

Load Testing and Analysis of Email Services

Brandon Rogers, Joseph J. Ekstrom, Charles Higby

Brigham Young University

Abstract

In modern business, electronic mail has become a requirement for efficient and profitable communication with clients, providers, and colleagues. Due to this dependency on electronic communication, mail servers used to send, relay, and receive messages are critical to a company's daily operations. It is imperative that the mail server is highly resistant to attacks to provide a company with the most cost effective and reliable service possible.

This paper describes the method and results of performance testing on several current email service implementations. Mail server software is configured on identical hardware where possible and tested for reactions to various simulated load conditions. For each configuration, throughput characteristics are measured and presented so that objective comparisons can be made.

Introduction

In 2003, Brigham Young University's School of Technology began building a laboratory for hardware and software testing and performance analysis. The lab contains 20 workstation computers, a few high-speed machines and switches, and one Itanium 64-bit computer. The purpose of this lab is to provide students and faculty with a means to perform research that can be used to characterize the performance of a system. This experimental environment is ideal for creating and performing benchmarking tests to scientifically describe the performance of these systems. This is one of two studies completed and used to christen this new lab.

Email Servers

Billions of email messages are sent daily to aide in business, education, and general communication¹. Email increases efficiency, enhances communication, and is one of the Internet's driving forces. With such demand for email, server performance and evaluations are also essential. Quantifying server performance can help in the decision of an appropriate email server for any given situation.

Two types of email servers help run the email system: mail / message transport agents (MTAs) and mail delivery agents (MDAs)². MTAs are burdened with the task of sending and forwarding email. MTAs are the programs responsible for delivering e-mail messages. Upon receiving a message the MTA stores it temporarily locally and analyses the recipients and either delivers it

(local addressee) or forwards it to another MTA (routing). In either case it may edit and/or add to the message headers³. Simple Mail Transport Protocol (SMTP) is by far the most popular of the transport agents.

MDAs have the responsibility to provide a way to retrieve messages from a server. MDAs interface with mail user agents (MUAs) and are commonly known as email clients carrying names such as Microsoft Outlook, Microsoft Outlook Express, Eudora, and Netscape Communicator. Two main protocols are used in MDAs, namely Post Office Protocol (POP) and Internet Message Access Protocol (IMAP). MDAs and MTAs work independently of one another yet interface to bring a suite of services known as email².

Many types of MTA servers and MDA servers exist. Among the most popular MTAs are Microsoft Exchange SMTP, Sendmail, and Postfix. Among the most popular MDAs are CommuniGate Pro, Cyrus, Dmail, Intermail, Post Office, and many more.

The purpose of this paper is to evaluate the performance of popular MTAs in terms of throughput and availability. Results from this study provide data on which to create mail server recommendations depending on load, throughput, and availability.

Method

Three popular SMTP servers were tested and rated: Microsoft Exchange, Postfix, and Sendmail. Each server has been loaded using the standard “out-of-the-box” installation. Changes in configuration are limited to removing external access restrictions, making it possible for an external testing client to be used. Each server was installed on its native operating systems as can be seen in Table 1.

Email Server	Native OS Platform
Sendmail	Red Hat Linux 9 (Kernel 2.4.20-8)
Postfix	Red Hat Linux 9 (Kernel 2.4.20-8)
Microsoft Exchange Server 2003	Microsoft Server 2003

Table 1 – Tested email servers and OS platforms.

The testing lab consists of a set of computers, clients and server, connected to a 100 Mbps Cisco Catalyst 3500 XL switch (Figure 1). The primary test client is equipped with an Intel Itanium 64-bit processor (900 MHz) with 1 gigabyte of RAM. A 100 Mbps FastEthernet network card was also installed on the primary test client. Secondary mail clients were included for preliminary tests. Each of these additional clients was outfitted with a Pentium 2 (500 MHz) processor, 512 MB RAM, and a 100 Mbps FastEthernet network card. The purpose of these additional test clients and the preliminary tests in which they were involved will be discussed later.

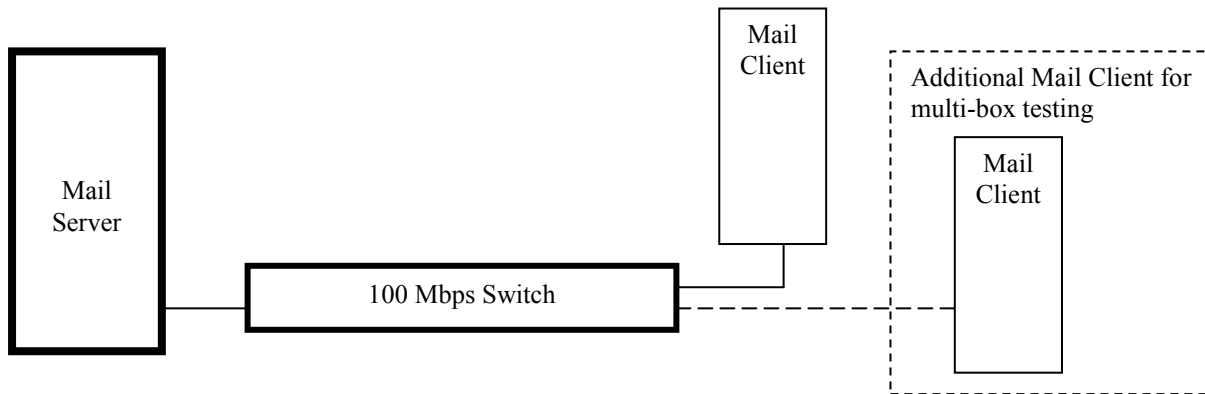


Figure 1 – Network configuration and topology for testing lab.

Each mail service was installed on an Intel Pentium 4 (1.8 GHz) computer with 512 MB RAM and a 100 Mbps FastEthernet network interface. The Postfix 1.1.13 (<http://www.postfix.org>) and Sendmail 8.12.9 (<http://www.sendmail.org>) servers were installed on Red Hat 9 Linux (Kernel 2.4.20-8). Microsoft Exchange Server 2003 was installed on Microsoft Server 2003. All Microsoft products were provided by the Microsoft Developer's Network Academic Alliance (MSDNAA). Each operating system was configured using the standard installation for a mail server. The mail server computer was configured to dual boot in order to provide access to both operating systems on identical hardware specifications.

Mail throughput is collected using the mail benchmark Postal (version 0.62), downloaded from <http://sourceforge.net/projects/postal/>. Postal floods the specified server with SMTP messages of random content and length, according to given parameters such as thread count, throughput throttle, and connections. For the purpose of testing, Postal was run using unthrottled throughput, a configuration of one message per connection, and variable thread counts.

All performance tests are automated through configuration of the Cron Daemon in Linux and Scheduled Tasks in Microsoft Server 2003. Each test spans 30 minutes, allowing for throughput and availability information to be collected. Server scripts for creating users, running and stopping benchmarking tests, and organizing collected data can be found in Appendix A.

Multiple client testing

To design an experiment that would give useful information, factors that were necessary to the performance of the mail servers needed to be determined. Unnecessary variables could be eliminated, if they were identified. To identify some of these variables that did not contribute to the results, preliminary tests were conducted.

Three factors were determined as possible contributors to the results of this study: concurrent processes in the test utility, multiple test clients, and the number of recipient users. Preliminary testing was then focused on determining the necessity of each of these three factors. Determining the necessity of multiple test clients required the employment of secondary test client machines. All preliminary tests in which multiple test client were used employed the

secondary test clients mentioned above. All secondary test clients were included in addition to the primary test client.

A comparison of the results of the preliminaries for PostFix and Exchange indicates that the number of processes and workstations running the benchmark utility did not affect throughput in a significant manner. All results from the multi-threaded tests against the Postfix and Exchange servers fell within accepted deviation of the single-threaded results (Appendix A). Multiple test clients and multiple threads in the test agent were eliminated as insignificant due to the test results (Appendix A).

Sendmail did exhibit failure in multiple process and multiple client benchmarks. Increase deviation began to occur in tests with 2 or more threads. Larger variation and eventual failure is caused by tests that include five or more test threads (Figure 2, 3). Adding a secondary client machine caused severely handicapped throughputs (Table 2, 3).

