

ITS323 Introduction to Data Communications Assignment

Students: Sivagorn Yang and Chanawatn Nakwangarth
and Kittisak Jockkaew
Group: G14

Experiment Setup

<i>Host CPU</i>	<i>Intel Core i7-3610QM @ 2.3GHz</i>
<i>Host RAM</i>	<i>8 GB</i>
<i>Host OS</i>	<i>Mac OSX 10.10</i>
<i>Virtual Machine</i>	<i>VirtualBox 4.3.10</i>
<i>Virtual Network</i>	<i>virtnet r4l</i>

Table 1: Experiment Setup

Parameter Values

Fixed Parameters

<i>Parameter</i>	<i>Value</i>	<i>Unit</i>
<i>Downlink data rate</i>	<i>100</i>	<i>Mb/s</i>
<i>Downlink delay</i>	<i>0</i>	<i>ms</i>
<i>Number of frames</i>	<i>100</i>	<i>frames</i>

Table 2: Fixed Parameters

WINDOWS SIZE - CLIENT

Attempt	Data rate (kbit)	Delay (ms)	Data Frame	Data size (bytes)	Windows size	Log level	Duration	Original Packets Sent	Retransmitted Packets Sent	Acks Received	Bytes Acked	Total Data Sent	Total Bytes Sent	Total Bytes Sent Inc Headers	Sending Rate	Throughput
1	1000	10	100	10000	1	1	1.577368021	100	0	100	1000000	1000000	1050000	1470000	931932.1683	633967.4614
2	1000	10	100	10000	3	1	0.63085103	102	0	100	1000000	1020000	1071000	1499400	2376789.334	1585160.286
3	1000	10	100	10000	7	1	0.325908899	106	0	100	1000000	1060000	1113000	1558200	4781090.677	3068342.111
4	1000	10	100	10000	15	1	0.274774075	114	0	100	1000000	1140000	1197000	1675800	6098828.657	3639353.537
5	1000	10	100	10000	31	1	0.267923117	130	0	100	1000000	1300000	1365000	1911000	7132643.214	3732414.031
6	1000	10	100	10000	63	1	0.265527964	162	0	100	1000000	1620000	1701000	2381400	8968546.918	3766081.682
7	1000	10	100	10000	127	1	0.25650692	193	0	100	1000000	1930000	2026500	2837100	11060520.32	3898530.303
8	1000	10	100	10000	255	1	0.272644997	215	0	100	1000000	2150000	2257500	3160500	11591997.06	3667773.157
9	1000	10	100	10000	511	1	0.270532131	215	0	100	1000000	2150000	2257500	3160500	11682530.97	3696418.594
10	1000	10	100	10000	1023	1	0.269388914	225	0	100	1000000	2250000	2362500	3307500	12277788.09	3712105.241
11	1000	10	100	10000	4095	1	0.267654181	212	0	100	1000000	2120000	2226000	3116400	11643382.49	3736164.322
12	1000	10	100	10000	8191	1	0.262081146	216	0	100	1000000	2160000	2268000	3175200	12115331.63	3815612.128
13	1000	10	100	10000	16383	1	0.269156933	218	0	100	1000000	2180000	2289000	3204600	11906065.23	3715304.635
14	1000	10	100	10000	32767	1	0.264754057	221	0	100	1000000	2210000	2320500	3248700	12270633.5	3777090.374
15	1000	10	100	10000	65535	1	0.267402172	213	0	100	1000000	2130000	2236500	3131100	11709328.97	3739685.404
16	1000	10	100	10000	131071	1	0.269766092	221	0	100	1000000	2210000	2320500	3248700	12042655.07	3706915.096
17	1000	10	100	10000	262143	1	0.264307022	231	0	100	1000000	2310000	2425500	3395700	12847558.77	3783478.744
18	1000	10	100	10000	524287	1	0.264590025	216	0	100	1000000	2160000	2268000	3175200	12000452.4	3779431.973
19	1000	10	100	10000	1048575	1	0.267503023	208	0	100	1000000	2080000	2184000	3057600	11430151.2	3738275.509
20	1000	10	100	10000	2097151	1	0.268393993	217	0	100	1000000	2170000	2278500	3189900	11885139.31	3725865.797

WINDOWS SIZE - SERVER

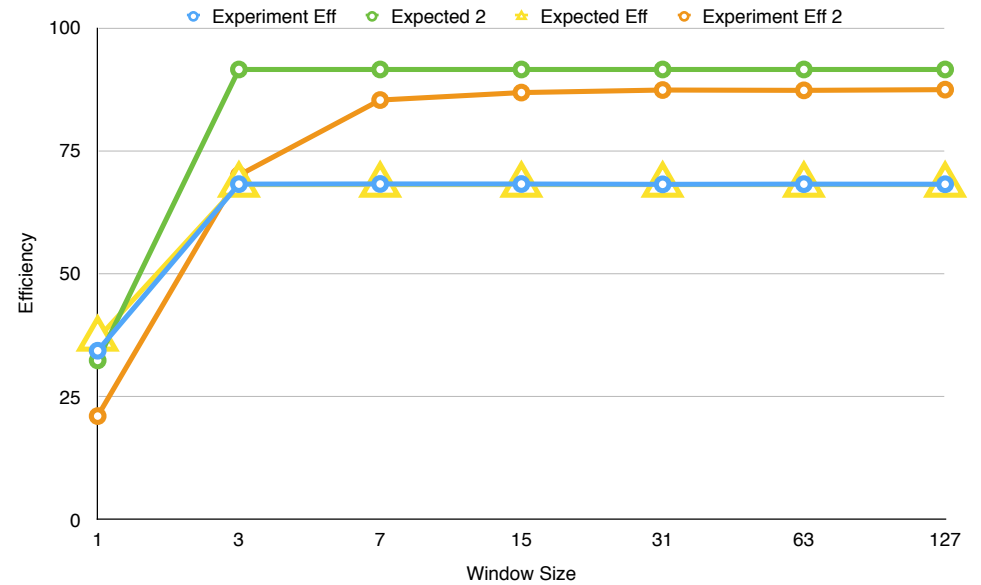
Attempt	Data rate (kbit)	Delay (ms)	Data Frame	Data size (bytes)	Windows size	Duration	Original Packets Received	Acks Sent	Total Data Received	Total Bytes Received	Total Bytes Received Inc Headers	Errors	receive Rate	Throughput
1	100000	0	100	10000	1	1.567732811	100	100	1000000	1000000	1470000	0	937659.7783	637863.7948
2	100000	0	100	10000	3	0.619282007	100	100	1000000	1000000	1470000	0	2373716.631	1614773.219
3	100000	0	100	10000	7	0.305036068	100	100	1000000	1000000	1470000	0	4819102.245	3278300.847
4	100000	0	100	10000	15	0.261750937	100	100	1000000	1000000	1470000	0	5616025.752	3820425.682
5	100000	0	100	10000	31	0.250560999	100	100	1000000	1000000	1470000	0	5866834.848	3991044.114
6	100000	0	100	10000	63	0.24793601	100	100	1000000	1000000	1470000	0	5928949.159	4033298.747
7	100000	0	100	10000	127	0.238026857	100	100	1000000	1000000	1470000	0	6175773.676	4201206.582
8	100000	0	100	10000	255	0.246649981	100	100	1000000	1000000	1470000	0	5959862.623	4054328.315
9	100000	0	100	10000	511	0.245346069	100	100	1000000	1000000	1470000	0	5991536.787	4075875.365
10	100000	0	100	10000	1023	0.244274855	100	100	1000000	1000000	1470000	0	6017811.379	4093749.237
11	100000	0	100	10000	4095	0.242815971	100	100	1000000	1000000	1470000	0	6053967.503	4118345.24
12	100000	0	100	10000	8191	0.240805864	100	100	1000000	1000000	1470000	0	6104502.497	4152722.787
13	100000	0	100	10000	16383	0.243040085	100	100	1000000	1000000	1470000	0	6048384.985	4114547.609
14	100000	0	100	10000	32767	0.240111828	100	100	1000000	1000000	1470000	0	6122147.389	4164726.115
15	100000	0	100	10000	65535	0.240875006	100	100	1000000	1000000	1470000	0	6102750.244	4151530.778
16	100000	0	100	10000	131071	0.242660999	100	100	1000000	1000000	1470000	0	6057833.786	4120975.364
17	100000	0	100	10000	262143	0.241865158	100	100	1000000	1000000	1470000	0	6077766.685	4134535.16
18	100000	0	100	10000	524287	0.242575884	100	100	1000000	1000000	1470000	0	6059959.368	4122421.339
19	100000	0	100	10000	1048575	0.242811203	100	100	1000000	1000000	1470000	0	6054086.392	4118426.117
20	100000	0	100	10000	2097151	0.245110989	100	100	1000000	1000000	1470000	0	5997283.142	4079784.45

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packet	data size	w	delay	r	t	tf	w*tf	throughput	Eff	Expected Eff
100	10000	1	10	10000	0.02176	0.01176	0.01176	428,604.1577	34.28833262	36.76471
100	10000	3	10	10000	0.02176	0.01176	0.03528	851,534.8748	68.12278998	68.0272108843537
100	10000	7	10	10000	0.02176	0.01176	0.08232	852,004.33	68.16034640	68.0272108843537
100	10000	15	10	10000	0.02176	0.01176	0.17640	851,840.2905	68.14722324	68.0272108843537
100	10000	31	10	10000	0.02176	0.01176	0.36456	851,016.0322	68.08128258	68.0272108843537
100	10000	63	10	10000	0.02176	0.01176	0.74088	851,539.8883	68.12319106	68.0272108843537
100	10000	127	10	10000	0.02176	0.01176	1.49352	851,282.5446	68.10260357	68.0272108843537

packet	data size	w	delay	r	t	tf	w*tf	throughput	Eff2	Expected Eff2
100	50000	1	10	80000	0.01547	0.00547	0.00547	2101729.567	21.01729567	32.32062
100	50000	3	10	80000	0.01547	0.00547	0.01641	6992597.45331	69.92597453	91.4076782449726
100	50000	7	10	80000	0.01547	0.00547	0.03829	8519934.26679	85.19934267	91.4076782449726
100	50000	15	10	80000	0.01547	0.00547	0.08205	8671704.46393	86.71704464	91.4076782449726
100	50000	31	10	80000	0.01547	0.00547	0.16957	8723539.57858	87.23539579	91.4076782449726
100	50000	63	10	80000	0.01547	0.00547	0.34461	8716650.42198	87.16650422	91.4076782449726
100	50000	127	10	80000	0.01547	0.00547	0.69469	8731079.34881	87.31079349	91.4076782449726



