.tamu.edu in 10.033 sec, pkt size 1472 bytes
[ 2] B 30905 ( 41.1 MB) N 31389 T 9 F 5 W 3000 S 180.775 Mbps RTT 0.064
[ 4] B 128103 ( 183.9 MB) N 128663 T 9 F 5 W 3000 S 569.161 Mbps RTT 0.060
[ 6] B 221188 ( 320.3 MB) N 221685 T 9 F 5 W 3000 S 545.068 Mbps RTT 0.062
[ 8] B 315311 ( 458.1 MB) N 315804 T 9 F 5 W 3000 S 551.159 Mbps RTT 0.065
[10] B 407656 ( 593.4 MB) N 408227 T 9 F 5 W 3000 S 540.738 Mbps RTT 0.064
[12] B 501430 ( 730.8 MB) N 501955 T 9 F 5 W 3000 S 549.111 Mbps RTT 0.065
[14] B 594701 ( 867.4 MB) N 595268 T 9 F 5 W 3000 S 546.170 Mbps RTT 0.062
[16] B 689132 ( 1005.7 MB) N 689681 T 9 F 5 W 3000 S 552.956 Mbps RTT 0.065
[18] B 784494 ( 1145.4 MB) N 785111 T 9 F 5 W 3000 S 558.407 Mbps RTT 0.061
[20] B 878975 ( 1283.8 MB) N 879500 T 9 F 5 W 3000 S 553.251 Mbps RTT 0.059
[22] B 973021 ( 1421.6 MB) N 973487 T 9 F 5 W 3000 S 550.702 Mbps RTT 0.065
[24] B 1067658 ( 1560.2 MB) N 1068199 T 9 F 5 W 3000 S 554.162 Mbps RTT 0.063
[26] B 1162854 ( 1699.7 MB) N 1163440 T 9 F 5 W 3000 S 557.438 Mbps RTT 0.065
[28] B 1258908 ( 1840.4 MB) N 1259467 T 9 F 5 W 3000 S 562.456 Mbps RTT 0.060
[30] B 1354122 ( 1979.8 MB) N 1354580 T 9 F 5 W 3000 S 557.538 Mbps RTT 0.065
[32] B 1448842 ( 2118.6 MB) N 1449343 T 9 F 5 W 3000 S 554.658 Mbps RTT 0.063
[34] B 1545327 ( 2259.9 MB) N 1545937 T 9 F 5 W 3000 S 564.985 Mbps RTT 0.061
[36] B 1642078 ( 2401.7 MB) N 1642646 T 9 F 5 W 3000 S 566.543 Mbps RTT 0.061
[38] B 1739053 ( 2543.7 MB) N 1739610 T 9 F 5 W 3000 S 567.854 Mbps RTT 0.063
[40] B 1832601 ( 2680.7 MB) N 1833125 T 9 F 5 W 3000 S 547.788 Mbps RTT 0.059
[42] B 1927577 ( 2819.9 MB) N 1928238 T 9 F 5 W 3000 S 556.148 Mbps RTT 0.064
[44] B 2021414 ( 2957.3 MB) N 2022047 T 9 F 5 W 3000 S 549.476 Mbps RTT 0.060
[46] B 2117183 ( 3097.6 MB) N 2117826 T 9 F 5 W 3000 S 560.792 Mbps RTT 0.061
[48] B 2211354 ( 3235.6 MB) N 2212057 T 9 F 5 W 3000 S 551.435 Mbps RTT 0.060
[50] B 2305077 ( 3372.8 MB) N 2305680 T 9 F 5 W 3000 S 548.811 Mbps RTT 0.058
[52] B 2383874 ( 3483.9 MB) N 2384388 T 11 F 10 W 3000 S 461.409 Mbps RTT 0.061
[54] B 2479245 ( 3623.6 MB) N 2479960 T 11 F 10 W 3000 S 558.462 Mbps RTT 0.063
[56] B 2572936 ( 3760.8 MB) N 2573581 T 11 F 10 W 3000 S 548.625 Mbps RTT 0.065
[58] B 2666362 ( 3897.7 MB) N 2667050 T 11 F 10 W 3000 S 547.070 Mbps RTT 0.066
[60] B 2758963 ( 4033.3 MB) N 2759459 T 11 F 10 W 3000 S 542.240 Mbps RTT 0.065
[62] B 2851429 ( 4168.8 MB) N 2852005 T 11 F 10 W 3000 S 541.452 Mbps RTT 0.060
[64] B 2933721 ( 4289.3 MB) N 2933721 T 11 F 10 W 3000 S 481.873 Mbps RTT 0.061
[64.73] <- FIN-ACK 2933721 39F2A0E6
Main:    transfer finished in 63.694 sec, 539448.13 Kbps, checksum 39F2A0E6
Main:    estRTT 0.061, ideal rate 575931.44 Kbps

C:\Users\raj_vardhan\Documents\github\csce612\hw3\x64\Debug\hw3.exe (process 43432) exited with code 0.
Press any key to close this window . . .