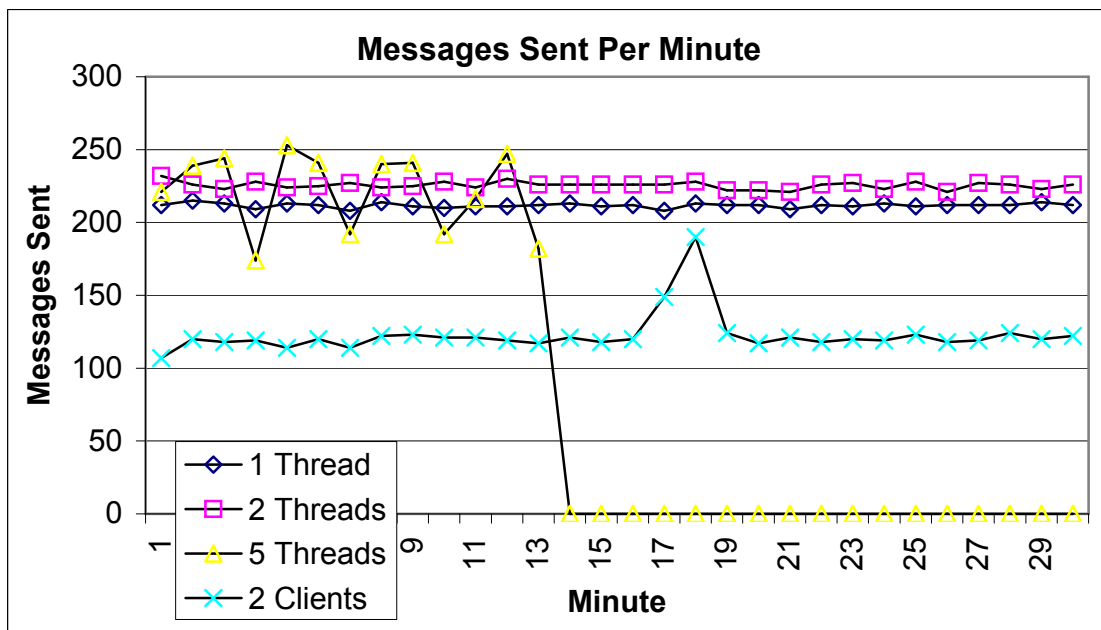


Figure 2 – SendMail message throughput in multi-threaded situations.

Minute	1 Thread	2 Threads	5 Threads	2 Clients	Average
1	212	232	221	107	193
2	215	226	239	120	200
3	213	223	244	118	199.5
4	209	228	174	119	182.5
5	213	224	253	114	201
6	212	225	241	120	199.5
7	208	227	192	114	185.25
8	214	224	240	122	200
9	211	225	241	123	200
10	210	228	192	121	187.75
11	211	224	216	121	193

12	211	230	247	119	201.75
13	212	226	182	117	184.25
14	213	226	0	121	140
15	211	226	0	118	138.75
16	212	226	0	120	139.5
17	208	226	0	149	145.75
18	213	228	0	190	157.75
19	212	222	0	124	139.5
20	212	222	0	117	137.75
21	209	221	0	121	137.75
22	212	226	0	118	139
23	211	227	0	120	139.5
24	213	223	0	119	138.75
25	211	228	0	123	140.5
26	212	221	0	118	137.75
27	212	227	0	119	139.5
28	212	226	0	124	140.5
29	214	223	0	120	139.25
30	212	226	0	122	140
AVERAGE	211.6666667	225.5333333	96.06666667	122.6	163.9666667
Min	208	221	0	107	137.75
Max	215	232	253	190	201.75
St. Dev	1.647010528	2.542512107	113.1367599	14.23836488	27.70657003

Table 2 – SendMail message throughput in multi-threaded situations.

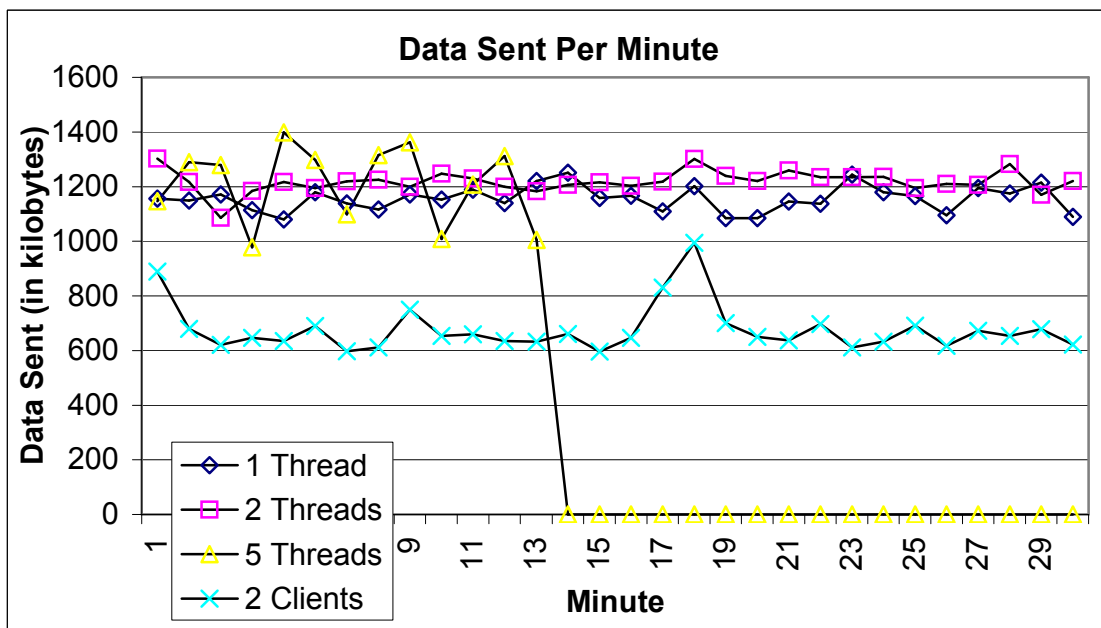


Figure 3 – SendMail data throughput in multi-threaded situations.

Minute	1 Thread	2 Threads	5 Threads	2 Clients	Average
1	1156	1302	1147	889	1123.5

2	1149	1217	1290	679	1083.75
3	1171	1086	1279	621	1039.25
4	1114	1184	978	647	980.75
5	1080	1217	1398	635	1082.5
6	1179	1195	1298	690	1090.5
7	1138	1219	1099	597	1013.25
8	1116	1225	1315	611	1066.75
9	1171	1199	1362	750	1120.5
10	1153	1248	1009	654	1016
11	1189	1230	1208	660	1071.75
12	1140	1200	1312	635	1071.75
13	1221	1183	1005	632	1010.25
14	1251	1206	0	661	779.5
15	1158	1216	0	596	742.5
16	1167	1203	0	647	754.25
17	1109	1218	0	830	789.25
18	1202	1301	0	994	874.25
19	1085	1239	0	700	756
20	1085	1220	0	650	738.75
21	1146	1259	0	637	760.5
22	1137	1234	0	697	767
23	1244	1234	0	611	772.25
24	1180	1236	0	632	762
25	1165	1195	0	691	762.75
26	1095	1210	0	617	730.5
27	1195	1207	0	672	768.5
28	1175	1283	0	654	778
29	1215	1170	0	678	765.75
30	1089	1220	0	622	732.75
AVERAGE	1155.833333	1218.533333	523.333333	676.3	893.5
Min	1080	1086	0	596	730.5
Max	1251	1302	1398	994	1123.5
St. Dev	46.26094155	40.10050592	615.7611681	87.14322337	152.032636

Figure 3 – SendMail message throughput in multi-threaded situations.

The variability of the number of users receiving mail on the mail server did influence throughput, however. Tests were performed, therefore, altering available users and maintaining constant the number of working threads and testing clients. Performance testing involved runs with one, ten, one hundred, and one thousand recipients for each server.