ERROR - CLIENT

Attempt	Data rate (kbit)	Data Frame	Delay (ms)	Data Frame	Data size (bytes)	Windows size	Log level	Duration	Original Packets Sent	Retransmitted Packets Sent	Acks Received	Bytes Aced	Total Data Sent	Total Bytes Sent	Total Bytes Sent Inc Headers	Sending Rate	Throughput
1	1000	100	10	100	10000	1	1	11.79804802	100	0	100	1000000	1000000	1050000	1470000	124596.8823	84759.78385
2	1000	100	10	100	10000	1	1	11.79198194	100	0	100	1000000	1000000	1050000	1470000	124660.9779	84803.38636
3	1000	100	10	100	10000	1	1	11.793607	100	0	100	1000000	1000000	1050000	1470000	124643.8007	84791.70116
4	1000	100	10	100	10000	1	1	14.79117322	100	3	100	1000000	1030000	1081500	1514100	102365.105	67607.88919
5	1000	100	10	100	10000	1	1	17.80915689	100	6	100	1000000	1060000	1113000	1558200	87494.31594	56150.88945
6	1000	100	10	100	10000	1	1	16.79591608	100	5	100	1000000	1050000	1102500	1543500	91897.33937	59538.28271
7	1000	100	10	100	10000	1	1	14.8202939	100	3	100	1000000	1030000	1081500	1514100	102163.9658	67475.04513
8	1000	100	10	100	10000	1	1	20.80558014	100	9	100	1000000	1090000	1144500	1602300	77012.99311	48064.02866
9	1000	100	10	100	10000	1	1	19.80047393	100	8	100	1000000	1080000	1134000	1587600	80179.89901	50503.84166
10	1000	100	10	100	10000	1	1	15.823488	100	4	100	1000000	1040000	1092000	1528800	96615.86625	63197.19143
11	1000	100	10	100	10000	1	1	25.81310606	100	14	100	1000000	1140000	1197000	1675800	64920.50961	38740.01051
12	1000	100	10	100	10000	1	1	23.80491686	100	12	100	1000000	1120000	1176000	1646400	69162.18232	42008.12823
13	1000	100	10	100	10000	1	1	24.82650495	100	13	100	1000000	1130000	1186500	1661100	66908.33058	40279.53198
14	1000	100	10	100	10000	1	1	23.79605985	100	12	100	1000000	1120000	1176000	1646400	69187.92483	42023.76387
15	1000	100	10	100	10000	1	1	28.79879093	100	17	100	1000000	1170000	1228500	1719900	59721.25719	34723.67998
16	1000	100	10	100	10000	1	1	37.81894803	100	26	100	1000000	1260000	1323000	1852200	48975.45004	26441.77197
17	1000	100	10	100	10000	1	1	29.80065393	100	18	100	1000000	1180000	1239000	1734600	58206.7764	33556.31062
18	1000	100	10	100	10000	1	1	33.79623103	100	22	100	1000000	1220000	1281000	1793400	53065.08878	29589.09824
19	1000	100	10	100	10000	1	1	33.80050683	100	22	100	1000000	1220000	1281000	1793400	53058.37599	29585.35518
20	1000	100	10	100	10000	1	1	33.8105402	100	22	100	1000000	1220000	1281000	1793400	53042.63077	29576.57565
21	1000	100	10	100	10000	1	1	33.79700994	100	22	100	1000000	1220000	1281000	1793400	53063.8658	29588.4163
22	1000	100	10	100	10000	1	1	40.79877496	100	29	100	1000000	1290000	1354500	1896300	46479.33674	24510.53986
23	1000	100	10	100	10000	1	1	56.80690813	100	45	100	1000000	1450000	1522500	2131500	37521.84497	17603.49283
24	1000	100	10	100	10000	1	1	34.81645679	100	23	100	1000000	1230000	1295500	1808100	51933.33794	28722.04963
25	1000	100	10	100	10000	1	1	41.803792	100	30	100	1000000	1300000	1365000	1911000	45713.55632	23921.27489
26	1000	100	10	100	10000	1	1	34.81583786	100	23	100	1000000	1230000	1291500	1808100	51933.26116	28722.56023
27	1000	100	10	100	10000	1	1	55.79808497	100	44	100	1000000	1440000	1512000	2116800	37936.78584	17921.76202
28	1000	100	10	100	10000	1	1	47.80893493	100	36	100	1000000	1360000	1428000	1999200	41816.45132	20916.5923
29	1000	100	10	100	10000	1	1	47.81108594	100	36	100	1000000	1360000	1428000	1999200	41814.57	20915.65126
30	1000	100	10	100	10000	1	1	48.82611704	100	37	100	1000000	1370000	1438500	2013900	41246.36818	20480.84223
31	1000	100	10	100	10000	1	1	58.80498008	100	47	100	1000000	1470000	1543500	2160900	36746.91396	17005.37459
32	1000	100	10	100	10000	1	1	55.82106614	100	44	100	1000000	1440000	1512000	2116800	37921.16751	17914.38375
33	1000	100	10	100	10000	1	1	59.81233501	100	48	100	1000000	1480000	1554000	2175600	36373.76804	16718.95939
34	1000	100	10	100	10000	1	1	57.80977488	100	46	100	1000000	1460000	1533000	2146200	37125.20944	17298.11268
35	1000	100	10	100	10000	1	1	61.8106761	100	50	100	1000000	1500000	1575000	2205000	35673.44898	16178.43491
36	1000	100	10	100	10000	1	1	70.81551909	100	59	100	1000000	1590000	1669500	2337300	33005.47719	14121.19847
37	1000	100	10	100	10000	1	1	65.81185508	100	54	100	1000000	1540000	1617000	2263800	34398.05788	15194.83076
38	1000	100	10	100	10000	1	1	70.81987	100	59	100	1000000	1590000	1669500	2337300	33003.44946	14120.33092
39	1000	100	10	100	10000	1	1	70.80158114	100	59	100	1000000	1590000	1669500	2337300	33011.97462	14123.97836
40	1000	100	10	100	10000	1	1	65.81282306	100	54	100	1000000	1540000	1617000	2263800	34397.55195	15194.60727
41	1000	100	10	100	10000	1	1	58.80559802	100	47	100	1000000	1470000	1543500	2160900	36746.50157	17005.18375
42	1000	100	10	100	10000	1	1	102.830529	100	91	100	1000000	1910000	2005500	2807700	27304.14817	9724.73846
43	1000	100	10	100	10000	1	1	89.79506516	100	78	100	1000000	1780000	1869000	2616600	29139.68596	11136.46945
44	1000	100	10	100	10000	1	1	67.79965401	100	56	100	1000000	1560000	1638000	2293200	33823.18145	14749.3378
45	1000	100	10	100	10000	1	1	98.82555103	100	87	100	1000000	1870000	1963500	2748900	27815.68098	10118.84062
46	1000	100	10	100	10000	1	1	97.81660891	100	86	100	1000000	1860000	1953000	2734200	27952.38012	10223.21272
47	1000	100	10	100	10000	1	1	83.80824304	100	72	100	1000000	1720000	1806000	2528400	30168.87013	11932.00053
48	1000	100	10	100	10000	1	1	99.84217501	100	88	100	1000000	1880000	1974000	2763600	27679.68546	10015.80745
49	1000	100	10	100	10000	1	1	124.8139369	100	113	100	1000000	2130000	2236500	3131100	25086.14083	8011.925787
50	1000	100	10	100	10000	1	1	103.8174021	100	92	100	1000000	1920000	2016000	2822400	27186.19367	9632.296508
51	1000	100	10	100	10000	1	1	104.8468609	100	93	100	1000000	1930000	2026500	2837100	27059.46536	9537.719981
52	1000	100	10	100	10000	1	1	107.8749111	100	96	100	1000000	1960000	2058000	2881200	26708.71263	9269.960655
53	1000	100	10	100	10000	1	1	91.83266282	100	80	100	1000000	1800000	1890000	2646000	28813.27753	10889.3717
54	1000	100	10	100	10000	1	1	109.825244	100	98	100	1000000	1980000	2079000	2910600	26502.10366	9105.374721
55	1000	100	10	100	10000	1	1	126.833776	100	115	100	1000000	2150000	2257500	3160500	24918.44128	7884.335163
56	1000	100	10	100	10000	1	1	156.821281	100	145	100	1000000	2450000	2572500	3601500	22965.6331	6376.685574
57	1000	100	10	100	10000	1	1	155.8355041	100	144	100	1000000	2440000	2562000	3586800	23016.57778	6417.022912
58	1000	100	10	100	10000	1	1	164.8403301	100	153	100	1000000	2530000	2656500	3719100	22561.833	6066.476567
59	1000	100	10	100	10000	1	1	139.8452141	100	128	100	1000000	2280000	2394000	3351600	23966.49768	7150.763122
60	1000	100	10	100	10000	1	1	119.852992	100	108	100	1000000	2080000	2184000	3057600	25511.25297	8343.55474
61	1000	100	10	100	10000	1	1	183.8460741	100	172	100	1000000	2720000	2856000	3998400	21748.62868	5439.332903
62	1000	100	10	100	10000	1	1	152.820359	100	141	100	1000000	2410000	2530500	3542700	2182.12065	6543.630748
63	1000	100	10	100	10000	1	1	175.8488121	100	164	100	1000000	2640000	2772000	3880800	22068.95772	5686.703186
64	1000	100	10	100	10000	1	1	148.8297331	100	137	100	1000000	2370000	2488500	3483900	23408.62895	6719.087503
65	1000	100	10	100	10000	1	1	222.868727	100	211	100	1000000	3110000	3265500	4571700	20512.9722	4486.946256
66	1000	100	10	100	10000	1	1	193.8474731	100	182	100	1000000	2820000	2961000	4145400	21384.85446	5158.695049

Attempt	Data rate (kbit)	Data Frame	Delay (ms)	Data Frame	Data size (bytes)	Windows size	Log level	Duration	Original Packets Sent	Retransmitted Packets Sent	Acks Received	Bytes Aced	Total Data Sent	Total Bytes Sent	Total Bytes Sent Inc Headers	Sending Rate	Throughput
77	1000	100	10	100	10000	1	1	321.9558349	100	310	100	1000000	4100000	4305000	6027000	18719.95891	3106.01608
78	1000	100	10	100	10000	1	1	353.9626288	100	342	100	1000000	4420000	4641000	6497400	18356.17512	2825.157004
79	1000	100	10	100	10000	1	1	306.9318919	100	295	100	1000000	3950000	4147500	5806500	18917.87772	3258.05179
80	1000	100	10	100	10000	1	1	409.988719	100	398	100	1000000	4980000	5229000	7320600	17855.61324	2439.091501
81	1000	100	10	100	10000	1	1	419.988672	100	408	100	1000000	5080000	5334000	7467600	17780.47956	2381.0166
82	1000	100	10	100	10000	1	1	448.0253172	100	436	100	1000000	5360000	5628000	7879200	17586.50616	2232.016722
83	1000	100	10	100	10000	1	1	523.061826	100	511	100	1000000	6110000	6415500	8981700	17171.39266	1911.819885
84	1000	100	10	100	10000	1	1	474.023262	100	462	100	1000000	5620000	5901000	8261400	17428.25861	2109.601111
85	1000	100	10	100	10000	1	1	662.125989	100	650	100	1000000	7500000	7875000	11025000	16650.90962	1510.286587
86	1000	100	10	100	10000	1	1	598.1056139	100	586	100	1000000	6860000	7203000	10084200	16860.23298	1671.945517
87	1000	100	10	100	10000	1	1	647.1390979	100	635	100	1000000	7350000	7717500	10804500	16695.79235	1545.262839
88	1000	100	10	100	10000	1	1	608.1094589	100	596	100	1000000	6960000	7308000	10231200	16824.60263	1644.440792
89	1000	100	10	100	10000	1	1	739.19891	100	727	100	1000000	8270000	8683500	12156900	16446.04698	1352.815848
90	1000	100	10	100	10000	1	1	719.1583741	100	707	100	1000000	8070000	8473500	11862900	16495.53204	1390.514296
91	1000	100	10	100	10000	1	1	1043.382386	100	1031	100	1000000	11310000	11875500	16625700	15934.42656	958.4213932
92	1000	100	10	100	10000	1	1	932.3115399	100	920	100	1000000	10200000	10710000	14994000	16082.6069	1072.602834
93	1000	100	10	100	10000	1	1	1074.384649	100	1062	100	1000000	11620000	12201000	17081400	15898.77519	930.7653466
94	1000	100	10	100	10000	1	1	1428.63807	100	1416	100	1000000	15160000	15918000	22285200	15598.91233	699.9673473
95	1000	100	10	100	10000	1	1	1549.685166	100	1537	100	1000000	16370000	17188500	24063900	15528.25085	645.2923612
96	1000	100	10	100	10000	1	1	1920.965561	100	1908	100	1000000	20080000	21084000	29517600	15366.02248	520.5715398
97	1000	100	10	100	10000	1	1	2357.263152	100	2344	100	1000000	24440000	25662000	35926800	15240.89492	424.2207745
98	1000	100	10	100	10000	1	1	3154.68873	100	3141	100	1000000	32410000	34030500	47642700	15102.18728	316.9884846

Attempt	Data rate (kbit)	Data Frame	Delay (ms)	Data Frame	Data size (bytes)	Windows size	Duration	Original Packets Received	Acks Sent	Total Data Received	Total Bytes Received	Total Bytes Received Inc Headers	Errors	receive Rate	Throughput
77	100000	100	0	100	10000	1	321.9412851	100	100	1000000	1000000	1470000	310	4566.049985	3106.156452
78	100000	100	0	100	10000	1	353.950932	100	100	1000000	1000000	1470000	342	4153.118037	2825.250365
79	100000	100	0	100	10000	1	306.9183931	100	100	1000000	1000000	1470000	295	4789.546775	3258.195085
80	100000	100	0	100	10000	1	409.972903	100	100	1000000	1000000	1470000	398	3585.602827	2439.185597
81	100000	100	0	100	10000	1	419.9745259	100	100	1000000	1000000	1470000	408	3500.212297	2381.096801
82	100000	100	0	100	10000	1	448.0109069	100	100	1000000	1000000	1470000	436	3281.170117	2232.088515
83	100000	100	0	100	10000	1	523.0481088	100	100	1000000	1000000	1470000	511	2810.448934	1911.870023
84	100000	100	0	100	10000	1	474.011441	100	100	1000000	1000000	1470000	462	3101.190969	2109.65372
85	100000	100	0	100	10000	1	662.115222	100	100	1000000	1000000	1470000	650	2220.157385	1510.311146
86	100000	100	0	100	10000	1	598.0921009	100	100	1000000	1000000	1470000	586	2457.81544	1671.983292
87	100000	100	0	100	10000	1	647.1237271	100	100	1000000	1000000	1470000	635	2271.590329	1545.299543
88	100000	100	0	100	10000	1	608.096673	100	100	1000000	1000000	1470000	596	2417.378791	1644.475368
89	100000	100	0	100	10000	1	739.187686	100	100	1000000	1000000	1470000	727	1988.669492	1352.836389
90	100000	100	0	100	10000	1	719.1445041	100	100	1000000	1000000	1470000	707	2044.095438	1390.541114
91	100000	100	0	100	10000	1	1043.37028	100	100	1000000	1000000	1470000	1031	1408.895795	958.4325135
92	100000	100	0	100	10000	1	932.301964	100	100	1000000	1000000	1470000	920	1576.742361	1072.613851
93	100000	100	0	100	10000	1	1074.374807	100	100	1000000	1000000	1470000	1062	1368.237593	930.7738727
94	100000	100	0	100	10000	1	1428.625138	100	100	1000000	1000000	1470000	1416	1028.961315	699.9736833
95	100000	100	0	100	10000	1	1549.672455	100	100	1000000	1000000	1470000	1537	948.5875516	645.2976542
96	100000	100	0	100	10000	1	1920.954842	100	100	1000000	1000000	1470000	1908	765.2444335	520.5744446
97	100000	100	0	100	10000	1	2357.25423	100	100	1000000	1000000	1470000	2344	623.6068988	424.2223801
98	100000	100	0	100	10000	1	3154.682928	100	100	1000000	1000000	1470000	3141	465.9739294	316.9890676