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Between ts and localhost receiver:

```
[Microsoft Visual Studio Debug Console]
Main:    sender W = 3000, RTT 0.010 sec, loss 0 / 0, link 10000 Mbps
Main:    initializing DWORD array with 2^30 elements...done in 3694 ms
Main:    connected to 127.0.0.1 in 3.712 sec, pkt size 1472 bytes
[ 1] B 77895 ( 114.7 MB) N 78393 T 0 F 0 W 3000 S 456.175 Mbps RTT 0.069
[ 3] B 161300 ( 236.9 MB) N 161804 T 0 F 0 W 3000 S 488.397 Mbps RTT 0.069
[ 6] B 244625 ( 359.0 MB) N 245282 T 0 F 0 W 3000 S 487.917 Mbps RTT 0.074
[ 8] B 327792 ( 480.8 MB) N 328314 T 0 F 0 W 3000 S 487.002 Mbps RTT 0.071
[10] B 410844 ( 602.5 MB) N 411347 T 0 F 0 W 3000 S 486.328 Mbps RTT 0.070
[12] B 494488 ( 725.0 MB) N 495071 T 0 F 0 W 3000 S 489.792 Mbps RTT 0.071
[14] B 577580 ( 846.7 MB) N 578232 T 0 F 0 W 3000 S 486.560 Mbps RTT 0.075
[16] B 661671 ( 969.9 MB) N 662107 T 0 F 0 W 3000 S 492.412 Mbps RTT 0.069
[18] B 745118 ( 1092.1 MB) N 745613 T 0 F 0 W 3000 S 488.636 Mbps RTT 0.070
[20] B 828119 ( 1213.7 MB) N 828609 T 0 F 0 W 3000 S 486.028 Mbps RTT 0.071
[22] B 911843 ( 1336.4 MB) N 912338 T 0 F 0 W 3000 S 490.261 Mbps RTT 0.073
[24] B 994215 ( 1457.0 MB) N 994734 T 0 F 0 W 3000 S 482.338 Mbps RTT 0.073
[26] B 1077037 ( 1578.4 MB) N 1077448 T 0 F 0 W 3000 S 484.986 Mbps RTT 0.071
[28] B 1159429 ( 1699.0 MB) N 1159883 T 0 F 0 W 3000 S 482.463 Mbps RTT 0.075
[30] B 1242592 ( 1820.9 MB) N 1243065 T 0 F 0 W 3000 S 486.974 Mbps RTT 0.073
[32] B 1326037 ( 1943.1 MB) N 1326564 T 0 F 0 W 3000 S 488.620 Mbps RTT 0.073
[34] B 1408789 ( 2064.3 MB) N 1409521 T 0 F 0 W 3000 S 484.575 Mbps RTT 0.074
[36] B 1492754 ( 2187.3 MB) N 1493204 T 0 F 0 W 3000 S 491.672 Mbps RTT 0.069
[38] B 1576425 ( 2309.9 MB) N 1577127 T 0 F 0 W 3000 S 489.953 Mbps RTT 0.075
[40] B 1660273 ( 2432.7 MB) N 1660644 T 0 F 0 W 3000 S 490.988 Mbps RTT 0.069
[42] B 1742686 ( 2553.4 MB) N 1743387 T 0 F 0 W 3000 S 482.580 Mbps RTT 0.070
[44] B 1826994 ( 2676.9 MB) N 1827593 T 0 F 0 W 3000 S 493.682 Mbps RTT 0.074
[46] B 1910842 ( 2799.7 MB) N 1911381 T 0 F 0 W 3000 S 490.987 Mbps RTT 0.069
[48] B 1993958 ( 2921.5 MB) N 1994538 T 0 F 0 W 3000 S 486.703 Mbps RTT 0.069
[50] B 2078172 ( 3044.9 MB) N 2078752 T 0 F 0 W 3000 S 493.129 Mbps RTT 0.069
[52] B 2161796 ( 3167.4 MB) N 2162283 T 0 F 0 W 3000 S 489.677 Mbps RTT 0.068
[54] B 2245596 ( 3290.1 MB) N 2246278 T 0 F 0 W 3000 S 490.705 Mbps RTT 0.068
[56] B 2329636 ( 3413.2 MB) N 2330125 T 0 F 0 W 3000 S 492.113 Mbps RTT 0.069
[58] B 2412284 ( 3534.3 MB) N 2412828 T 0 F 0 W 3000 S 483.958 Mbps RTT 0.070
[60] B 2495344 ( 3655.9 MB) N 2495875 T 0 F 0 W 3000 S 486.373 Mbps RTT 0.075
[62] B 2578455 ( 3777.7 MB) N 2579072 T 0 F 0 W 3000 S 486.673 Mbps RTT 0.070
[64] B 2662520 ( 3900.8 MB) N 2663074 T 0 F 0 W 3000 S 492.258 Mbps RTT 0.069
[66] B 2746653 ( 4024.1 MB) N 2747300 T 0 F 0 W 3000 S 492.653 Mbps RTT 0.069
[68] B 2831114 ( 4147.8 MB) N 2831636 T 0 F 0 W 3000 S 494.580 Mbps RTT 0.069
[70] B 2914516 ( 4270.0 MB) N 2915080 T 0 F 0 W 3000 S 488.373 Mbps RTT 0.069
[71.40] <-- FIN-ACK 2933721 39F2A0E6
Main:    transfer finished in 70.373 sec, 488250.66 Kbps, checksum 39F2A0E6
Main:    estRTT 0.068, ideal rate 514670.13 Kbps

C:\Users\raj_vardhan\Documents\github\csce612\hw3\x64\Release\hw3.exe (process 6300) exited with code 0.
Press any key to close this window . . .
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