Results

As noted above, the lack of influence that multi-threaded testing exhibited on the results, only significant variations in performance occurring from the change in the number of users will be reported. Postfix exhibited the best throughput performance, followed by Microsoft Exchange 2003 and SendMail respectively. An analysis and report of the data for each of the three email servers follows.

Sendmail

Sendmail's performance shows the lowest throughput of the three tested MTAs. Message throughput, or messages per minute, for all configurations exhibited a very low standard deviation (1.64 – 3.99) (Table 5). Data throughput, however, yielded much more deviation, up to 55.89 (Table 6). Low deviation on messages, but high deviation on data throughput seems to indicate that the server's throttling agent is focused on messages or connections. An arbitrary amount of data was transmitted, yet a fairly specific number of connections were made.

For one-recipient test, SendMail averaged 211.67 messages per minute (1155.83 kB / min). For a ten recipient test, SendMail averaged 206.83 messages per minute (1123.2 kB / min). For 10- and 100-user tests, averages were 193.3 and 195.47 messages per minute (1055.5 and 1095.72 kB / min), respectively (Figure 4, 5).

Overall, SendMail averaged 201.82 messages sent per minute, with a minimum and maximum throughput of 186 and 215 messages per minute, respectively.

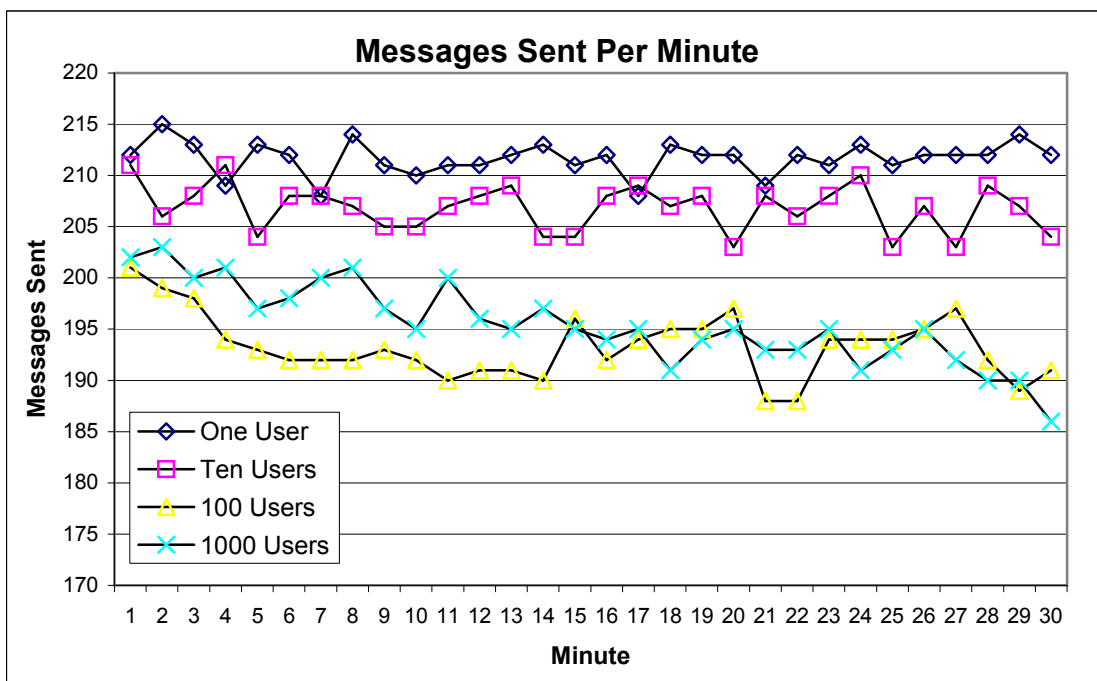


Figure 4 – SendMail message throughput test results.

Minute	One User	Ten Users	100 Users	1000 Users	Average
1	212	211	201	202	206.5
2	215	206	199	203	205.75
3	213	208	198	200	204.75
4	209	211	194	201	203.75
5	213	204	193	197	201.75
6	212	208	192	198	202.5

7	208	208	192	200	202
8	214	207	192	201	203.5
9	211	205	193	197	201.5
10	210	205	192	195	200.5
11	211	207	190	200	202
12	211	208	191	196	201.5
13	212	209	191	195	201.75
14	213	204	190	197	201
15	211	204	196	195	201.5
16	212	208	192	194	201.5
17	208	209	194	195	201.5
18	213	207	195	191	201.5
19	212	208	195	194	202.25
20	212	203	197	195	201.75
21	209	208	188	193	199.5
22	212	206	188	193	199.75
23	211	208	194	195	202
24	213	210	194	191	202
25	211	203	194	193	200.25
26	212	207	195	195	202.25
27	212	203	197	192	201
28	212	209	192	190	200.75
29	214	207	189	190	200
30	212	204	191	186	198.25
Average	211.666667	206.833333	193.3	195.466667	201.81667
Min	208	203	188	186	198.25
Max	215	211	201	203	206.5
St Dev.	1.64701053	2.30566519	3.12001326	3.989065514	1.7269833

Table 5 – SendMail message throughput test results.

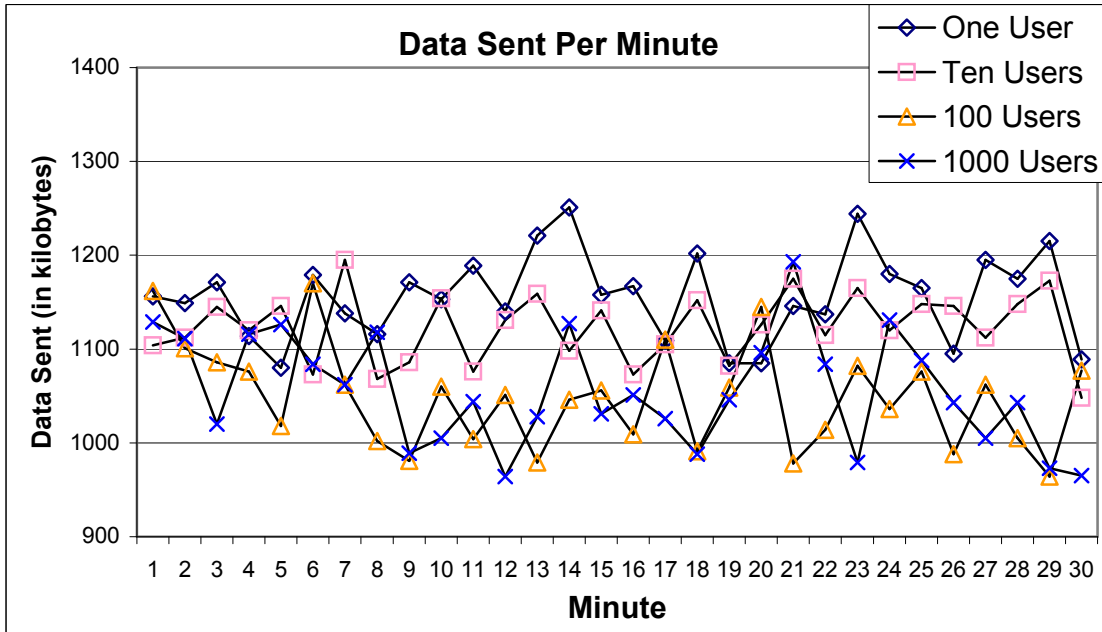


Figure 5 – SendMail data throughput test results.