Error Rate Experiment										Expected Error Rate																
Attempt	Data Frame	Error Rate	Timeout	Data Rate (kb/s)	Delay (ms)	Data Size (Bytes)	Windows	Size	Errors	Throughput (Byte/sec)	Efficiency	Attempt	Data Frame	Error Rate	Timeout	Data Rate (kb/s)	Delay (ms)	Data Size (Bytes)	Windows	Size	Errors	Total Time (s)	Total Time with Error (s)	Average Time (s)	Throughput	Efficiency
1	100	0	1	1000	0	10000	1	0	0	184842.76161	67.87	1	100	0	1	1000	0	10000	1	0	0	1276	1.2452	0.1276	624959.247648903	62.70
2	100	0.01	1	1000	0	10000	1	0	84890.86182	67.91	2	100	0.01	1	1000	10	10000	1	0	0	1276	1.2452	0.1276	576468.553640399	57.65	
3	100	0.02	1	1000	0	10000	1	0	84879.77946	67.90	3	100	0.02	1	1000	10	10000	1	0	0	1276	1.2452	0.1276	533504.054630815	53.35	
4	100	0.03	1	1000	0	10000	1	3	67687.62678	54.15	4	100	0.03	1	1000	10	10000	1	3	0	1276	1.2452	0.161128	496499.67727521	49.65	
5	100	0.04	1	1000	0	10000	1	6	56198.98176	44.96	5	100	0.04	1	1000	10	10000	1	6	0	1276	1.2452	0.172104	464295.664787003	46.43	
6	100	0.05	1	1000	0	10000	1	5	59579.37848	47.66	6	100	0.05	1	1000	10	10000	1	5	0	1276	1.2452	0.18348	436014.824504033	43.60	
7	100	0.06	1	1000	0	10000	1	3	67552.41858	54.04	7	100	0.06	1	1000	10	10000	1	3	0	1276	1.2452	0.194656	410981.423639652	41.10	
8	100	0.07	1	1000	0	10000	1	9	48052.43995	38.47	8	100	0.07	1	1000	10	10000	1	9	0	1276	1.2452	0.205832	388664.485288974	38.87	
9	100	0.08	1	1000	0	10000	1	9	50537.0243	40.17	9	100	0.08	1	1000	10	10000	1	9	0	1276	1.2452	0.217008	368650.9036855	36.87	
10	100	0.09	1	1000	0	10000	1	4	63248.58336	50.60	10	100	0.09	1	1000	10	10000	1	4	0	1276	1.2452	0.228184	350594.257266066	35.06	
11	100	0.10	1	1000	0	10000	1	14	38762.85871	31.01	11	100	0.10	1	1000	10	10000	1	14	0	1276	1.2452	0.24	334224.598930481	33.42	
12	100	0.11	1	1000	0	10000	1	12	42029.18765	33.62	12	100	0.11	1	1000	10	10000	1	12	0	1276	1.2452	0.25	319315.387808539	31.93	
13	100	0.12	1	1000	0	10000	1	13	40208.9891	32.24	13	100	0.12	1	1000	10	10000	1	13	0	1276	1.2452	0.26	305659.52358574	30.57	
14	100	0.13	1	1000	0	10000	1	12	42049.10002	33.64	14	100	0.13	1	1000	10	10000	1	12	0	1276	1.2452	0.27	293160.564040925	29.32	
15	100	0.14	1	1000	0	10000	1	17	34739.42059	27.79	15	100	0.14	1	1000	10	10000	1	17	0	1276	1.2452	0.28	281626.67567872	28.16	
16	100	0.15	1	1000	0	10000	1	26	26456.20957	21.16	16	100	0.15	1	1000	10	10000	1	26	0	1276	1.2452	0.30	270955.993767782	27.10	
17	100	0.16	1	1000	0	10000	1	18	33517.46912	26.86	17	100	0.16	1	1000	10	10000	1	18	0	1276	1.2452	0.31	261082.97168555	26.11	
18	100	0.17	1	1000	0	10000	1	22	25559.56686	23.68	18	100	0.17	1	1000	10	10000	1	22	0	1276	1.2452	0.32	251895.537409	25.19	
19	100	0.18	1	1000	0	10000	1	22	25956.83028	23.68	19	100	0.18	1	1000	10	10000	1	22	0	1276	1.2452	0.33	243322.684446175	24.33	
20	100	0.19	1	1000	0	10000	1	22	25986.68019	23.67	20	100	0.19	1	1000	10	10000	1	22	0	1276	1.2452	0.34	235327.878356435	23.53	
21	100	0.20	1	1000	0	10000	1	22	25959.76488	23.68	21	100	0.20	1	1000	10	10000	1	22	0	1276	1.2452	0.35	227842.331105491	22.78	
22	100	0.21	1	1000	0	10000	1	29	24518.32896	19.61	22	100	0.21	1	1000	10	10000	1	29	0	1276	1.2452	0.36	220813.920105924	22.08	
23	100	0.22	1	1000	0	10000	1	45	17607.6215	14.09	23	100	0.22	1	1000	10	10000	1	45	0	1276	1.2452	0.37	214206.15200685	21.42	
24	100	0.23	1	1000	0	10000	1	23	28733.72821	22.99	24	100	0.23	1	1000	10	10000	1	23	0	1276	1.2452	0.38	207982.36309561	20.80	
25	100	0.24	1	1000	0	10000	1	30	23929.39357	19.14	25	100	0.24	1	1000	10	10000	1	30	0	1276	1.2452	0.40	202110.028699624	20.21	
26	100	0.25	1	1000	0	10000	1	23	28732.02403	22.99	26	100	0.25	1	1000	10	10000	1	23	0	1276	1.2452	0.41	196506.196560197	19.66	
27	100	0.26	1	1000	0	10000	1	44	17925.96604	14.34	27	100	0.26	1	1000	10	10000	1	44	0	1276	1.2452	0.42	191307.009488828	19.13	
28	100	0.27	1	1000	0	10000	1	36	20922.49765	16.74	28	100	0.27	1	1000	10	10000	1	36	0	1276	1.2452	0.43	186327.302539641	18.63	
29	100	0.28	1	1000	0	10000	1	36	20921.49469	16.74	29	100	0.28	1	1000	10	10000	1	36	0	1276	1.2452	0.44	181600.261504377	18.16	
30	100	0.29	1	1000	0	10000	1	37	20407.14789	16.39	30	100	0.29	1	1000	10	10000	1	37	0	1276	1.2452	0.45	177337.13210421	17.73	
31	100	0.30	1	1000	0	10000	1	47	17009.54102	13.61	31	100	0.30	1	1000	10	10000	1	47	0	1276	1.2452	0.46	172830.971310059	17.28	
32	100	0.31	1	1000	0	10000	1	44	17918.94471	14.34	32	100	0.31	1	1000	10	10000	1	44	0	1276	1.2452	0.474056	168756.43383904	16.88	
33	100	0.32	1	1000	0	10000	1	48	16722.33337	13.38	33	100	0.32	1	1000	10	10000	1	48	0	1276	1.2452	0.485232	164869.588155769	16.49	
34	100	0.33	1	1000	0	10000	1	46	17500.46812	14.34	34	100	0.33	1	1000	10	10000	1	46	0	1276	1.2452	0.496482	161153.297316055	16.11	
35	100	0.34	1	1000	0	10000	1	50	16182.23078	12.95	35	100	0.34	1	1000	10	10000	1	50	0	1276	1.2452	0.507584	157609.380910352	15.76	
36	100	0.35	1	1000	0	10000	1	59	14124.03044	11.30	36	100	0.35	1	1000	10	10000	1	59	0	1276	1.2452	0.51876	154213.89467191	15.42	
37	100	0.36	1	1000	0	10000	1	54	15197.54665	12.16	37	100	0.36	1	1000	10	10000	1	54	0	1276	1.2452	0.529936	150961.623554784	15.10	
38	100	0.37	1	1000	0	10000	1	38	14022.66007	11.30	38	100	0.37	1	1000	10	10000	1	38	0	1276	1.2452	0.540112	147943.69864074	14.79	
39	100	0.38	1	1000	0	10000	1	59	14127.24435	11.30	39	100	0.38	1	1000	10	10000	1	59	0	1276	1.2452	0.552288	144851.961295556	14.49	
40	100	0.39	1	1000	0	10000	1	54	15198.08577	12.16	40	100	0.39	1	1000	10	10000	1	54	0	1276	1.2452	0.563464	141978.901935172	14.20	
41	100	0.40	1	1000	0	10000	1	47	17009.01244	13.61	41	100	0.40	1	1000	10	10000	1	47	0	1276	1.2452	0.57484	139217.597104274	13.92	
42	100	0.41	1	1000	0	10000	1	91	9726.16458	7.78	42	100	0.41	1	1000	10	10000	1	91	0	1276	1.2452	0.585816	135661.650975234	13.66	
43	100	0.42	1	1000	0	10000	1	78	11138.34461	8.91	43	100	0.42	1	1000	10	10000	1	78	0	1276	1.2452	0.596992	134005.145797599	13.41	
44	100	0.43	1	1000	0	10000	1	56	14752.48479	11.80	44	100	0.43	1	1000	10	10000	1	56	0	1276	1.2452	0.608168	131542.660071033	13.15	
45	100	0.44	1	1000	0	10000	1	87	10120.16011	8.10	45	100	0.44	1	1000	10	10000	1	87	0	1276	1.2452	0.619344	129168.927122891	12.92	
46	100	0.45	1	1000	0	10000	1	86	10224.58317	8.18	46	100	0.45	1	1000	10	10000	1	86	0	1276	1.2452	0.63052	126879.102192927	12.69	
47	100	0.46	1	1000	0	10000	1	72	11933.75295	9.55	47	100	0.46	1	1000	10	10000	1	72	0	1276	1.2452	0.641696	124669.6234945	12.47	
48	100	0.47	1	1000	0	10000	1	88	10017.6686	8.01	48	100	0.47	1	1000	10	10000	1	88	0	1276	1.2452	0.652872	122535.506462476	12.25	
49	100	0.48	1	1000	0	10000	1	113	8012.657568	6.41	49	100	0.48	1	1000	10	10000	1	113	0	1276	1.2452	0.664048	120473.21880346	12.05	
50	100	0.49	1	1000	0	10000	1	92	9693.436017	7.71	50	100	0.49	1	1000	10	10000	1	92	0	1276	1.2452	0.675224	118479.200976269	11.85	
51	100	0.50	1	1000	0	10000	1	91	9535.18177	7.63	51	100	0.50	1	1000	10	10000	1	91	0	1276	1.2452	0.6864	116		

