Application Response Times for Internet Protocol Version 4 (IPv4) versus Internet Protocol Version 6 (IPv6)

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Abstract

This paper presents test methods and statistical analysis methods conducted in measuring response times of common network applications such as Hyper Text Transfer Protocol (HTTP), File Transfer Protocol (FTP), and Email (SMTP and IMAP) over an i) IPv4, ii) IPv6 and iii) IPv6 tunneled in IPv4 networks. The information gained from this test would help compare the response times of the common applications running over different versions of IP networks. After analysis of the test results, we have concluded that the IPv6 protocol is not likely to cause noticeable increase in the response time of the common applications (such as web browser, file transfer, reading Emails) in a Local Area Network (LAN) environment, with the exception of SMTP. Although the tests were conducted in a LAN environment, the results obtained from this test may give some indication about the application response time when application servers reside outside the LAN.

1 Introduction

Many user applications require network connectivity to operate. One of the most common network layer connectivity protocols in use today is Internet Protocol (IP). The current IP version is 4 but a new IP protocol, IPv6, has emerged. Yet due to a number of

differences between IPv4 and IPv6, there are several transition issues and impacts that may require closer scrutiny. For instance, the basic IPv6 header size is twice as large as the IPv4 header size. The address size of IPv6 is 128 bits whereas that of IPv4 is 32 bits. All of these differences may impact several characteristics of networks, such as bandwidth utilization, routing performance and application response time. The objective of this test is to measure the response times of common network applications such as Hyper Text Transfer Protocol (HTTP), File Transfer Protocol (FTP), and Email (SMTP and IMAP) over an i) IPv4, ii) IPv6 and iii) IPv6 tunneled in IPv4 network. The information gained from this test will help compare the response times of the common applications running over different versions of IP networks.

2 Testing

The particular protocols and applications used for this testing are HTTP (web), FTP (file transfer), SMTP (sending an Email), and IMAP (retrieving an Email) in a client/server paradigm. The measurement of response time differs depending on each application's protocol. Table 2-1 shows when the measurement begins and ends per application.

Table 2-1 Measurement Detail of Response Time per Application

Application (Protocol)	Beginning of Measurement	End of Measurement
Web (HTTP)	When the socket(s) open(s)	When </html> is seen by the client's simulation software
File Transfer (FTP)	When the socket(s) open(s)	When "Transfer Complete" is seen by the client's

		simulation software
Sending an Email (SMTP)	When the socket(s) open(s)	When "250 ok queued as …" or "250 ok message accepted for delivery" is seen by the client's simulation software
Retrieving an Email (IMAP)	When the socket(s) open(s)	When "Fetch complete" is seen by the client's simulation software

2.1 Test Equipment and Tools

	Hardware	Operating System	Network Stack	Network Interface
Client Machine	3 GHZ Pentium 4 PC with 1 GB of RAM and a 10/100 Mb	Fedora Linux core 2	IPv4 and IPv6[1]	100 Mbps full duplex copper Ethernet
Server Machine	Dual 500 MHZ processor Pentium 3 server with 256 MB of RAM	Red Hat Linux version 9	IPv4 and IPv6	100 Mbps full duplex copper Ethernet
Ethernet Switch	Netgear 10/100 Ethernet Switch, FS108	Not applicable	Not applicable	100 Mbps full duplex copper Ethernet
Simulation Software	• Suite of in-house developed software for HTTP, FTP, SMTP and IMAP • IPv4, IPv6 and IPv6-tunneled-in-IPv4 versions • Capable of simulating thousands of concurrent connections and timing each one with sub-millisecond accuracy.			

[1] The dual-stack allowed us to use the exact same machine with the exact same hardware and software configuration for both the IPv4 and IPv6 testing thus introducing less variables in the testing.

2.2 Testbed Configuration and Setup

The testbed will be configured as illustrated in Figure 2-1. The client and server machines will each reside in the same LAN in order to eliminate additional complicating factors that may be caused by intermediate devices such as routers. The simulation software will be installed on the client machine for one of each server applications: HTTP, FTP, SMTP, IMAP and DNS. The server machine will have HTTP, FTP, SMTP, IMAP and DNS servers installed, configured and running. DNS lookups will be performed by each client-simulation thread within a test run.