Minute	One User	Ten Users	100 Users	1000 Users	Average
1	1156	1104	1162	1129	1137.75
2	1149	1112	1101	1111	1118.25
3	1171	1145	1086	1020	1105.5
4	1114	1120	1076	1116	1106.5
5	1080	1146	1018	1126	1092.5
6	1179	1073	1170	1084	1126.5
7	1138	1195	1062	1062	1114.25
8	1116	1068	1002	1118	1076
9	1171	1086	981	989	1056.75
10	1153	1154	1060	1005	1093
11	1189	1076	1004	1044	1078.25
12	1140	1131	1051	964	1071.5
13	1221	1159	979	1028	1096.75
14	1251	1098	1046	1127	1130.5
15	1158	1141	1056	1031	1096.5
16	1167	1073	1009	1051	1075
17	1109	1105	1110	1026	1087.5
18	1202	1152	991	988	1083.25
19	1085	1082	1059	1046	1068
20	1085	1126	1145	1096	1113
21	1146	1175	978	1193	1123
22	1137	1115	1014	1084	1087.5
23	1244	1165	1082	979	1117.5
24	1180	1120	1036	1131	1116.75
25	1165	1148	1076	1088	1119.25
26	1095	1146	988	1043	1068
27	1195	1112	1062	1005	1093.5

28	1175	1148	1005	1043	1092.75
29	1215	1173	964	973	1081.25
30	1089	1048	1077	965	1044.75
Average	1155.833333	1123.2	1048.333333	1055.5	1095.716667
Min	1080	1048	964	964	1044.75
Max	1251	1195	1170	1193	1137.75
St Dev.	46.26094155	36.66286292	54.88504182	59.43512836	23.04126109

Table 6 – SendMail data throughput test results.

Microsoft Exchange 2003

Microsoft Exchange 2003 ranked second in the throughput race for SMTP servers. As with SendMail, message or connection throughput exhibited a lower standard deviation than that of the data throughput. Deviation and variation was much higher for Exchange 2003 (as much as 8 or 9 times that of SendMail) than the other two mail servers.

SMTP requests to one user through Exchange 2003 exhibited an average throughput of 306.5 messages per minute (1631.33 kilobytes). Single user throughput readings ranged from 262 to 351 emails per minute (1371 to 1964 kilobytes). A ten-user recipient list averaged 314.07 emails per minute (1684.6 kilobytes) with a minimum of 292 messages per minute (1521 kilobytes) and a maximum of 341 (1879 kilobytes). One hundred users resulted in an average of 320 email messages sent every minute. Minimum throughput for a 100-user test measured 294 messages per minute (1513 kilobytes). Maximum throughput for a 100-user system measured 335 messages per minute (1873 kilobytes). One thousand users yielded an average of 307.8 messages per minute (1639.3 kilobytes) with a minimum and maximum of 262 (1425 kilobytes) and 333 (1777 kilobytes) messages per minute, respectively.

Overall, Microsoft Exchange 2003 averaged 312.09 messages per minute, or 1665.5 kilobytes per minute (Table 4). Exchange 2003 had a minimum and maximum throughout of 262 messages per minute (1371 kilobytes) and 351 messages per minute (1964 kilobytes), respectively (Graphs 3,4).

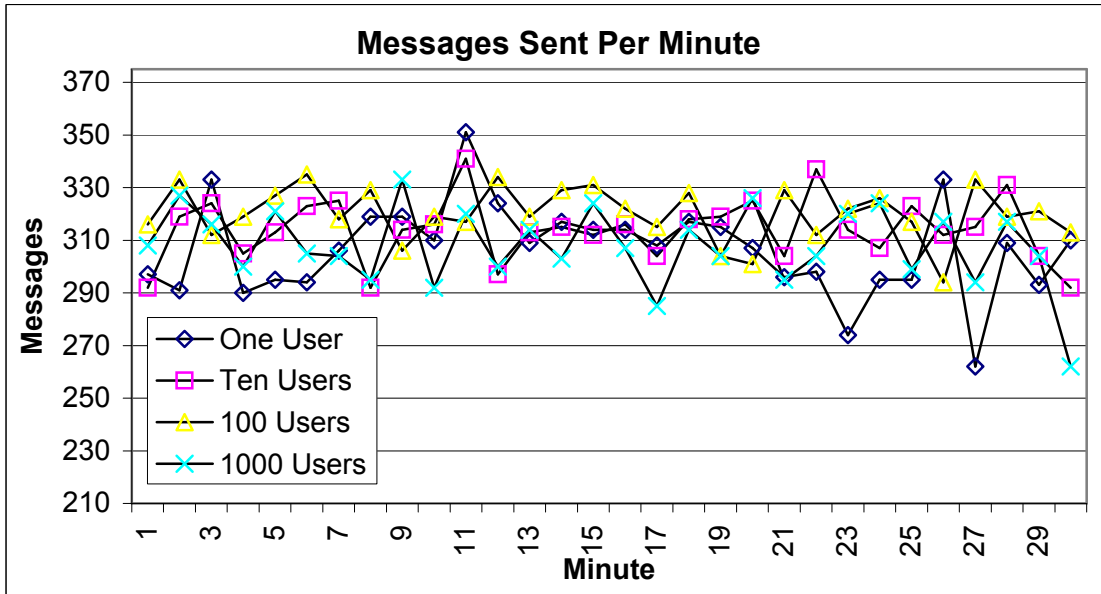


Figure 6 – Exchange 2003 message throughput test results.

Minute	One User	Ten Users	100 Users	1000 Users	Average
1	297	292	316	308	303.25
2	291	319	333	327	317.5
3	333	324	312	316	321.25
4	290	305	319	300	303.5
5	295	313	327	321	314
6	294	323	335	305	314.25
7	306	325	318	304	313.25
8	319	292	329	295	308.75
9	319	314	306	333	318
10	310	316	319	292	309.25
11	351	341	317	320	332.25
12	324	297	334	300	313.75
13	309	313	319	314	313.75
14	317	315	329	303	316
15	314	312	331	324	320.25
16	314	316	322	307	314.75
17	308	304	315	285	303
18	317	318	328	314	319.25
19	315	319	304	304	310.5
20	307	325	301	326	314.75
21	296	304	329	295	306
22	298	337	312	304	312.75
23	274	314	322	320	307.5
24	295	307	326	324	313
25	295	323	317	299	308.5
26	333	312	294	317	314
27	262	315	333	294	301
28	309	331	319	317	319

	29	293	304	321	304	305.5
	30	310	292	313	262	294.25
Average	306.5	314.06667	320	307.8	312.09167	
Min	262	292	294	262	294.25	
Max	351	341	335	333	332.25	
St. Dev.	17.621989	12.187991	10.194657	14.761086	7.3851795	

Table 7 – Exchange 2003 message throughput test results.

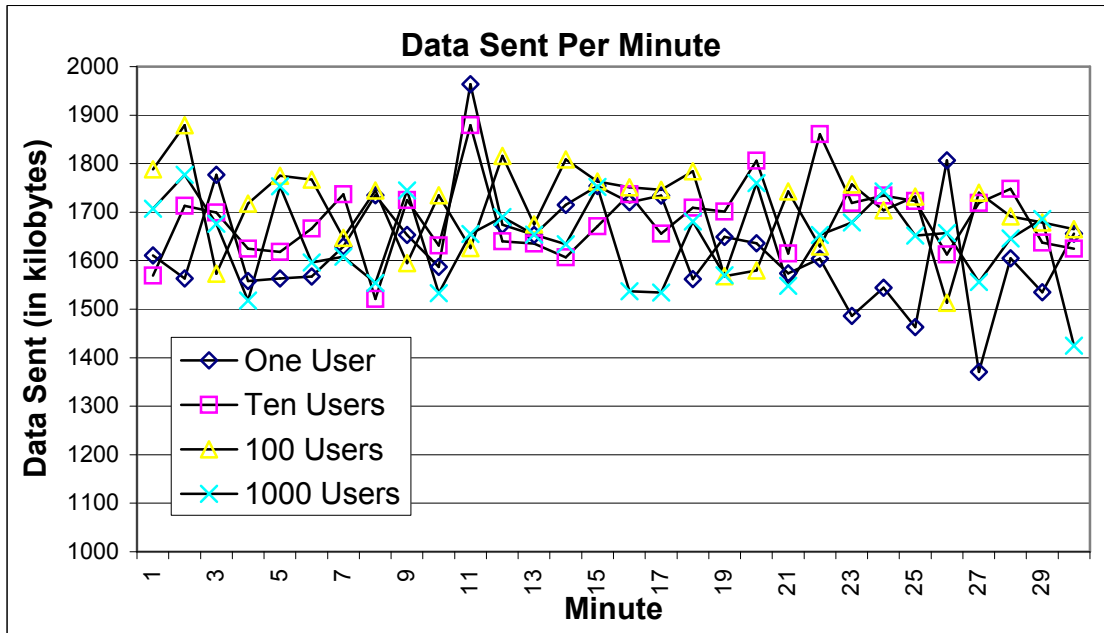


Figure 7 – Exchange 2003 data throughput test results.