RTT - CLIENT

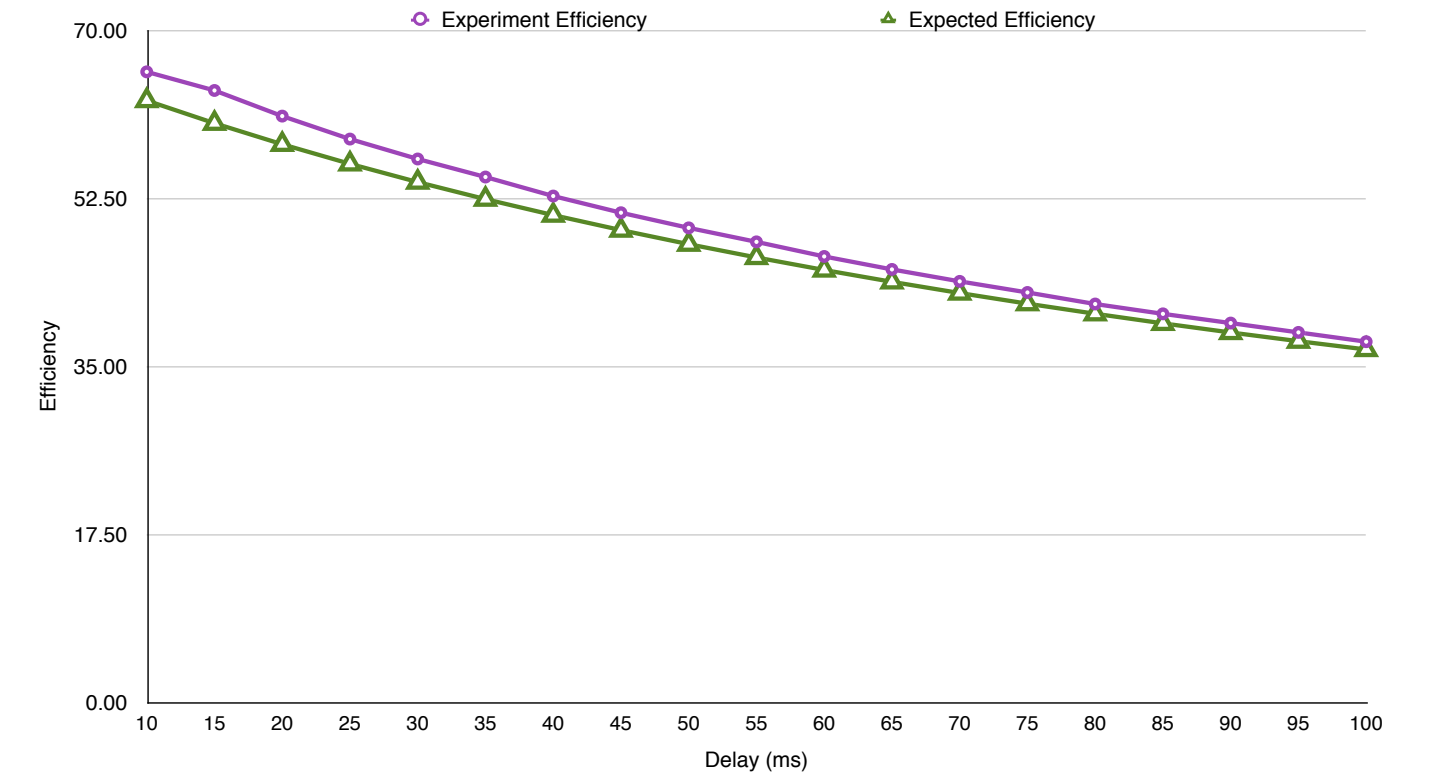
Attempt	Data rate (kbit)	Delay (ms)	Data Frame	Data size (bytes)	Windows size	Log level	Duration	Original Packets Sent	Retransmitted Packets Sent	Acks Received	Bytes Aced	Total Data Sent	Total Bytes Sent	Total Bytes Sent Inc Headers	Sending Rate	Throughput
1	1000	10	100	10000	1	1	11.7994909286	100	0	100	1000000	1000000	1050000	1470000	124,581.645843	84,749.4189408
2	1000	15	100	10000	1	1	12.1611609459	100	0	100	1000000	1000000	1050000	1470000	120,876.617499	82,228.9914959
3	1000	20	100	10000	1	1	12.6961519718	100	0	100	1000000	1000000	1050000	1470000	115,783.113125	78,764.0225337
4	1000	25	100	10000	1	1	13.2196011543	100	0	100	1000000	1000000	1050000	1470000	111,198.513695	75,645.2474115
5	1000	30	100	10000	1	1	13.706758976	100	0	100	1000000	1000000	1050000	1470000	107,246.359448	72,956.7071072
6	1000	35	100	10000	1	1	14.1803789139	100	0	100	1000000	1000000	1050000	1470000	103,664.366723	70,519.9773626
7	1000	40	100	10000	1	1	14.7186419964	100	0	100	1000000	1000000	1050000	1470000	99,873.3443181	67,941.0505565
8	1000	45	100	10000	1	1	15.2245650291	100	0	100	1000000	1000000	1050000	1470000	96,554.4826526	65,683.3215324
9	1000	50	100	10000	1	1	15.7136700153	100	0	100	1000000	1000000	1050000	1470000	93,549.1198788	63,638.8570604
10	1000	55	100	10000	1	1	16.1962049007	100	0	100	1000000	1000000	1050000	1470000	90,762.0031365	61,742.8592765
11	1000	60	100	10000	1	1	16.7253010273	100	0	100	1000000	1000000	1050000	1470000	87,890.7947666	59,789.6563038
12	1000	65	100	10000	1	1	17.2288339138	100	0	100	1000000	1000000	1050000	1470000	85,322.0831633	58,042.2334444
13	1000	70	100	10000	1	1	17.7217071056	100	0	100	1000000	1000000	1050000	1470000	82,949.1194746	56,427.9724317
14	1000	75	100	10000	1	1	18.204182148	100	0	100	1000000	1000000	1050000	1470000	80,750.6752048	54,932.4321121
15	1000	80	100	10000	1	1	18.7330708504	100	0	100	1000000	1000000	1050000	1470000	78,470.8503876	53,381.5308759
16	1000	85	100	10000	1	1	19.2108118534	100	0	100	1000000	1000000	1050000	1470000	76,519.4105911	52,054.0208103
17	1000	90	100	10000	1	1	19.6827020645	100	0	100	1000000	1000000	1050000	1470000	74,684.8677169	50,806.0324605
18	1000	95	100	10000	1	1	20.1793000698	100	0	100	1000000	1000000	1050000	1470000	72,846.9270448	49,555.7326835
19	1000	100	100	10000	1	1	20.7029349804	100	0	100	1000000	1000000	1050000	1470000	71,004.4252852	48,302.330126

RTT - SERVER

Attempt	Data rate (kbit)	Delay (ms)	Data Frame	Data size (bytes)	Windows size	Duration	Original Packets Received	Acks Sent	Total Data Received	Total Bytes Received	Total Bytes Received Inc Headers	Errors	receive Rate	Throughput
1	100000	0	100	10000	1	12.179432869	100	100	1000000	1000000	1470000	0	120,695.275044	82,105.6292817
2	100000	0	100	10000	1	12.5500099659	100	100	1000000	1000000	1470000	0	117,131.38109	79,681.2116259
3	100000	0	100	10000	1	13.0987100601	100	100	1000000	1000000	1470000	0	112,224.791087	76,343.395297
4	100000	0	100	10000	1	13.6325519085	100	100	1000000	1000000	1470000	0	107,830.141405	73,353.8376903
5	100000	0	100	10000	1	14.1322600842	100	100	1000000	1000000	1470000	0	104,017.332772	70,760.0903214
6	100000	0	100	10000	1	14.6174559593	100	100	1000000	1000000	1470000	0	100,564.694985	68,411.3571324
7	100000	0	100	10000	1	15.1666250229	100	100	1000000	1000000	1470000	0	96,923.3430497	65,934.2469726
8	100000	0	100	10000	1	15.6829040051	100	100	1000000	1000000	1470000	0	93,732.6403022	63,763.7008859
9	100000	0	100	10000	1	16.183660984	100	100	1000000	1000000	1470000	0	90,832.3525468	61,790.7160182
10	100000	0	100	10000	1	16.6753129959	100	100	1000000	1000000	1470000	0	88,154.2673508	59,968.8893543
11	100000	0	100	10000	1	17.2212250233	100	100	1000000	1000000	1470000	0	85,359.781201	58,067.878368
12	100000	0	100	10000	1	17.7366831303	100	100	1000000	1000000	1470000	0	82,879.0811227	56,380.3272943
13	100000	0	100	10000	1	18.2399759293	100	100	1000000	1000000	1470000	0	80,592.2116181	54,824.6337538
14	100000	0	100	10000	1	18.7336130142	100	100	1000000	1000000	1470000	0	78,468.5793864	53,379.9859771
15	100000	0	100	10000	1	19.2770168781	100	100	1000000	1000000	1470000	0	76,256.6121767	51,875.2463787
16	100000	0	100	10000	1	19.7645061016	100	100	1000000	1000000	1470000	0	74,375.7517867	50,595.7495148
17	100000	0	100	10000	1	20.2446680069	100	100	1000000	1000000	1470000	0	72,611.7118591	49,395.7223531
18	100000	0	100	10000	1	20.7555670738	100	100	1000000	1000000	1470000	0	70,824.371831	48,179.844783
19	100000	0	100	10000	1	21.2897949219	100	100	1000000	1000000	1470000	0	69,047.1658085	46,970.8610942

RTT (Delay) Experiment							
Attempt	Data Rate (kbit)	Delay (ms)	Data Frame	Data size (bytes)	Windows size	Throughput	Efficiency
1	1000	10	100	10000	1	82,105.63	65.68
2	1000	15	100	10000	1	79,681.21	63.74
3	1000	20	100	10000	1	76,343.40	61.07
4	1000	25	100	10000	1	73,353.84	58.68
5	1000	30	100	10000	1	70,760.09	56.61
6	1000	35	100	10000	1	68,411.36	54.73
7	1000	40	100	10000	1	65,934.25	52.75
8	1000	45	100	10000	1	63,763.70	51.01
9	1000	50	100	10000	1	61,790.72	49.43
10	1000	55	100	10000	1	59,968.89	47.98
11	1000	60	100	10000	1	58,067.88	46.45
12	1000	65	100	10000	1	56,380.33	45.10
13	1000	70	100	10000	1	54,824.63	43.86
14	1000	75	100	10000	1	53,379.99	42.70
15	1000	80	100	10000	1	51,875.25	41.50
16	1000	85	100	10000	1	50,595.75	40.48
17	1000	90	100	10000	1	49,395.72	39.52
18	1000	95	100	10000	1	48,179.84	38.54
19	1000	100	100	10000	1	46,970.86	37.58

RTT (Delay) Expected									
Attempt	Data Rate (kbit)	Delay (ms)	Data Frame	Data Size (bytes)	Windows Size	Header Size	Total Time With No Error (t)	Throughput	Efficiency
1	1000	10	100	10000	1	4,700.00	0.13	626,959.25	62.70
2	1000	15	100	10000	1	4,700.00	0.13	603,318.25	60.33
3	1000	20	100	10000	1	4,700.00	0.14	581,395.35	58.14
4	1000	25	100	10000	1	4,700.00	0.14	561,009.82	56.10
5	1000	30	100	10000	1	4,700.00	0.15	542,005.42	54.20
6	1000	35	100	10000	1	4,700.00	0.15	524,246.40	52.42
7	1000	40	100	10000	1	4,700.00	0.16	507,614.21	50.76
8	1000	45	100	10000	1	4,700.00	0.16	492,004.92	49.20
9	1000	50	100	10000	1	4,700.00	0.17	477,326.97	47.73
10	1000	55	100	10000	1	4,700.00	0.17	463,499.42	46.35
11	1000	60	100	10000	1	4,700.00	0.18	450,450.45	45.05
12	1000	65	100	10000	1	4,700.00	0.18	438,116.10	43.81
13	1000	70	100	10000	1	4,700.00	0.19	426,439.23	42.64
14	1000	75	100	10000	1	4,700.00	0.19	415,368.64	41.54
15	1000	80	100	10000	1	4,700.00	0.20	404,858.30	40.49
16	1000	85	100	10000	1	4,700.00	0.20	394,866.73	39.49
17	1000	90	100	10000	1	4,700.00	0.21	385,356.45	38.54
18	1000	95	100	10000	1	4,700.00	0.21	376,293.51	37.63
19	1000	100	100	10000	1	4,700.00	0.22	367,647.06	36.76