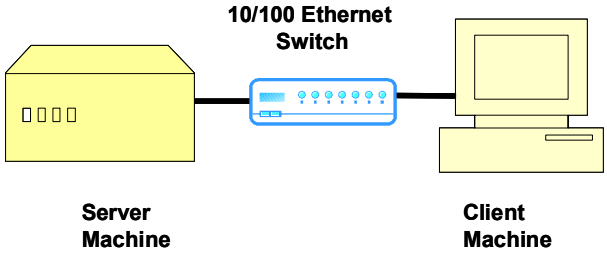

Figure 2-1: Testbed Setup

2.3 Application Response Time Test for HTTP over IPv6 versus IPv4

This test will measure the response time of HTTP operations over i) IPv4, ii) IPv6 and iii) IPv6 tunneled in IPv4. The software will simulate and time a full web page retrieval operation including the name resolution lookup. Apache web server version 2.0 will be used as the web server application. The following will be the steps taken to perform this test.

1. Run the HTTP simulation software, simulating only one IPv4 client connection. Run the Ethereal program, or any other protocol analysis tool, in the background to verify the traffic content. This needs to be done only once for the test setup verification.

2. Take the average of the application response times with the following equation.

$$\frac{\sum_{1}^{n} x}{n}$$

Where n = number of connections, x = application response time

3. Repeat 1-2 eleven times; discard the first value and obtain the average of the remaining ten with the process described in section 6 Appendix A.

4. Repeat steps 1-3 for values of 10, 100, 500, 1000 and 5000 connections.

5. Run the HTTP simulation software, simulating only one IPv6 client connection[2].

6. Take the average of the application response times as before.

7. Repeat 5-6 eleven times; discard the first value and obtain the average of the remaining ten with the process described in section 6 Appendix A.

8. Repeat steps 5-7 for values of 10, 100, 500, 1000 and 5000 connections.

9. Configure an IPv4 tunnel and routes on the server machine and client machine. Repeat steps 5-8.

2.4 Application Response Time Test for FTP Over IPv6 versus IPv4

This test will measure the response time of FTP operations over i) IPv4, ii) IPv6 and iii) IPv6 tunneled in IPv4. The software will simulate and time a full remote file retrieval operation including the name resolution lookup. Proftpd will be used as the FTP server application. The exact same procedure will be taken as in section 2.3 except that i) FTP simulation software is used and ii) only 10 and 100[3] connections are tested.

2.5 Application Response Time Test for SMTP IPv6 versus IPv4

This test will measure the response time of SMTP operations over i) IPv4, ii) IPv6 and iii) IPv6 tunneled in IPv4. The software will simulate and time a full Email transmission operation. Postfix will be used as the server application. The exact same procedure will be taken as in section 2.3 except that i) SMTP simulation software is used and ii) only 10, 100 and 500[4] connections are tested.

2.6 Application Response Time Test for IMAP IPv6 versus IPv4

This test will measure the response time of IMAP operations over i) IPv4, ii) IPv6 and iii) IPv6 tunneled in IPv4. The software will simulate and time a full IMAP Email retrieval

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[2] We edited the /etc/resolv.conf file to force the DNS lookup to occur over either IPv4 or IPv6.

[3] A maximum of 100 connections was used here due to the limitations of the server. When more connections were attempted, erratic behavior was exhibited on the server.

[4] A maximum of 500 connections was used here due to the limitations of the server. When more connections were attempted, erratic behavior was exhibited on the server.

operation including the name resolution lookup. The server will be configured to have 500 users each having the same e-mail message in their inbox. The IMAP simulation software used is unique in the sense that each thread logs on as a different user and retrieves a different copy of the test Email message. This was done to ensure that the client requests were serviced in parallel rather than sequentially. The Courier IMAP server will be used as the server application. The exact same procedure will be taken as in section 2.3 except that i) IMAP simulation software is used and ii) only 10, 100 and 200[5] connections are tested.