Minute	One User	Ten Users	100 Users	1000 Users	Average
1	1611	1569	1788	1707	1668.75
2	1563	1713	1879	1777	1733
3	1777	1699	1573	1676	1681.25
4	1558	1625	1718	1518	1604.75
5	1563	1618	1775	1753	1677.25
6	1567	1666	1767	1596	1649
7	1629	1737	1647	1608	1655.25
8	1735	1521	1745	1554	1638.75
9	1653	1725	1595	1745	1679.5
10	1587	1631	1735	1533	1621.5
11	1964	1879	1626	1655	1781
12	1674	1640	1816	1690	1705
13	1653	1635	1675	1654	1654.25
14	1715	1607	1809	1634	1691.25
15	1754	1671	1763	1752	1735
16	1720	1737	1751	1537	1686.25
17	1734	1656	1746	1534	1667.5
18	1562	1709	1784	1681	1684

19	1649	1701	1568	1570	1622
20	1636	1806	1580	1760	1695.5
21	1574	1615	1743	1548	1620
22	1604	1861	1629	1653	1686.75
23	1486	1719	1757	1679	1660.25
24	1544	1734	1704	1743	1681.25
25	1463	1723	1732	1652	1642.5
26	1807	1613	1513	1657	1647.5
27	1371	1719	1740	1556	1596.5
28	1605	1748	1691	1646	1672.5
29	1535	1637	1679	1686	1634.25
30	1656	1625	1665	1425	1592.75
Average	1631.6333	1684.6333	1706.4333	1639.3	1665.5
Min	1371	1521	1513	1425	1592.75
Max	1964	1879	1879	1777	1781
St. Dev.	114.85418	79.12168	85.236662	87.094538	41.807183

Table 8 – Exchange 2003 data throughput test results.

Postfix

Postfix had the highest maximum throughput of the three tested MTAs. Variation for message / connection throughput exhibited the same characteristics as the previous two. Standard deviation for message throughput was much lower than data throughput deviation. A noticeable increase in the deviation occurred in the 1000-user system. This is most probably caused by the steady decline in message and data throughput during the tests. Although further tests are warranted, Postfix exhibited a decreasing ability to handle high volume tests when recipient count is increased.

Sending email to one user on the Postfix server resulted in an average of 418.53 messages per minute (2214.9 kilobytes), with a minimum and maximum throughput of 406 emails per minute (1341 kilobytes) to 439 messages per minute (2408 kilobytes). Ten user tests averaged a throughput of 392.23 messages per minute (2133.3 kilobytes), with a minimum of 379 messages or 2029 kilobytes per minute and a maximum of 408 messages or 2265 kilobytes per minute. Tests involving 100 recipients averaged 341.7 messages per minute (1861.23 kilobytes). A minimum throughput of 325 messages per minute (1719 kilobytes) and a maximum of 360 messages per minute (1995 kilobytes) were recorded for the 100 user tests. One thousand user tests registered an average of 342.67 messages or 1860.3 kilobytes per minute. A minimum of 314 messages or 1624 kilobytes per minute and a maximum 392 messages or 2094 kilobytes per minute were recorded for the 1000-user tests.

Average throughput measured for Postfix measured 373.78 messages per minute (2017.43 kilobytes) (Table 5). Results for the Postfix test ranged from 314 messages per minute (1341 kilobytes) to 439 messages per minute (2408 kilobytes) (Graphs 5, 6).

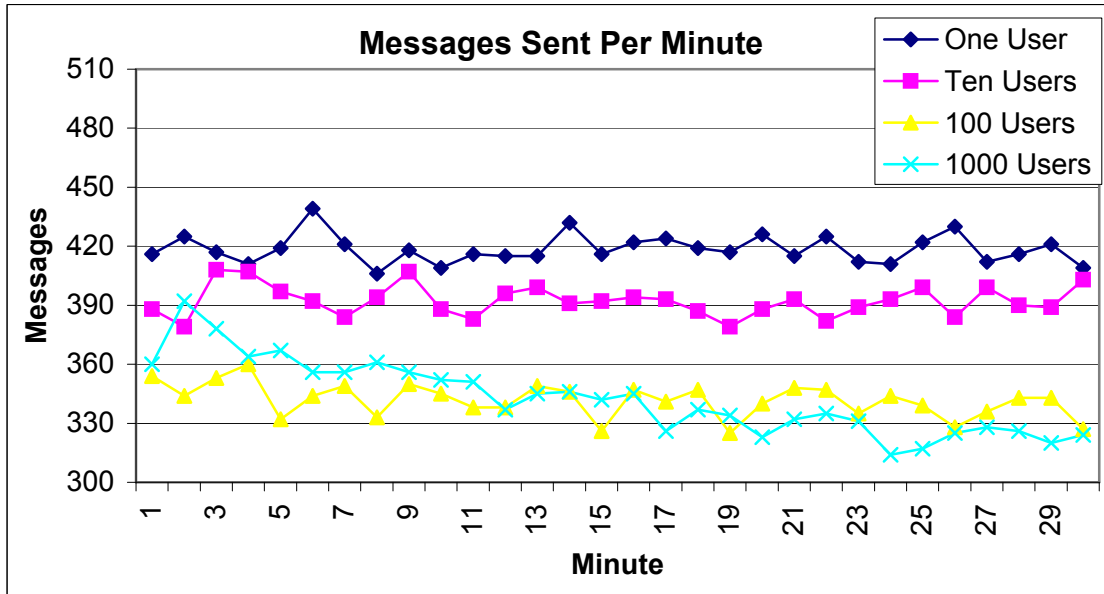


Figure 8 – Postfix message throughput test results.

Minute	One User	Ten Users	100 Users	1000 Users	Average
1	416	388	354	360	379.5
2	425	379	344	392	385
3	417	408	353	378	389
4	411	407	360	364	385.5
5	419	397	332	367	378.75
6	439	392	344	356	382.75
7	421	384	349	356	377.5
8	406	394	333	361	373.5
9	418	407	350	356	382.75
10	409	388	345	352	373.5
11	416	383	338	351	372
12	415	396	338	337	371.5
13	415	399	349	345	377
14	432	391	346	346	378.75
15	416	392	326	342	369
16	422	394	347	345	377
17	424	393	341	326	371
18	419	387	347	337	372.5
19	417	379	325	334	363.75
20	426	388	340	323	369.25
21	415	393	348	332	372
22	425	382	347	335	372.25
23	412	389	335	331	366.75
24	411	393	344	314	365.5
25	422	399	339	317	369.25
26	430	384	328	325	366.75
27	412	399	336	328	368.75
28	416	390	343	326	368.75
29	420	390	343	326	368.75
30	412	400	328	328	368.75

29	421	389	343	320	368.25
30	409	403	327	324	365.75
Average	418.53333	392.23333	341.7	342.66667	373.78333
Min	406	379	325	314	363.75
Max	439	408	360	392	389
St. Dev.	7.2954087	7.8066432	8.6628418	18.88136	6.6266616

Table 9 – Postfix message throughput test results.