DATA SIZE - CLIENT

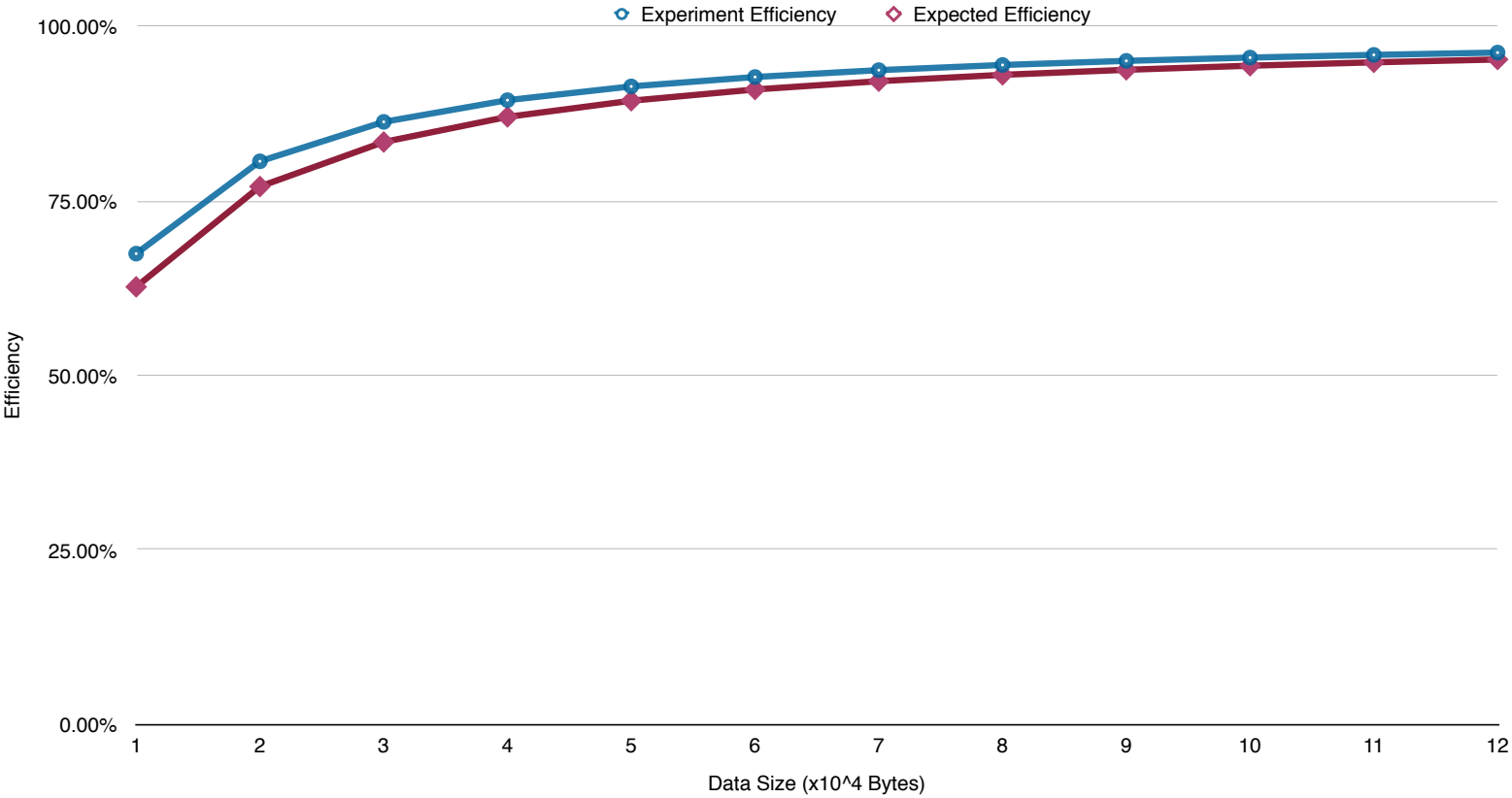
Attempt	Packets	Data Size	Datarate (Mb/s)	Windows Size	Duration	Packet Sent	Ack Sent	Data Received	Byte Received	Total Byte Received Inc Headers	Error	Receive Rate	Throughput	Efficiency
1	100	10000	1	1	11.860	100	100	1000000	1000000	1470000	0	123,951.20	84,320.54	67.46%
2	100	20000	1	1	19.830	100	100	2000000	2000000	2470000	0	124,558.94	100,857.44	80.69%
3	100	30000	1	1	27.799	100	100	3000000	3000000	3470000	0	124,826.02	107,918.75	86.33%
4	100	40000	1	1	35.776	100	100	4000000	4000000	4470000	0	124,945.50	111,808.06	89.45%
5	100	50000	1	1	43.755	100	100	5000000	5000000	5470000	0	125,014.33	114,272.69	91.42%
6	100	60000	1	1	51.744	100	100	6000000	6000000	6470000	0	125,038.18	115,955.04	92.76%
7	100	70000	1	1	59.735	100	100	7000000	7000000	7470000	0	125,052.16	117,184.09	93.75%
8	100	80000	1	1	67.733	100	100	8000000	8000000	8470000	0	125,049.42	118,110.43	94.49%
9	100	90000	1	1	75.728	100	100	9000000	9000000	9470000	0	125,052.75	118,846.33	95.08%
10	100	100000	1	1	83.727	100	100	10000000	10000000	10470000	0	125,049.28	119,435.80	95.55%
11	100	110000	1	1	91.729	100	100	11000000	10190000	10660000	0	116,211.57	119,918.13	95.93%
12	100	120000	1	1	99.725	100	100	12000000	10190000	10660000	0	106,894.09	120,331.05	96.26%

DATA SIZE - SERVER

Attempt	Packets	Frame Size	Windows Size	Duration	Packet Sent	Ack Sent	Data Received	Byte Received	Total Byte Received Inc Headers	Error	Receive Rate	Throughput
1	100	10000	1	11.8595058918	100	100	1000000	1000000	1470000	0	123,951.201122	84,320.5449808
2	100	20000	1	19.8299689293	100	100	2000000	2000000	2470000	0	124,558.944535	100,857.444968
3	100	30000	1	27.798691988	100	100	3000000	3000000	3470000	0	124,826.017048	107,918.746727
4	100	40000	1	35.7755968571	100	100	4000000	4000000	4470000	0	124,945.504553	111,808.057766
5	100	50000	1	43.7549850941	100	100	5000000	5000000	5470000	0	125,014.32667	114,272.693483
6	100	60000	1	51.7441949844	100	100	6000000	6000000	6470000	0	125,038.180649	115,955.036151
7	100	70000	1	59.7350730896	100	100	7000000	7000000	7470000	0	125,052.161379	117,184.086968
8	100	80000	1	67.7332217693	100	100	8000000	8000000	8470000	0	125,049.418568	118,110.430761
9	100	90000	1	75.7280399799	100	100	9000000	9000000	9470000	0	125,052.754601	118,846.33489
10	100	100000	1	83.7269921303	100	100	10000000	10000000	10470000	0	125,049.279015	119,435.796576
11	100	110000	1	91.7292461395	100	100	11000000	10190000	10660000	0	116,211.573175	119,918.13367
12	100	120000	1	99.7248809338	100	100	12000000	10190000	10660000	0	106,894.086011	120,331.053671

Experiment Data Size									
Attempt	Packets	Data Size	Data Rate (kbit)	Windows Size	Duration	Error	Receive Rate	Throughput	Efficiency
1	100	10000	1,000	1	11.860	0	123,951.20	84,320.54	67.46%
2	100	20000	1,000	1	19.830	0	124,558.94	100,857.44	80.69%
3	100	30000	1,000	1	27.799	0	124,826.02	107,918.75	86.33%
4	100	40000	1,000	1	35.776	0	124,945.50	111,808.06	89.45%
5	100	50000	1,000	1	43.755	0	125,014.33	114,272.69	91.42%
6	100	60000	1,000	1	51.744	0	125,038.18	115,955.04	92.76%
7	100	70000	1,000	1	59.735	0	125,052.16	117,184.09	93.75%
8	100	80000	1,000	1	67.733	0	125,049.42	118,110.43	94.49%
9	100	90000	1,000	1	75.728	0	125,052.75	118,846.33	95.08%
10	100	100000	1,000	1	83.727	0	125,049.28	119,435.80	95.55%
11	100	110000	1,000	1	91.729	0	116,211.57	119,918.13	95.93%
12	100	120000	1,000	1	99.725	0	106,894.09	120,331.05	96.26%

Expected Data Size										
Attempt	Packets	Data Size	Data Rate (kbit)	Windows Size	Delay (ms)	Total Time With No Error (t)	Error	Receive Rate	Throughput	Efficiency
1	100	10000	1,000	1	10	0.128	0	123,951.20	626,959.25	62.70%
2	100	20000	1,000	1	10	0.208	0	124,558.94	770,712.91	77.07%
3	100	30000	1,000	1	10	0.288	0	124,826.02	834,492.35	83.45%
4	100	40000	1,000	1	10	0.368	0	124,945.50	870,511.43	87.05%
5	100	50000	1,000	1	10	0.448	0	125,014.33	893,655.05	89.37%
6	100	60000	1,000	1	10	0.528	0	125,038.18	909,780.14	90.98%
7	100	70000	1,000	1	10	0.608	0	125,052.16	921,658.99	92.17%
8	100	80000	1,000	1	10	0.688	0	125,049.42	930,773.71	93.08%
9	100	90000	1,000	1	10	0.768	0	125,052.75	937,988.54	93.80%
10	100	100000	1,000	1	10	0.848	0	125,049.28	943,841.43	94.38%
11	100	110000	1,000	1	10	0.928	0	116,211.57	948,684.78	94.87%
12	100	120000	1,000	1	10	1.008	0	106,894.09	952,759.03	95.28%



TIMEOUT - CLIENT

Frame No	Frame Size	Windows Size	Duration	Datarate (Kb/s)	Original Packets Received	Acks Sent	Total Data Received	Total Bytes Received	Total Bytes Received Inc Header	Timeout	Errors	ReceiveRate	Throughput	Efficiency
100	10000	1	12.45	1000	100	100	1000000	1000000	1470000	0.1	6	118,053.93	80,308.80	64.25%
100	10000	1	14.86	1000	100	100	1000000	1000000	1470000	0.5	6	98,934.22	67,302.19	53.84%
100	10000	1	16.10	1000	100	100	1000000	1000000	1470000	0.6	7	91,322.91	62,124.43	49.70%
100	10000	1	14.70	1000	100	100	1000000	1000000	1470000	0.7	4	100,033.64	68,050.09	54.44%
100	10000	1	15.06	1000	100	100	1000000	1000000	1470000	0.8	4	97,589.99	66,387.75	53.11%
100	10000	1	18.19	1000	100	100	1000000	1000000	1470000	0.9	7	80,830.83	54,986.96	43.99%
100	10000	1	16.87	1000	100	100	1000000	1000000	1470000	1.0	5	87,131.53	59,273.15	47.42%
100	10000	1	27.86	1000	100	100	1000000	1000000	1470000	2.0	8	52,759.40	35,890.75	28.71%
100	10000	1	36.86	1000	100	100	1000000	1000000	1470000	5.0	5	39,877.19	27,127.34	21.70%