3 Test Results

The application response times, and the respective confidence levels and confidence intervals for various applications operating with varying number of server to client connections, for IPv4, IPv6 and IPv6 tunneled in IPv4 are listed in the following sections. The upper and lower bound in the confidence interval in Table 3-1, Table 3-3, Table 3-5 and Table 3-7 indicates the range of values that the application response time will be within with 95% confidence in our test environment[6]. The confidence levels in Table 3-2, Table 3-4, Table 3-6 and Table 3-8 indicates the confidence level with which we can say there is a

[5] A maximum of 200 connections was used here due to the limitations of the server. When more connections were attempted, erratic behavior was exhibited on the server.

[6] For example, referring to Table 3-1, for 10 concurrent IPv4 HTTP connections, we can say with 95% confidence that the true average response time in our test environment is between 9.8 and 12.0 milliseconds.

difference in protocols application response time in our test environment[7]. The reader may refer to a statistics book for further explanation of confidence values and confidence levels. [1] [2]

3.1 Application Response Times for HTTP

Table 3-1 shows the test results obtained by running the tests detailed in section 2.3. The table contains the average response time and the upper and lower bounds of the confidence interval for a 95% confidence level for each number of concurrent connections.

Table 3-1: HTTP Average Application Response Times

Protocol	Number of connections	1	10	100	500	1000
IPv4	Average Response Time per Connection (milliseconds)	6.7	10.9	84.8	417.7	813.1
	95% Confidence Interval (milliseconds)	4.7 – 8.6	9.8-12.0	83.1 – 86.6	409.0 – 426.3	796.2 - 830.1
IPv6	Average Response Time per Connection (milliseconds)	5.8	10.3	87.8	424.0	816.8
	95% Confidence Interval (milliseconds)	5.7 – 5.9	9.0 – 11.7	84.1 – 91.2	416.8 – 431.2	800.8 – 832.8

[7] For example, referring to Table 3-2, for 100 concurrent connections, we can say with 90% confidence that there is a difference in application response time for HTTP running over IPv4 vs. IPv6 in our environment, and we can say with 99% confidence that there is a difference in application response time for HTTP running over IPv4 vs. a tunneled connection in our environment.

Tunneled	Average Response Time per Connection (milliseconds)	8.7	12.1	93.5	463.8	916.0
	95% Confidence Interval (milliseconds)	5.0 – 12.4	10.6 – 13.5	88.2 – 98.7	453.9 – 473.6	905.0 – 927.0

Table 3-2 shows the actual and percentage increase in average application response time of IPv6 and tunneled traffic for HTTP. The table also gives a confidence value for the likelihood of a difference in application response time between IPv4 and IPv6/Tunneled traffic. It is important to note that the confidence value listed below is not indicative of the accuracy or precision of the values of the differences in application response time[8]. Rather, the confidence value is an indicator of with what level of confidence we can claim that any difference in application response time does exist between the IP protocols. A negative value in the actual and percentage increase fields indicates that there was a decrease in average application response time.

Table 3-2: % Increase in IPv6 and Tunneled Traffic Average Application Response Times for HTTP

Protocol	Number of Connections	1	10	100	500	1000
IPv6	Actual Increase (IPv6 Average Response Time – IPv4 Average Response Time) (milliseconds)	-0.9	-0.6	2.8	6.3	3.7

[8] Information about the precision of the values is listed in section 6 Appendix A, where the upper and lower bounds for the confidence interval for a 95% confidence level are listed.

	Percentage Increase (100 * Actual Increase / IPv4 Average Response Time)	-13.4%	-5.2%	3.3%	1.5%	0.4%
	Confidence Level	80%	73%	90%	85%	62%
Tunneled	Actual Increase (Tunneled Average Response Time – IPv4 Average Response Time) (milliseconds)	2.0	1.2	8.6	46.1	102.9
	Percentage Increase (100 * Actual Increase / IPv4 Average Response Time)	30.4%	10.7%	10.1%	11.0%	12.7%
	Confidence Level	82%	88%	99%	99%	99%

3.2 Application Response Times for FTP

Table 3-3 shows the test results obtained by running the tests detailed in section 2.4. The table contains the average response time and the upper and lower bounds of the confidence interval for a 95% confidence level for each number of concurrent connections.