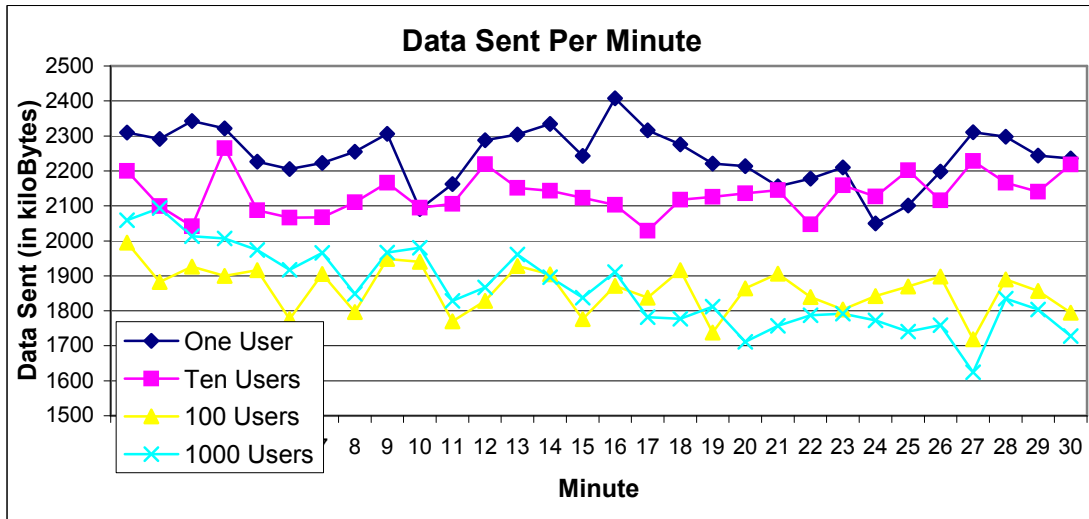


Figure 9 – Postfix data throughput test results.

Minute	One User	Ten Users	100 Users	1000 Users	Average
1	2310	2200	1995	2059	2141
2	2291	2099	1882	2094	2091.5
3	2343	2042	1926	2013	2081
4	2322	2265	1900	2007	2123.5
5	2226	2087	1916	1974	2050.75
6	2205	2066	1776	1917	1991
7	2223	2067	1905	1966	2040.25
8	2255	2110	1796	1849	2002.5
9	2306	2166	1948	1967	2096.75
10	2091	2095	1940	1980	2026.5
11	2162	2106	1770	1828	1966.5
12	2288	2219	1828	1867	2050.5
13	2304	2151	1928	1961	2086
14	2334	2143	1904	1896	2069.25
15	2243	2123	1776	1838	1995
16	2408	2103	1871	1911	2073.25
17	2316	2029	1838	1782	1991.25
18	2276	2118	1916	1777	2021.75
19	2221	2126	1738	1812	1974.25
20	2214	2136	1864	1711	1981.25
21	2156	2145	1906	1757	1991

22	2178	2047	1839	1787	1962.75
23	2210	2159	1804	1792	1991.25
24	2050	2127	1842	1773	1948
25	2101	2202	1870	1741	1978.5
26	2198	2116	1898	1759	1992.75
27	2311	2228	1719	1624	1970.5
28	2298	2166	1890	1835	2047.25
29	2244	2140	1857	1804	2011.25
30	2236	2218	1795	1728	1994.25
Average	2244	2133.3	1861.2333	1860.3	2024.7083
Min	2050	2029	1719	1624	1948
Max	2408	2265	1995	2094	2141
St. Dev.	80.500589	57.747459	66.704021	113.76478	51.509084

Table 10 – Postfix data throughput test results.

Server Averages

When averaging scores for all tests, interesting trends can be seen. Postfix exhibited a cyclic trend in message and data throughput. This trend is probably due to the server’s increasing inability to handle large-volume sends intended for many users. Postfix also yielded the highest average throughput. Exchange 2003’s message throughput tended to match the measured data throughput. This trend opposed with the results of the other servers, as SendMail’s and Postfix’s mail throughput often disagreed with the data throughput trends. SendMail’s results showed the smallest deviation, allowing for a higher predictability of results.

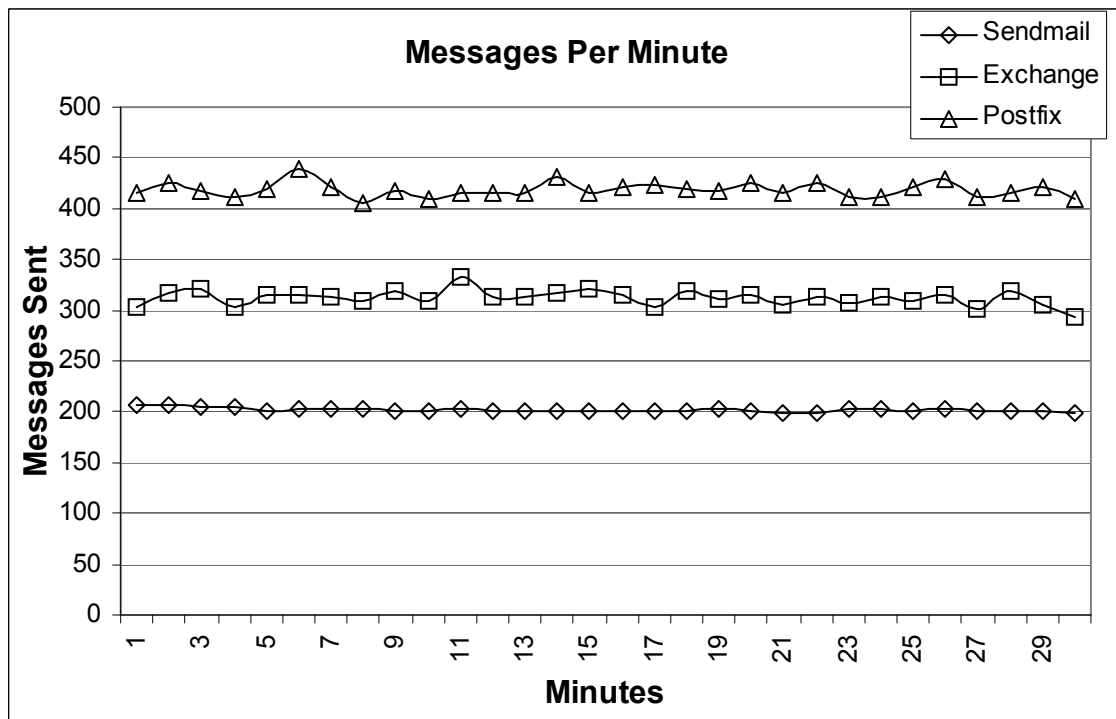


Figure 10 – Message throughput comparison for SendMail, Exchange 2003, and Postfix.

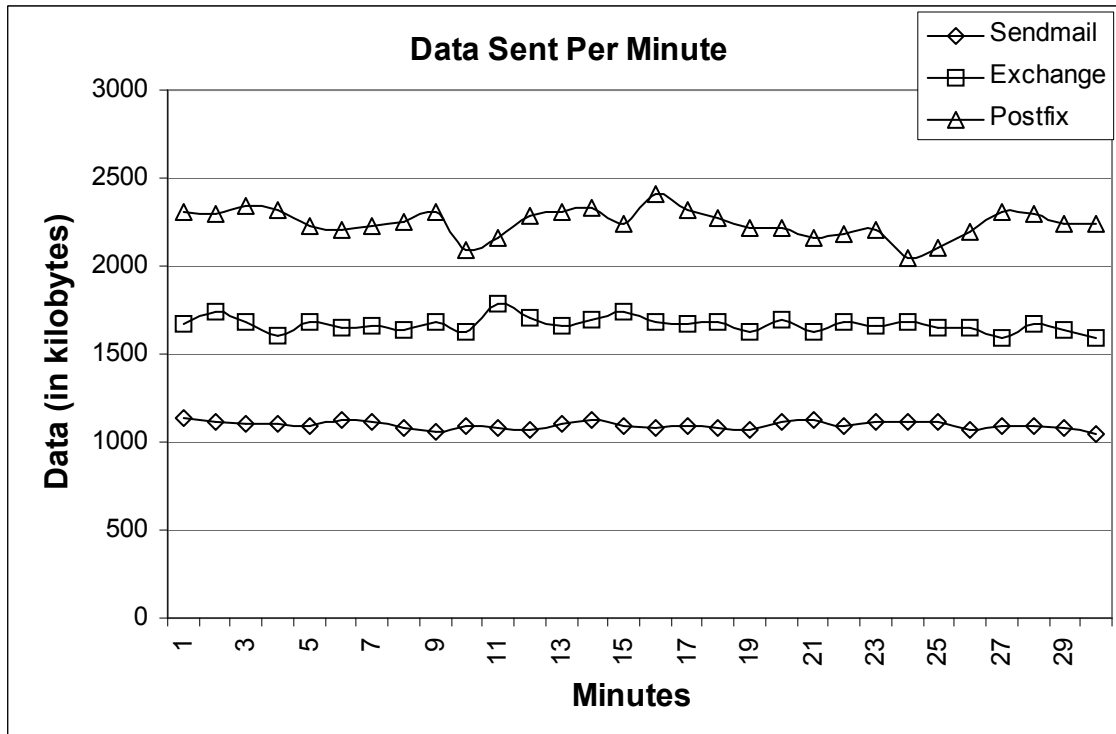


Figure 11 – Data throughput comparison for SendMail, Exchange 2003, and Postfix.