TIMEOUT - SERVER

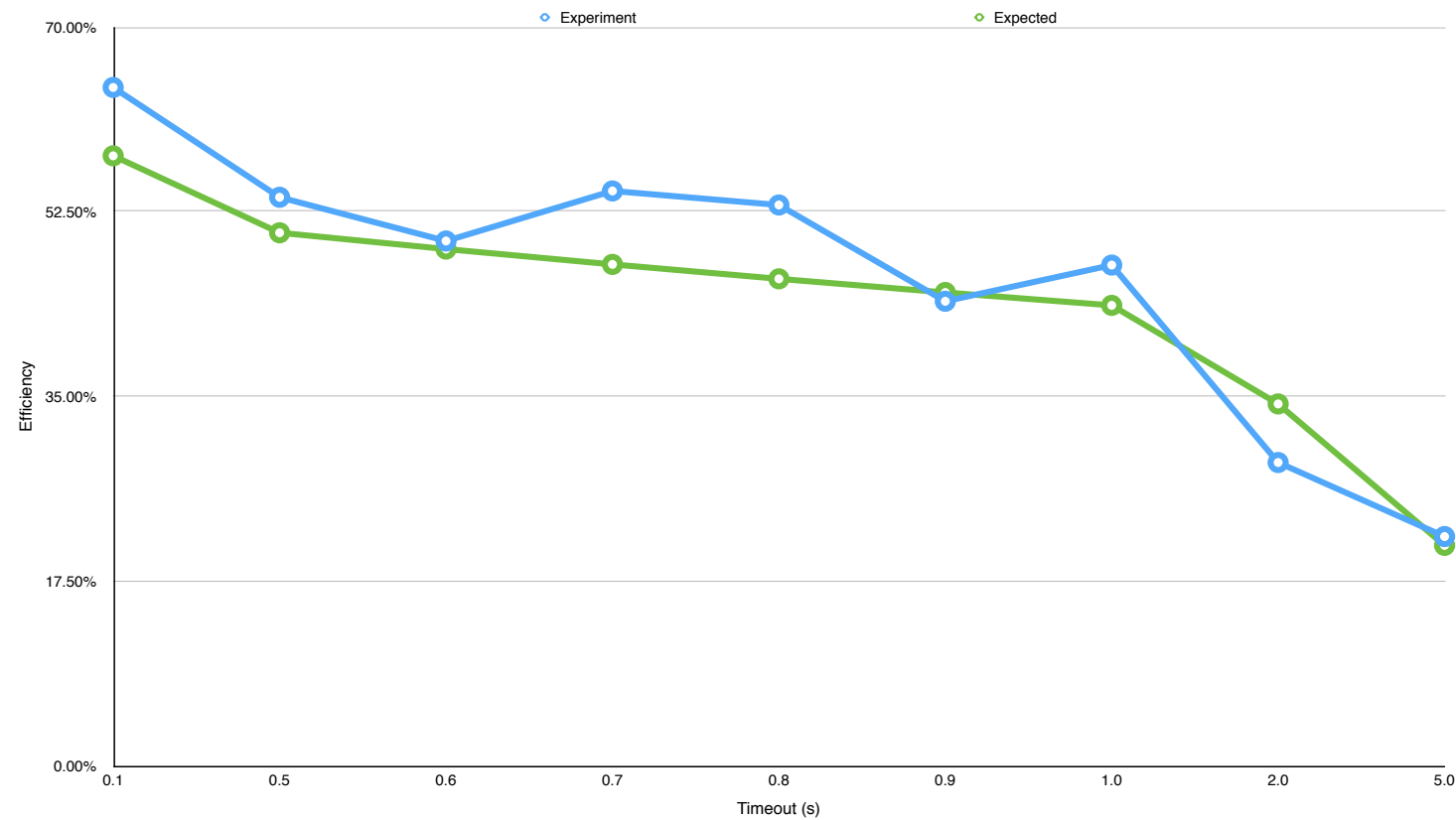
Frame No	Frame Size	Windows Size	Duration	Datarate (Kb/s)	Timeout (t0)	Error Rate	Delay (ms)	Total Time With No Error (t)	Total Time With Error (t1)	Average Time (Ta)	Throughput	Efficiency
100	10000	1	12.45	1000	0.1	5%	10.00	0.1276	0.345	0.138	577,700.75	57.77%
100	10000	1	14.86	1000	0.5	5%	10.00	0.1276	0.745	0.158	504,795.56	50.48%
100	10000	1	16.10	1000	0.6	5%	10.00	0.1276	0.845	0.163	489,356.50	48.94%
100	10000	1	14.70	1000	0.7	5%	10.00	0.1276	0.945	0.168	474,833.81	47.48%
100	10000	1	15.06	1000	0.8	5%	10.00	0.1276	1.045	0.173	461,148.26	46.11%
100	10000	1	18.19	1000	0.9	5%	10.00	0.1276	1.145	0.178	448,229.49	44.82%
100	10000	1	16.87	1000	1.0	5%	10.00	0.1276	1.245	0.183	436,014.82	43.60%
100	10000	1	27.86	1000	2.0	5%	10.00	0.1276	2.245	0.233	342,641.77	34.26%
100	10000	1	36.86	1000	5.0	5%	10.00	0.1276	5.245	0.383	208,615.83	20.86%

Timeout Experiment

Attempt	Frame No	Frame Size	Windows Size	Duration	Datarate (Kb/s)	Timeout	Errors	Throughput	Efficiency
1	100	10000	1	12.45	1000	0.1	6	80,308.80	64.25%
2	100	10000	1	14.86	1000	0.5	6	67,302.19	53.84%
3	100	10000	1	16.10	1000	0.6	7	62,124.43	49.70%
4	100	10000	1	14.70	1000	0.7	4	68,050.09	54.44%
5	100	10000	1	15.06	1000	0.8	4	66,387.75	53.11%
6	100	10000	1	18.19	1000	0.9	7	54,986.96	43.99%
7	100	10000	1	16.87	1000	1.0	5	59,273.15	47.42%
8	100	10000	1	27.86	1000	2.0	8	35,890.75	28.71%
9	100	10000	1	36.86	1000	5.0	5	27,127.34	21.70%

Timeout Expected

Attempt	Frame No	Frame Size	Windows Size	Duration	Datarate (Kb/s)	Timeout (t0)	Error Rate	Delay (ms)	Total Time With No Error (t)	Total Time With Error (t1)	Average Time (Ta)	Throughput	Efficiency
1	100	10000	1	12.45	1000	0.1	5%	10.00	0.1276	0.345	0.138	577,700.75	57.77%
2	100	10000	1	14.86	1000	0.5	5%	10.00	0.1276	0.745	0.158	504,795.56	50.48%
3	100	10000	1	16.10	1000	0.6	5%	10.00	0.1276	0.845	0.163	489,356.50	48.94%
4	100	10000	1	14.70	1000	0.7	5%	10.00	0.1276	0.945	0.168	474,833.81	47.48%
5	100	10000	1	15.06	1000	0.8	5%	10.00	0.1276	1.045	0.173	461,148.26	46.11%
6	100	10000	1	18.19	1000	0.9	5%	10.00	0.1276	1.145	0.178	448,229.49	44.82%
7	100	10000	1	16.87	1000	1.0	5%	10.00	0.1276	1.245	0.183	436,014.82	43.60%
8	100	10000	1	27.86	1000	2.0	5%	10.00	0.1276	2.245	0.233	342,641.77	34.26%
9	100	10000	1	36.86	1000	5.0	5%	10.00	0.1276	5.245	0.383	208,615.83	20.86%



DATA RATE - SERVER

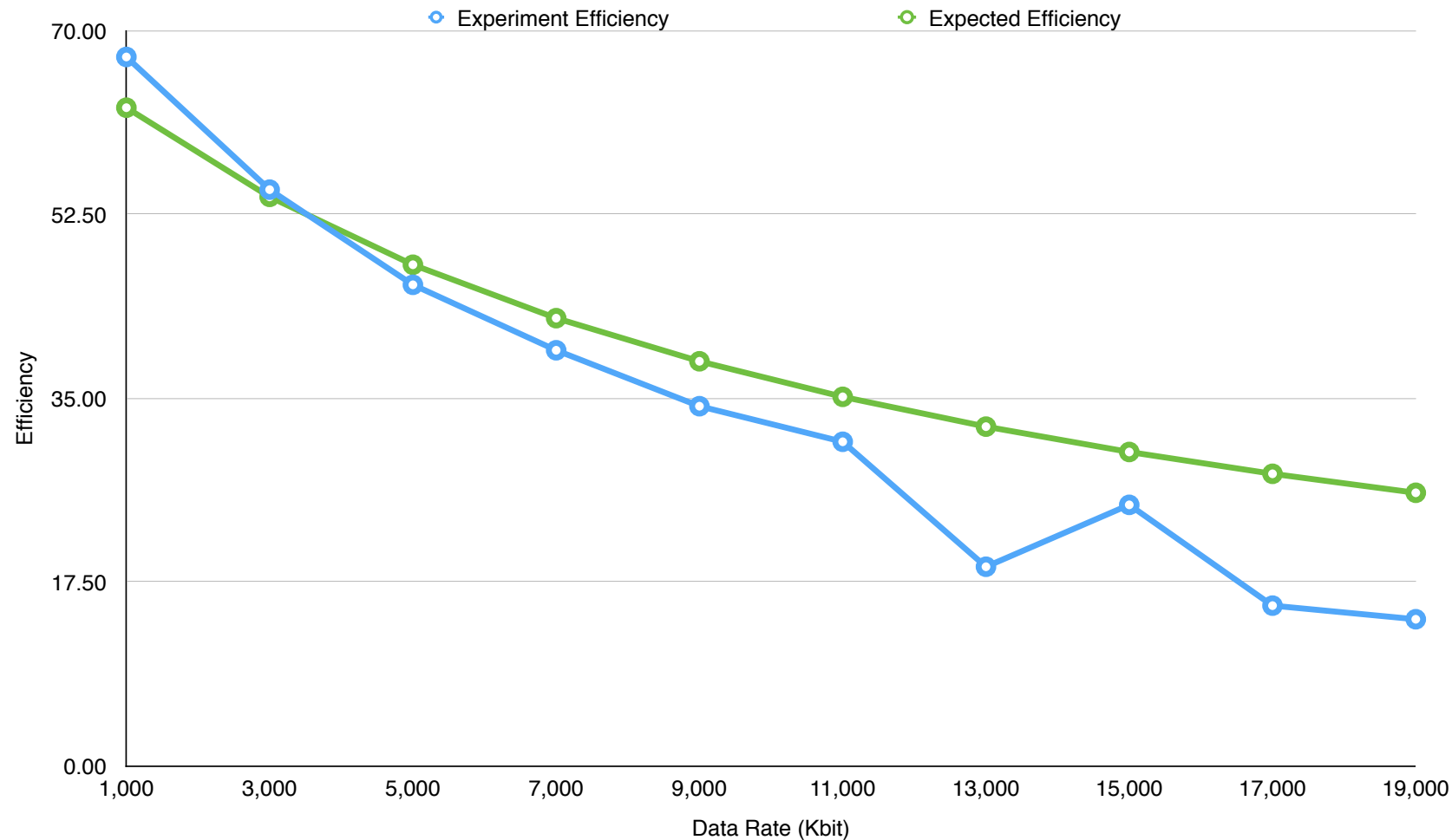
Packets	Frame Size	Windows Size	Data Rate	Duration	Pack Sent	Ack Sent	Data Received	Byte Received	Total Byte Received Inc Head	Error	Receive Rate	Throughput	Efficiency
100	10000	1	1,000	11.8468091488	100	100	1000000	1000000	1470000	0	124,084.04504	84,410.9149933	67.5287320
100	10000	1	3,000	4.8585088253	100	100	1000000	1000000	1470000	0	302,561.969702	205,824.469185	54.8865251
100	10000	1	5,000	3.49172902107	100	100	1000000	1000000	1470000	0	420,994.868482	286,391.066994	45.8225707
100	10000	1	7,000	2.88703203201	100	100	1000000	1000000	1470000	0	509,173.429217	346,376.482461	39.5858837
100	10000	1	9,000	2.59476399422	100	100	1000000	1000000	1470000	0	566,525.511868	385,391.504672	34.2570226
100	10000	1	11,000	2.35607004166	100	100	1000000	1000000	1470000	0	623,920.330894	424,435.599248	30.8680436
100	10000	1	13,000	3.2454419136	100	100	1000000	1000000	1470000	0	452,942.9394	308,124.448571	18.9615045
100	10000	1	15,000	2.1454398632	100	100	1000000	1000000	1470000	0	685,174.180461	466,104.884667	24.8589272
100	10000	1	17,000	3.08422708511	100	100	1000000	1000000	1470000	0	476,618.601495	324,230.341153	15.2578984
100	10000	1	19,000	3.01626682281	100	100	1000000	1000000	1470000	0	487,357.414431	331,535.656075	13.9593960

Experiment Data Rate

Attempt	Packets	Frame Size	Windows Size	Data Rate	Duration	Throughput	Efficiency
1	100	10000	1	1,000	11.8468091488	84,410.9149933	67.5287320
2	100	10000	1	3,000	4.8585088253	205,824.469185	54.8865251
3	100	10000	1	5,000	3.49172902107	286,391.066994	45.8225707
4	100	10000	1	7,000	2.88703203201	346,376.482461	39.5858837
5	100	10000	1	9,000	2.59476399422	385,391.504672	34.2570226
6	100	10000	1	11,000	2.35607004166	424,435.599248	30.8680436
7	100	10000	1	13,000	3.2454419136	308,124.448571	18.9615045
8	100	10000	1	15,000	2.1454398632	466,104.884667	24.8589272
9	100	10000	1	17,000	3.08422708511	324,230.341153	15.2578984
10	100	10000	1	19,000	3.01626682281	331,535.656075	13.9593960

Expected - Data Rate

Attempt	Packets	Frame Size	Windows Size	Data Rate	Delay (ms)	Total Time With No Error (t)	Throughput	Efficiency
1	100	10000	1	1,000	10	0.1276000	626,959.2476489	62.6959248
2	100	10000	1	3,000	10	0.0492000	1,626,016.2601626	54.2005420
3	100	10000	1	5,000	10	0.0335200	2,386,634.8448687	47.7326969
4	100	10000	1	7,000	10	0.0268000	2,985,074.6268657	42.6439232
5	100	10000	1	9,000	10	0.0230667	3,468,208.0924856	38.5356455
6	100	10000	1	11,000	10	0.0206909	3,866,432.3374341	35.1493849
7	100	10000	1	13,000	10	0.0190462	4,200,323.1017771	32.3101777
8	100	10000	1	15,000	10	0.0178400	4,484,304.9327354	29.8953662
9	100	10000	1	17,000	10	0.0169176	4,728,789.9860918	27.8164117
10	100	10000	1	19,000	10	0.0161895	4,941,482.4447334	26.0078023



Variable Parameters

<i>Parameter</i>	<i>Range</i>	<i>Unit</i>	<i>Count</i>
<i>Uplink data rate</i>	<i>1, 3, 5... ,19</i>	<i>Mb/s</i>	<i>9</i>
<i>Uplink delay</i>	<i>10, 15, ... ,100</i>	<i>ms</i>	<i>19</i>
<i>Frame error rate</i>	<i>0, 0.01, ... ,0.97</i>	<i>-</i>	<i>98</i>
<i>Max windows size ($2^n - 1$)</i>	<i>1, 3, 7, ... , 2097151</i>	<i>frames</i>	<i>20</i>
<i>Data size</i>	<i>1000, 2000, ... , 12000</i>	<i>Bytes</i>	<i>12</i>
<i>Timeout</i>	<i>0, 0.5 : 0.1 : 1.0, 2.0, 5.0</i>	<i>s</i>	<i>9</i>

Table 3: Variable Parameters

Performance Metrics

The performance metric(s) are: Throughput, in bits per second, as measured at the server

Mathematical Model

The variables use in the mathematical model used to calculate expected efficiency are:

- Data Size, **s** Bytes
- Frame Number, **n**
- Header Size, **h** Bytes
- Data Link delay, **p** seconds
- Data Rate, **r** b/s
- Error rate, E_r

Stop-and-wait flow control with no errors

Expected throughput of the stop-and-wait flow control with no errors, **ρ_1** , is calculated as:

- *Total time with no error, $t = \frac{(s+h)*8}{r} + p$*
- *Throughput, $\rho_1 = \frac{8ns}{nt}$*

Note: the size of an ack is very small ,so we treated it as zero. No transmission time and propagation delay for an ack.