Table 3-3: FTP Average Application Response Times

Protocol	Number of Connections	1	10	100
IPv4	Average Response Time per Connection (milliseconds)	107.9	1404.8	9468.9
	95% Confidence Interval (milliseconds)	106.9 – 108.9	1253.5 – 1556.0	7644.7 – 11293.0
IPv6	Average Response Time per Connection (milliseconds)	108.2	1137.1	8229.8

	95% Confidence Interval (milliseconds)	107.6 – 108.8	982.5 – 1291.7	7234.2 – 9225.4
Tunneled	Average Response Time per Connection (milliseconds)	115.1	1236.6	8553.2
	95% Confidence Interval (milliseconds)	107.2 – 123.0	1086.5 – 1386.7	7018.8 – 10087.7

Table 3-4 shows the actual and percentage increase in average application response time of IPv6 and tunneled traffic for FTP. The table also gives a confidence value for the likelihood of a difference in application response time between IPv4 and IPv6/Tunneled traffic. It is important to note that the confidence value listed below is not indicative of the accuracy or precision of the values of the differences in application response time[9]. Rather, the confidence value is an indicator of with what level of confidence we can claim that any difference in application response time does exist between the IP protocols. A negative value in the actual and percentage increase fields indicates that there was a decrease in average application response time.

Table 3-4: % Increase in IPv6 and Tunneled Traffic Average Application Response Times for FTP

Protocol	Number of Connections	1	10	100

[9] Information about the precision of the values is listed in section 6 Appendix A, where the upper and lower bounds for the confidence interval for a 95% confidence level are listed.

IPv6	Actual Increase (IPv6 Average Response Time – IPv4 Average Response Time) (milliseconds)	0.3	-267.7	-1239.1
	Percentage Increase (100 * Actual Increase / IPv4 Average Response Time)	0.2%	-19.1%	-13.1%
	Confidence Level	66%	98%	86%
Tunneled	Actual Increase (Tunneled Average Response Time – IPv4 Average Response Time) (milliseconds)	7.1	-168.2	-915.6
	Percentage Increase (100 * Actual Increase / IPv4 Average Response Time)	6.6%	-12.0%	-9.7%
	Confidence Level	94%	93%	76%

3.3 Application Response Times for SMTP

Table 3-5 shows the test results obtained by running the tests detailed in section 2.5. The table contains the average response time and the upper and lower bounds of the confidence interval for a 95% confidence level for each number of concurrent connections.

Table 3-5: SMTP Average Application Response Times

Protocol	Number of Connections	1	10	100	500
IPv4	Average Response Time per Connection (milliseconds)	104.8	689.1	9308.6	27645.0

	95% Confidence Interval (milliseconds)	90.9 – 118.7	562.8 – 815.4	8893.9 – 9723.3	24661.9 – 30628.1
IPv6	Average Response Time per Connection (milliseconds)	73.1	716.2	10823.9	37430.9
	95% Confidence Interval (milliseconds)	61.0 - 85.2	551.6 – 880.8	10604.1 – 11043.6	37240.8 – 37621.0
Tunneled	Average Response Time per Connection (milliseconds)	80.2	709.2	11400.6	37477.7
	95% Confidence Interval (milliseconds)	70.5 – 89.8	553.0 - 865.5	11203.4 – 11597.8	5453.9 – 136368.9

Table 3-6 shows the actual and percentage increase in average application response time of IPv6 and tunneled traffic for SMTP. The table also gives a confidence value for the likelihood of a difference in application response time between IPv4 and IPv6/Tunneled traffic. It is important to note that the confidence value listed below is not indicative of the accuracy or precision of the values of the differences in application response time[10]. Rather, the confidence value is an indicator of with what level of confidence we can claim that any difference in application response time does exist between the IP protocols. A negative

[10] Information about the precision of the values is listed in section 6, Appendix A, where the upper and lower bounds for the confidence interval for a 95% confidence level are listed.

value in the actual and percentage increase fields indicates that there was a decrease in average application response time.