Recommendations for further research

Only three MTAs were tested and additional MTAs should be tested. Additional testing would allow for objective comparisons of many different mail servers. The three MTAs tested in this report should also be studied to determine the nature of the trends and variations discovered in the enclosed results.

Testing should also be expanded to include MDAs utilizing both the POP and IMAP protocols. Expanding the benchmarking tests would provide a consistent performance evaluation of the entire email server suite.

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BRANDON ROGERS

Brandon Rogers is a graduate student at Brigham Young University. Brandon is currently pursuing a Master's Degree in Information Technology. Mr. Rogers has worked extensively with custom database applications and has worked for success of large database systems in international networks.

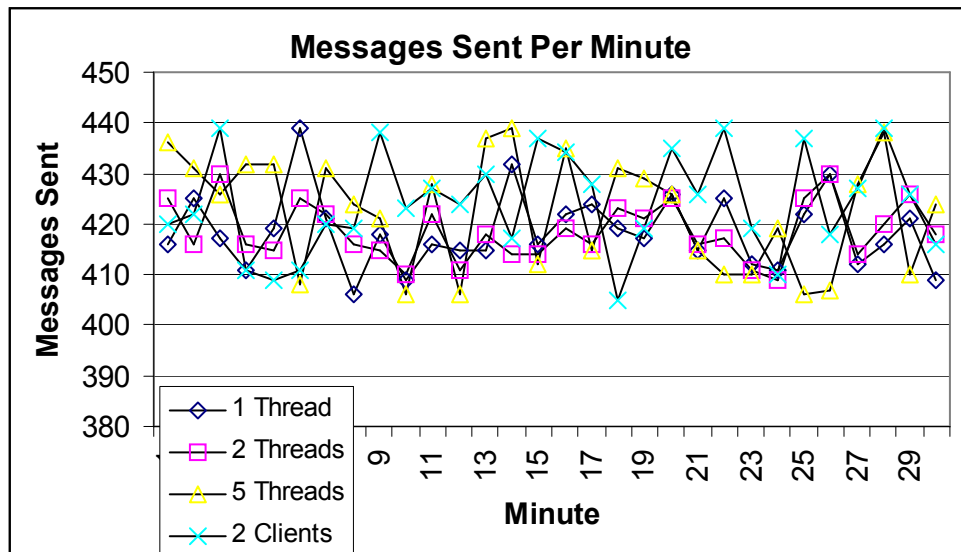
JOSEPH EKSTROM

Joseph J. Ekstrom (Ph. D. Computer Science, BYU 1992) has been Associate Professor of Information Technology at BYU since 2001. During 30 years of industrial experience he held positions from developer through senior management. His research interests include network and systems management, distributed computing, system modeling and architecture, system development, and IT curriculum and instruction.

CHARLES HIGBY

Charles Higby is a graduate student at Brigham Young University. Charles is currently pursuing a Master's Degree in Information Technology. Mr. Higby has over 4yrs experience as a network administrator. Mr. Higby is the father of 1 son and is currently living in Provo, UT.

Appendix A – Preliminary Test Results

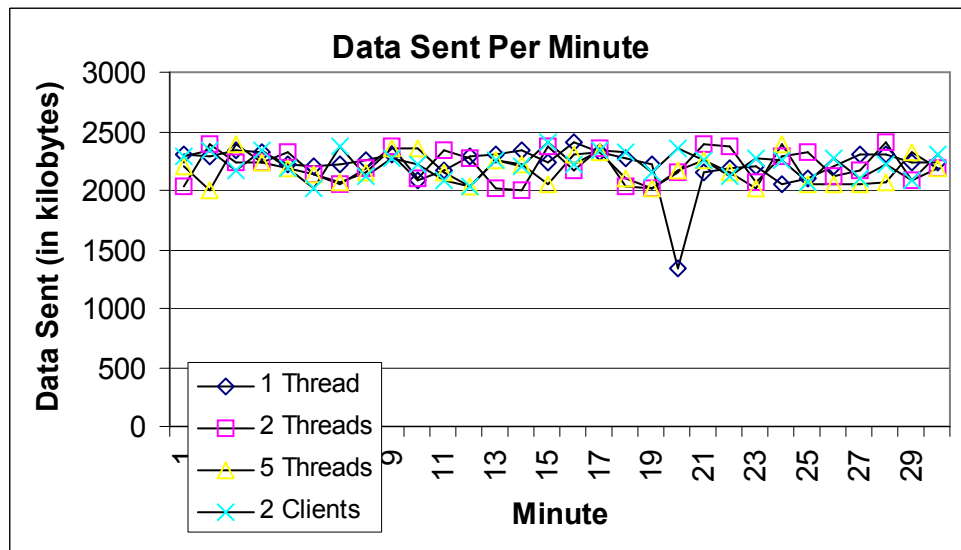


Postfix Preliminary Testing Message Throughput

Minute	1 Thread	2 Threads	5 Threads	2 Clients	Average
1	416	425	436	420	424.25
2	425	416	431	422	423.5
3	417	430	426	439	428
4	411	416	432	411	417.5
5	419	415	432	409	418.75
6	439	425	408	411	420.75
7	421	422	431	420	423.5
8	406	416	424	419	416.25

9	418	415	421	438	423
10	409	410	406	423	412
11	416	422	428	427	423.25
12	415	411	406	424	414
13	415	418	437	430	425
14	432	414	439	417	425.5
15	416	414	412	437	419.75
16	422	419	435	434	427.5
17	424	416	415	428	420.75
18	419	423	431	405	419.5
19	417	421	429	419	421.5
20	426	425	426	435	428
21	415	416	415	426	418
22	425	417	410	439	422.75
23	412	411	410	419	413
24	411	409	419	410	412.25
25	422	425	406	437	422.5
26	430	430	407	418	421.25
27	412	414	428	427	420.25
28	416	420	438	439	428.25
29	421	426	410	426	420.75
30	409	418	424	416	416.75
AVERAGE	418.5333333	418.6333333	422.4	424.1666667	420.9333333
Min	406	409	406	405	412
Max	439	430	439	439	428.25
St. Dev	7.295408728	5.684117821	11.08462744	9.979576846	4.581603644

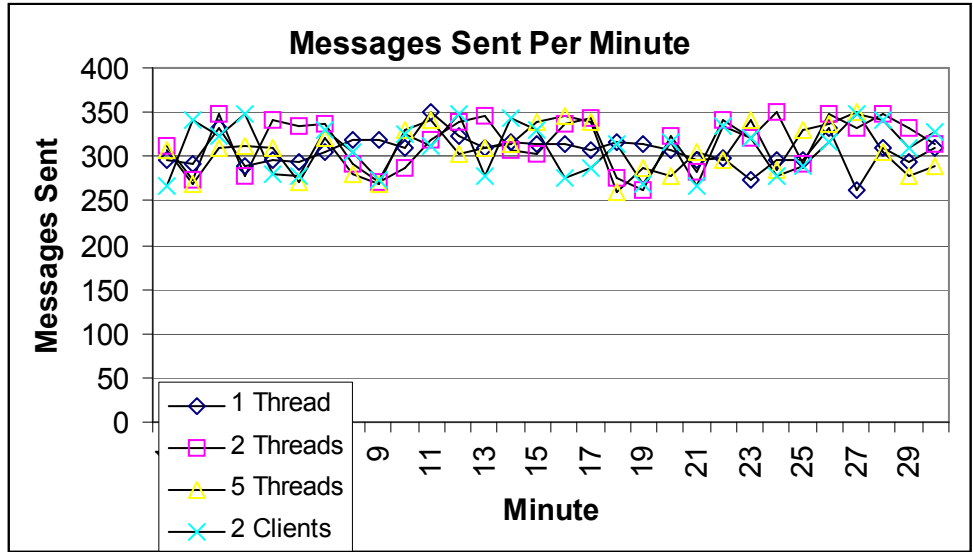
Postfix Preliminary Testing Message Throughput