Expected efficiency, **η_1** , is calculated as:

- *Efficiency, $\eta_1 = \left(\frac{\rho_1}{r}\right) * 100$*

Stop-and-wait flow control with errors

Expected throughput of the stop-and-wait flow control with errors, ρ_2 , is calculated as:

- Total time with no error, $t = \frac{(s+h)*8}{r} + p$
- Time out, t_o
- Total Time with Error, $t_1 = t + t_o + \frac{(s+h)*8}{r}$
- Average Time, $t_a = t * (1 - E_r) + (t_1 * E_r)$

Expected throughput, ρ_2 , is calculated as:

- Throughput, $\rho_2 = \frac{8ns}{nt_a}$

Note: the size of an ack is very small ,so we treated it as zero. So, no transmission time and propagation delay for an ack.

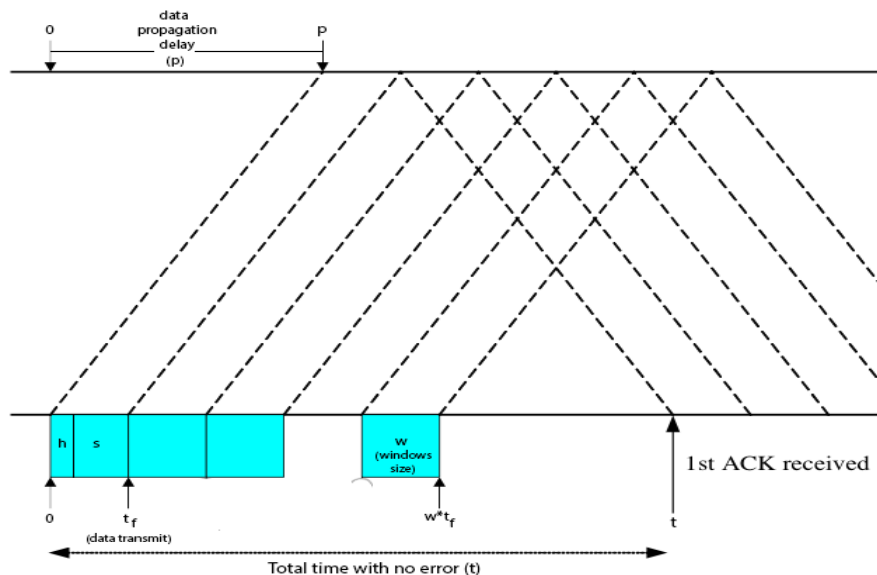
Expected efficiency, η_2 , is calculated as:

- Efficiency, $\eta_2 = ((\frac{\rho_2}{r}) * 100)$

Sliding Windows flow control with no errors

Expected throughput of the stop-and-wait flow control with errors, ρ_2 , is calculated as:

- Total time with no error for 1 frame, $t = \frac{(s+h)*8}{r} + p$
- Windows size, w
- Data transmit time for 1 frame, $t_f = \frac{(s+h)*8}{r}$



If $w * t_f$ is less than total time with no error for 1 frame (t)

Expected efficiency, η_3 , is calculated as:

$$\text{Efficiency, } \eta_3 = \left(\frac{ws}{tr} \right) * 100$$

Else If $w * t_f$ is larger than total time with no error for 1 frame (t)

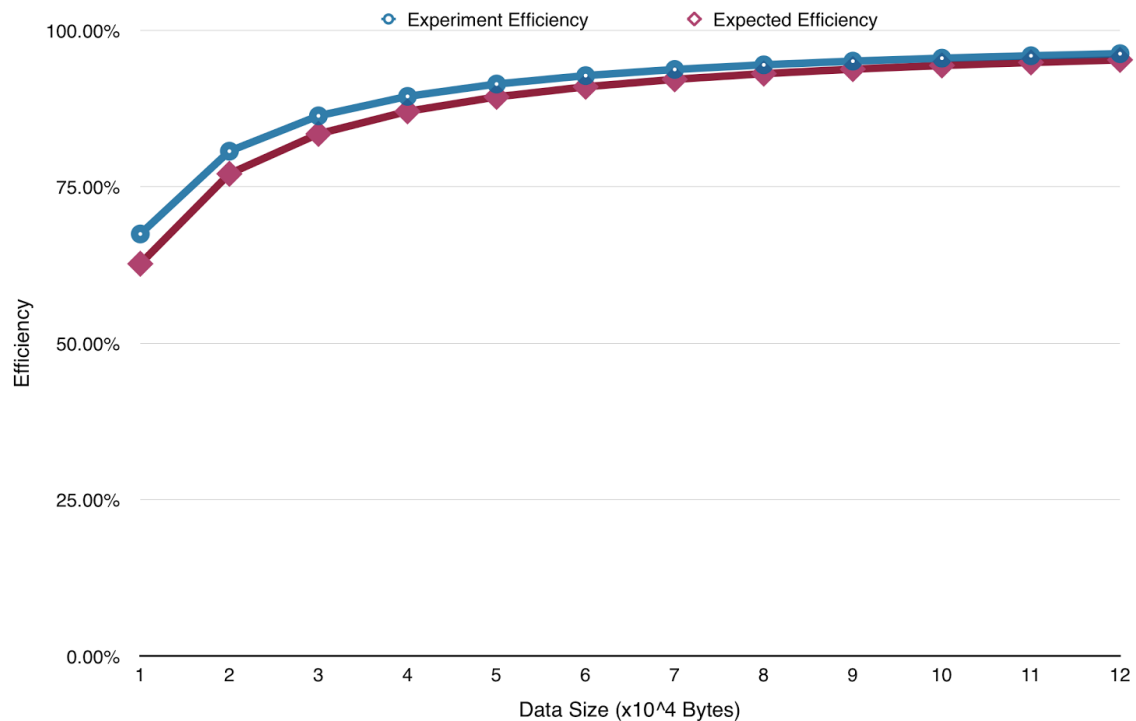
Expected efficiency, η_4 , is calculated as:

$$\text{Efficiency, } \eta_4 = \left(\frac{s}{s+h} \right) * 100$$

Results and Conclusions

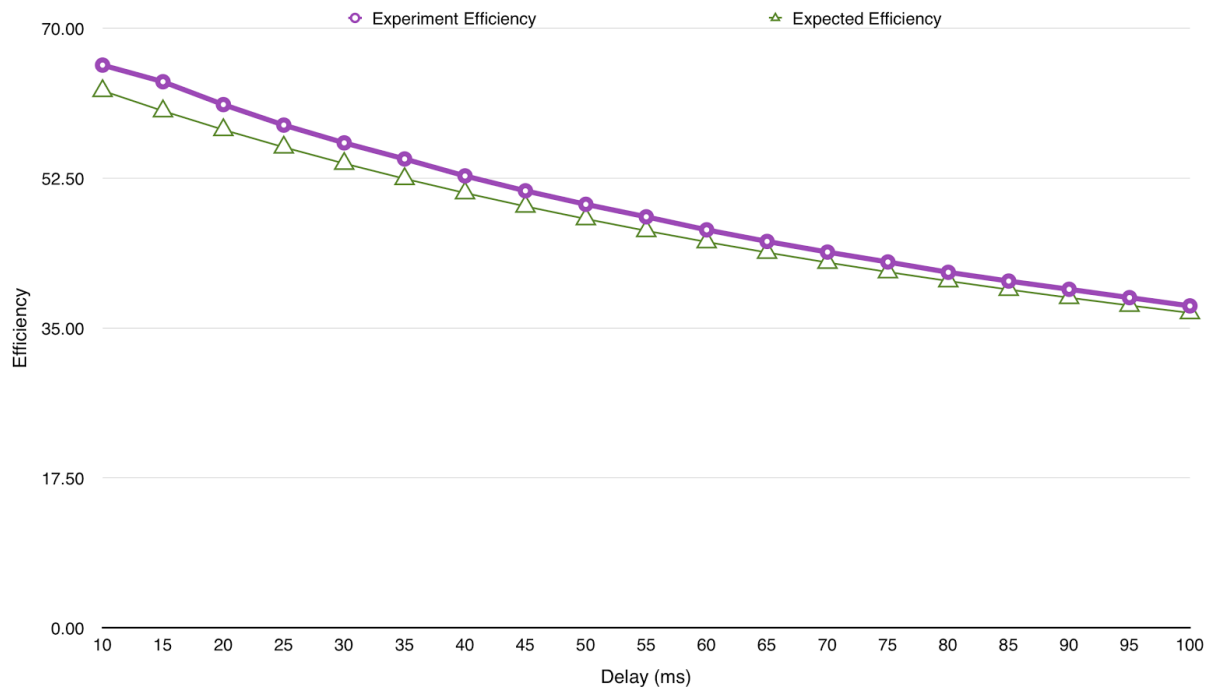
Stop-and-wait flow control with no errors

Illustration 1: Stop and Wait Efficiency with Varying Data Size



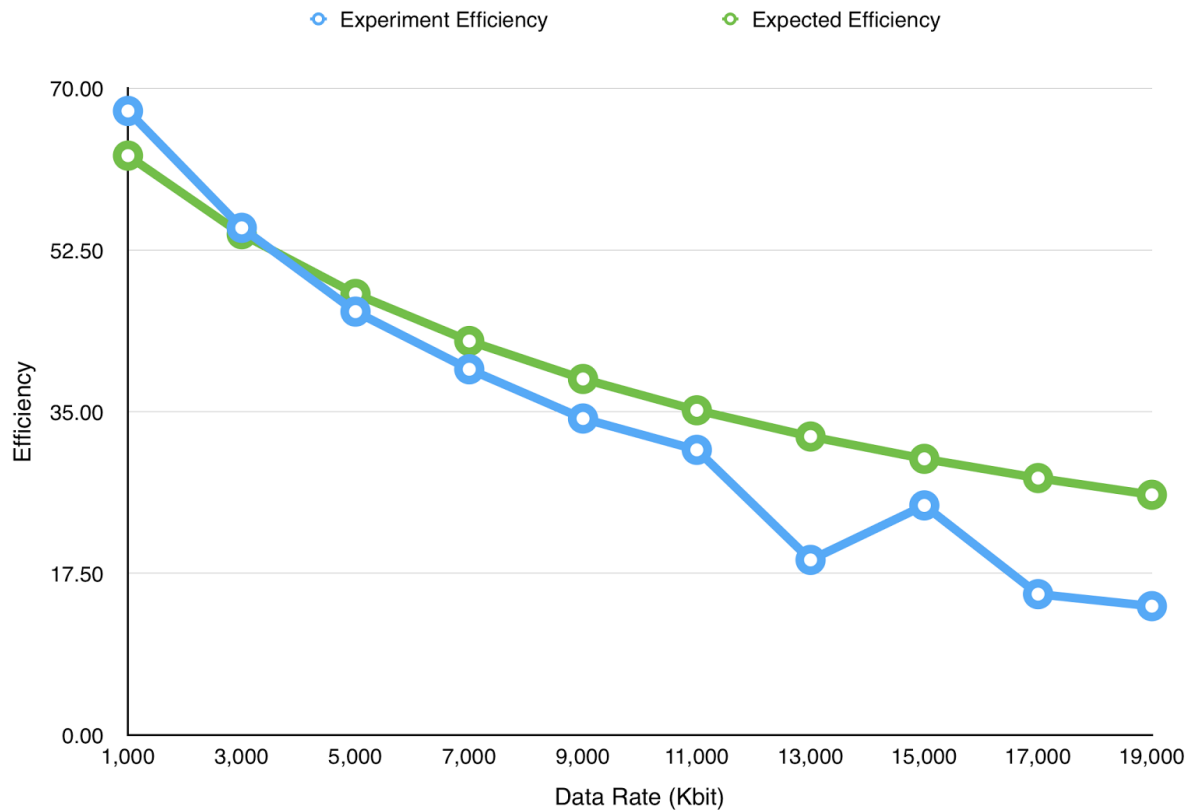
We have observed the increasing of the data size per frames. The efficiency of the stop and wait flow control is increasing as the data size increased. The increase of the efficiency is clearly observed between 10,000 Bytes and 50,000 Bytes. This is because the ratio of current data size and next data size is decreased while data size is increase. The expected efficiency is a little bit lower than the experiment because delay time that we set in the program might not execute exactly 10ms.