Table 3-6: % Increase in IPv6 and Tunneled Traffic Average Application Response Times for SMTP

Protocol	Number of connections	1	10	100	500
IPv6	Actual Increase (IPv6 Average Response Time – IPv4 Average Response Time) (milliseconds)	-31.8	27.1	1515.2	9785.3
	Percentage Increase (100 * Actual Increase / IPv4 Average Response Time)	-30.3%	3.9%	16.3%	35.4%
	Confidence Level	99%	59%	99%	99%
Tunneled	Actual Increase (Tunneled Average Response Time – IPv4 Average Response Time) (milliseconds)	-24.7	20.1	2092.0	9832.7
	Percentage Increase (100 * Actual Increase / IPv4 Average Response Time)	-23.6%	2.9%	22.5%	35.6%
	Confidence Level	99%	57%	99%	99%

3.4 Application Response Times for IMAP

Table 3-7 shows the test results obtained by running the tests detailed in section 2.6. The table contains the average response time and the upper and lower bounds of the confidence interval for a 95% confidence level for each number of concurrent connections.

Table 3-7: IMAP Average Application Response Times

Protocol	Number of connections	1	10	100	200
IPv4	Average Response Time per Connection (milliseconds)	87.0	322.3	2276.5	3835.2
	95% Confidence Interval (milliseconds)	76.3 – 97.6	309.1 – 335.5	2080.2 – 2472.7	3566.4-4104.1
IPv6	Average Response Time per Connection (milliseconds)	78.6	331.8	2195.6	4211.6
	95% Confidence Interval (milliseconds)	77.8 – 79.4	319.4 – 344.2	2185.4 – 2205.8	4193.3 – 4229.9
Tunneled	Average Response Time per Connection (milliseconds)	82.0	344.2	2264.2	4338.3
	95% Confidence Interval (milliseconds)	81.3 – 82.8	333.9 – 354.4	2231.7 – 2296.7	4181.6 – 4495.0

Table 3-8 shows the percentage increase in average application response time of IPv6 and tunneled traffic for IMAP. The table also gives a confidence value for the likelihood of a difference in application response time between IPv4 and IPv6/Tunneled traffic. It is

important to note that the confidence value listed below is not indicative of the accuracy or precision of the values of the differences in application response time[11]. Rather, the confidence value is an indicator of with what level of confidence we can claim that any difference in application response time does exist between the IP protocols. A negative value in the actual and percentage increase fields indicates that there was a decrease in average application response time.

Table 3-8: % Increase of IPv6 and Tunneled Traffic Average Application Response Times for IMAP

Protocol	Number of Connections	1	10	100	200
IPv6	Actual Increase (IPv6 Average Response Time – IPv4 Average Response Time) (milliseconds)	-8.4	9.5	-80.8	376.4
	Percentage Increase (100 * Actual Increase / IPv4 Average Response Time)	-9.7%	2.9%	-3.5%	9.8%
	Confidence Level	92%	84%	77%	98%
Tunneled	Actual Increase (Tunneled Average Response Time – IPv4 Average Response Time) (milliseconds)	-4.9	21.9	-12.3	503.1

[11] Information about the precision of the values is listed in Appendix A, where the upper and lower bounds for the confidence interval for a 95% confidence level are listed.

	Percentage Increase (100 * Actual Increase/ IPv4 Average Response Time)	-5.7%	6.8%	-0.5%	13.1%
	Confidence Level	80%	98%	54%	99%

4 Analysis

1. The reader should note the confidence levels and the confidence intervals published with the data. These figures give a good idea of the likelihood of an increase or decrease in application response time between IPv4 and IPv6. They also give the reader an idea of the variance exhibited by the data. The detailed explanation is provided in section 6 Appendix A.