Postfix Preliminary Testing Data Throughput

Minute	1 Thread	2 Threads	5 Threads	2 Clients	Average
1	2310	2032.618753	2199.260506	2288	2207.46981
2	2291	2395.576823	2002.555728	2340	2257.28314
3	2343	2244.511343	2384.335447	2171	2285.7117
4	2322	2230.428155	2242.959971	2343	2284.59703
5	2226	2319.442847	2194.40532	2192	2232.96204
6	2205	2132.733385	2139.178161	2016	2123.22789
7	2223	2059.108424	2068.435737	2375	2181.38604
8	2255	2188.360019	2153.250324	2126	2180.65259
9	2306	2368.274057	2355.959347	2265	2323.80835
10	2091	2104.047403	2361.273116	2217	2193.33013
11	2162	2334.078311	2147.8008	2080	2180.96978
12	2288	2267.623817	2036.184482	2040	2157.95207
13	2304	2018.034958	2252.330708	2262	2209.09142
14	2334	2005.853466	2224.413271	2211	2193.81668
15	2243	2371.416577	2047.267774	2399	2265.17109
16	2408	2166.731984	2301.337555	2219	2273.76738
17	2316	2359.346442	2320.66189	2345	2335.25208
18	2276	2025.937047	2104.951313	2320	2181.72209
19	2221	2012.265878	2011.371454	2159	2100.90933
20	1341	2147.715341	2163.584585	2353	2001.32498
21	2156	2396.89377	2248.739762	2252	2263.40838
22	2178	2378.248344	2157.736885	2120	2208.49631
23	2210	2061.521983	2018.481054	2272	2140.50076
24	2050	2291.929195	2386.962629	2255	2245.97296
25	2101	2321.152585	2044.514112	2075	2135.41667
26	2198	2124.069824	2057.628493	2266	2161.42458
27	2311	2174.270927	2053.964445	2094	2158.30884
28	2298	2399.30831	2069.345787	2218	2246.16352
29	2244	2091.446332	2329.509697	2078	2185.73901
30	2236	2178.95816	2191.906937	2307	2228.46627
AVERAGE	2214.9	2206.730149	2175.67691	2221.933333	2204.8101
Min	1341	2005.853466	2002.555728	2016	2001.32498
Max	2408	2399.30831	2386.962629	2399	2335.25208
St. Dev	183.5506789	135.5511747	121.6775391	106.4094024	69.5717991

Postfix Preliminary Testing Data Throughput

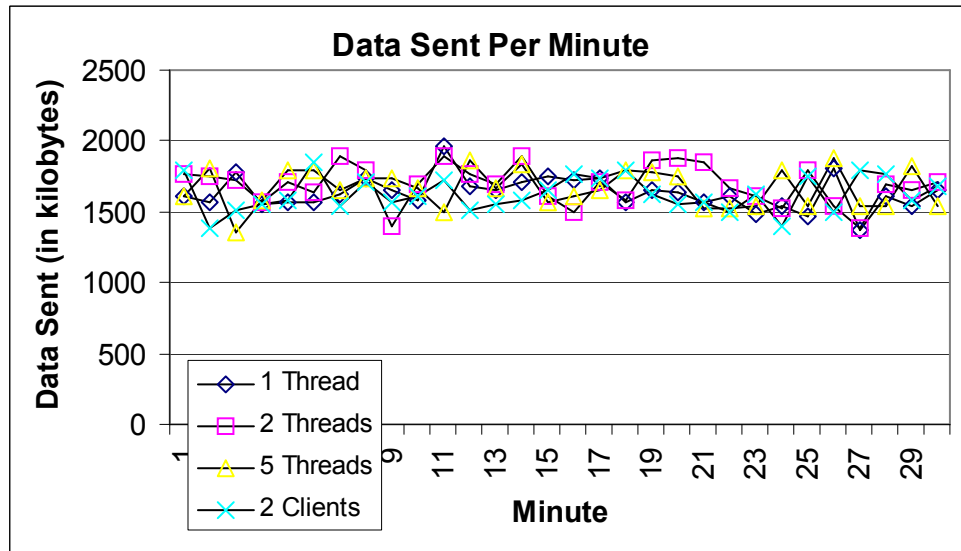


Exchange 2003 Preliminary Testing Message Throughput

Minute	1 Thread	2 Threads	5 Threads	2 Clients	Average
1	297	312	308	267	296
2	291	273	268	341	293.25
3	333	349	309	323	328.5
4	290	279	311	349	307.25
5	295	342	309	280	306.5
6	294	335	272	277	294.5
7	306	337	321	330	323.5
8	319	292	281	305	299.25
9	319	272	268	274	283.25
10	310	286	331	325	313
11	351	319	341	311	330.5
12	324	338	302	348	328
13	309	346	309	277	310.25
14	317	308	314	344	320.75
15	314	302	340	330	321.5
16	314	337	346	275	318
17	308	343	339	286	319
18	317	275	261	314	291.75
19	315	263	287	269	283.5
20	307	323	277	316	305.75
21	296	282	305	266	287.25
22	298	341	296	335	317.5
23	274	322	341	322	314.75
24	295	351	284	278	302
25	295	291	329	289	301
26	333	349	336	317	333.75
27	262	333	350	349	323.5
28	309	349	305	342	326.25
29	293	332	279	309	303.25

	30	310	313	289	327	309.75
AVERAGE	306.5	316.4666667	306.9333333	309.1666667	309.7666667	
Min	262	263	261	266	283.25	
Max	351	351	350	349	333.75	
St. Dev	17.62198862	28.14216781	26.33986533	28.2184622	14.4883921	

Exchange 2003 Preliminary Testing Message Throughput



Exchange 2003 Preliminary Testing Data Throughput

Minute	1 Thread	2 Threads	5 Threads	2 Clients	Average
1	1611	1770	1617	1794	1698
2	1563	1746	1814	1379	1625.5
3	1777	1721	1355	1505	1589.5
4	1558	1562	1577	1551	1562
5	1563	1709	1792	1586	1662.5
6	1567	1644	1792	1854	1714.25
7	1629	1893	1656	1543	1680.25
8	1735	1799	1744	1707	1746.25
9	1653	1399	1733	1566	1587.75
10	1587	1689	1671	1605	1638
11	1964	1893	1504	1718	1769.75
12	1674	1768	1867	1514	1705.75
13	1653	1694	1664	1549	1640
14	1715	1889	1832	1586	1755.5
15	1754	1608	1574	1646	1645.5
16	1720	1503	1610	1760	1648.25
17	1734	1713	1651	1738	1709
18	1562	1579	1795	1796	1683
19	1649	1860	1785	1631	1731.25
20	1636	1878	1749	1552	1703.75

21	1574	1846	1520	1569	1627.25
22	1604	1661	1519	1501	1571.25
23	1486	1610	1546	1620	1565.5
24	1544	1525	1787	1399	1563.75
25	1463	1794	1541	1752	1637.5
26	1807	1546	1872	1501	1681.5
27	1371	1388	1539	1798	1524
28	1605	1688	1533	1761	1646.75
29	1535	1653	1824	1581	1648.25
30	1656	1712	1537	1679	1646
AVERAGE	1631.633333	1691.333333	1666.666667	1624.7	1653.58333
Min	1371	1388	1355	1379	1524
Max	1964	1893	1872	1854	1769.75
St. Dev	114.8541754	138.4879762	133.9782106	121.6190066	62.5660111

Exchange 2003 Preliminary Testing Data Throughput