Illustration 2: Stop and Wait Efficiency with Varying RTT



We have observed the increasing of the delay. The efficiency of the stop and wait flow control is decreasing as the delay increased. We use uplink delay as the RTT because, the ack is very small so, we assume it to be zero. As the result, there is no any transmission and propagation delay for the ack. It is decreased because from throughput formula, we can see that if we increase total time by increasing the delay it will cause drop in efficiency.

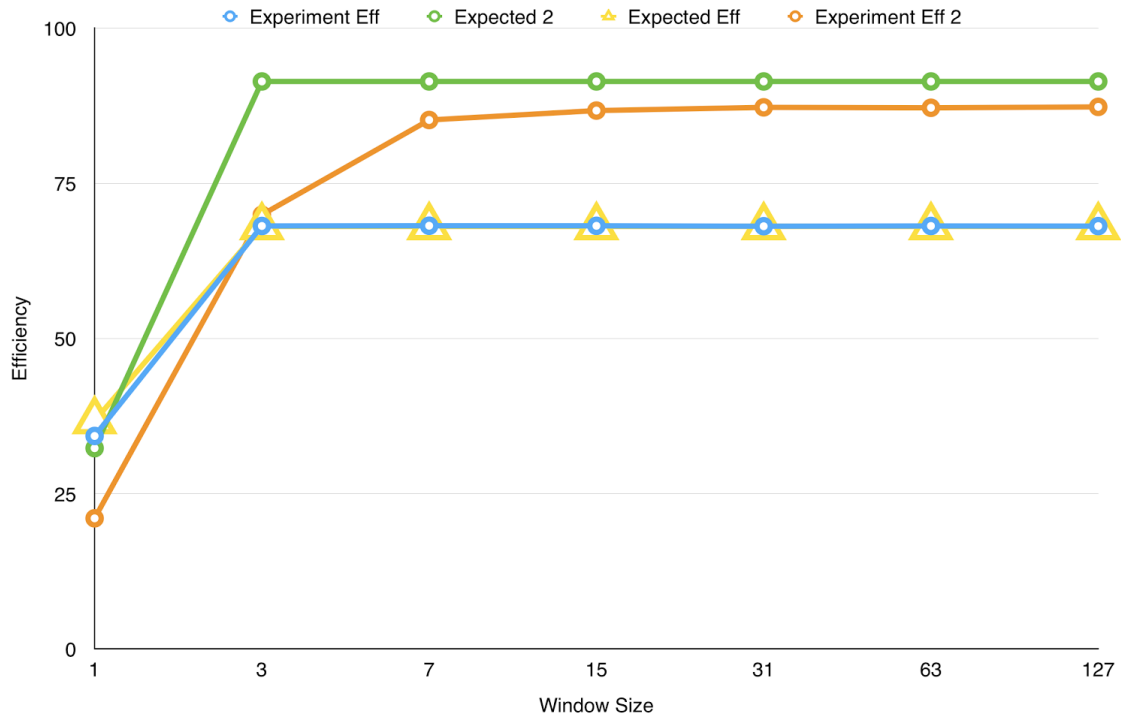
Illustration 3: Stop and Wait Efficiency with Varying Uplink Data Rate



We have observed the increasing of the uplink data rate. The efficiency of the stop and wait flow control is decreasing as the delay uplink data rate increases. The reason is, according to the formula, we have used the data rate as the denominator which is inversed variant to the efficiency.

Sliding Windows flow control with no errors

Illustration 4: Stop and Wait Efficiency with Varying Windows Size

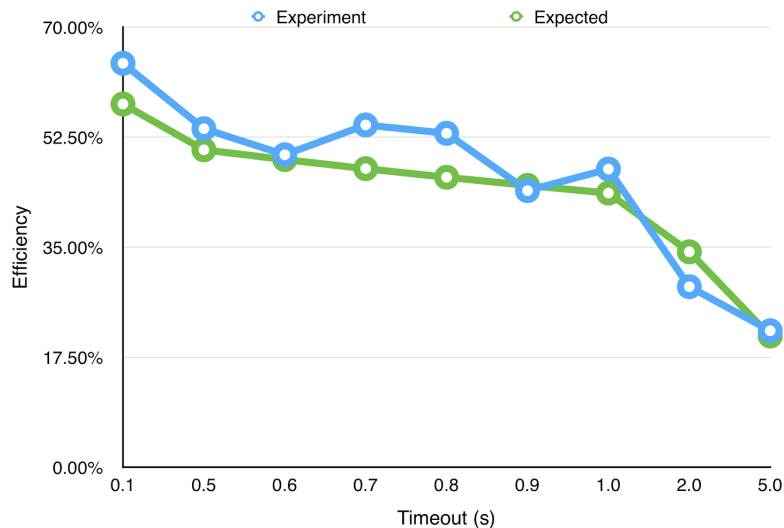


We have observed the increasing of the windows size. The efficiency of the sliding windows flow control is increasing as the windows size increases. The expected efficiency may look a bit different because, we have calculated efficiency from the formulas depends on the value of $w * t_f$ as mentioned before. First, the efficiency will increased dramatically but, at windows size = 31 the efficiency becomes almost stable no matter how much we increased later. This is because, at the certain data propagation delay, the increasing of the windows size will not affect in the efficiency anymore. Because when $w * t_f$ is higher than t from the equation, the efficiency will be calculated as *Efficiency*, $\eta_4 = \left(\frac{s}{s+h}\right) * 100$ which is not depends on the windows size, so the efficiency is stable.

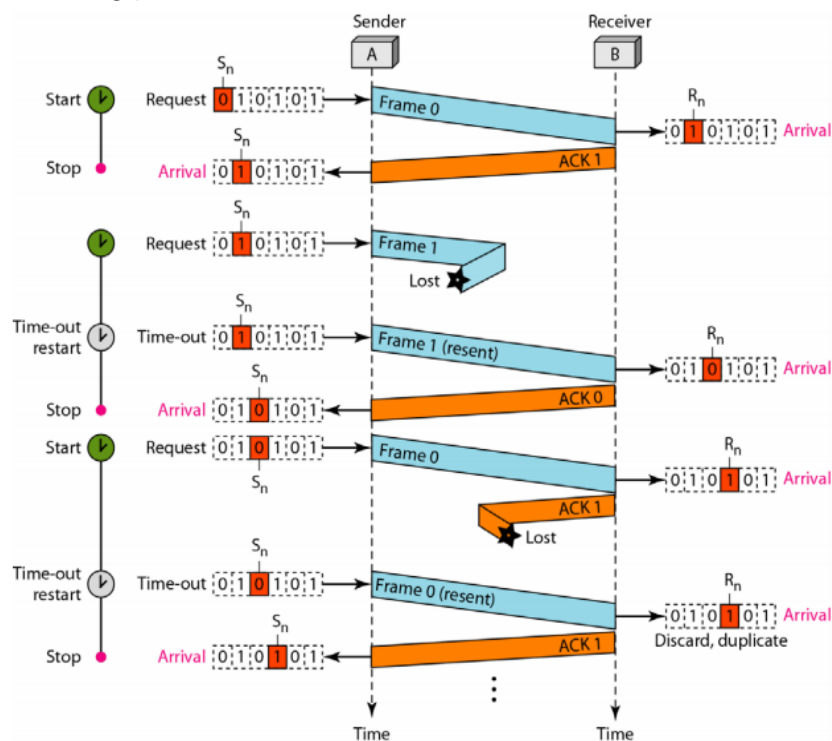
As the result we can conclude that data rate, data size and delay has also affect to the efficiency of the Sliding Windows flow control.

Stop-and-wait flow control with errors

Illustration 5: Stop and Wait Efficiency with Varying Timeout

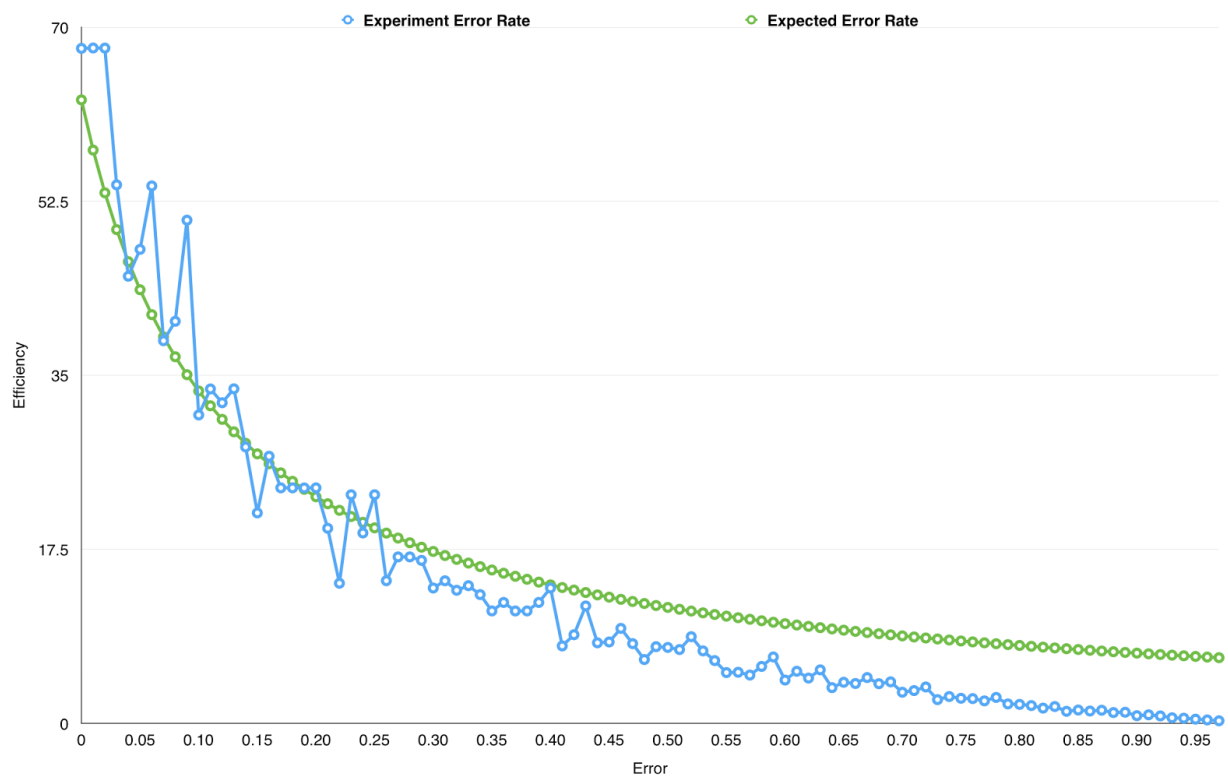


We have observed the increasing of the timeout. The efficiency of the stop and wait flow control is decreasing as the timeout increases. We have also set the timeout for this observation because when the data is successfully transmitted, the server should send back an ack to the sender within the timeout period. If the ack fails to propagate the sender has to wait until timeout expires to resend that data frame again, as well as the data transmission. If we don't set the error rate timeout will be useless, as error never occurs. This following picture also shows how the timeout works.



From: http://www.eecs.yorku.ca/course_archive/2010-11/F/3213/CSE3213_11_FlowErrorControl_F2010.pdf

Illustration 6: Stop and Wait Efficiency with Varying Error rate



We have observed the increasing of the error rate. The efficiency of the stop and wait flow control is decreasing as the error rate increases. This happens because, when data frame transmission gets an error, it has to send that frame again. This makes duration time increases dramatically and efficiency in vice versa.

Appendix
Result From Spread Sheet