2. While conducting IPv4 tests, sometimes as much as ten percent of the threads could not make successful TCP connections (for example, out of 100 threads, only 97 make a TCP connection and complete the operation, and the other three time-out and quit)[12]. This behavior was not experienced in IPv6. There are several speculations as to why this occurred; it may be a built-in feature in the Linux IPv4 stack to mitigate denial of service attacks, or it may be some bug or inefficiency in the Linux IPv4 stack that causes it to drop certain connections. Without further testing and research it is inconclusive why the server exhibited this behavior, we felt however it was noteworthy and wanted to clarify that the

[12] This did not affect the values obtained for average time. The simulation program only takes into consideration threads that completed the operation, and ignores all others.

IPv4 connection figures were averaged over less number of connections than those of IPv6.

3. The data obtained from the FTP, HTTP and IMAP tests show, at most, 13.1 % increase in the average application response time when utilizing IPv6 or tunneling IPv6 through IPv4. Specifically, the 13.1% increase (or 503.1 milliseconds) in average response time is observed with IPv6 IMAP traffic tunneled in IPv4 for 200 connections. It is also important to note that the increase in application response time is not consistent for all number of connections. The confidence level for IMAP 100 connections for IPv6 and tunneled traffic in Table 3-8 is relatively low, suggesting a higher than normal degree of variance in one of the sets of data. Upon closer examination of the data, an outlier in the IPv4 IMAP data for 100 concurrent connections slightly raised the average response time. This outlier was not eliminated since its cause could not be determined.

4. FTP traffic exhibited lower application response times for IPv6 than IPv4. A separate test [13] that was conducted by an external entity strongly suggests that this is operating system/implementation specific.

5. SMTP shows signs of noticeable increases in application response times when using IPv6 only when the SMTP server was handling a significantly large number of simultaneous connections. The fact that this is the only application/protocol that exhibited this type of behavior leads us to believe that this is an

application/implementation specific behavior rather than an IPv6 specific behavior. The reasons why this particular application/protocol exhibited this behavior are inconclusive at the time of this writing; research is ongoing however to try and determine the exact cause.

6. The DNS server and the application server resided on the same machine for all of the tests. If the DNS server and the application server resided on two different machines they could theoretically service twice the bandwidth of client traffic (100 Mbps for DNS traffic and 100 Mbps for application traffic). It is important to note however that all the client traffic was originating from a single 100 Mbps link; therefore, the added availability of network bandwidth would not have had a significant effect. What may have had a significant effect, however, was the extra load on the server CPU of having to service both DNS requests and application requests simultaneously. This variable was constant however in both the IPv4 and IPv6 tests. It is important therefore to not interpret the results by their absolute values, but rather compare their relative values.

5 Conclusion

Tests were conducted to determine approximately how much increase of application response times would be experienced by end users after transitioning to IPv6. After analysis of the test results, we have concluded that the IPv6 protocol is not likely to cause noticeable increase in the response time of the common applications (such as web browser, file transfer,

reading Emails) in a LAN environment, with the exception of SMTP. This is indicated by the relatively small to no increase in application response time for HTTP, FTP and IMAP. Among these three protocols, the 13.1% increase (or 503.1 milliseconds) in average response time is observed with IPv6 IMAP traffic tunneled in IPv4 for 200 connections. This increase should not be noticeable to an end user retrieving e-mail. Especially, FTP exhibited lower response times over IPv6 than IPv4. Although the tests were conducted in a LAN environment, the results obtained may give some indication about the application response time even when application servers reside outside the LAN. Determining whether the results obtained for SMTP are IPv6 specific or implementation specific is a topic for further research.

6 Appendix A: 95% Confidence Interval for Differences in Application Response Time between IPv4 and IPv6/Tunneled Traffic

Table 6-1 lists the upper and lower bounds for the confidence intervals with a 95% confidence level for the differences in average application response times between IPv4 and IPv6 and IPv4 and tunneled traffic. We can say with 95% confidence that the differences in response time will lay within these bounds. A confidence interval with both positive upper and lower bounds indicates that we can say with 95% confidence that IPv6 or tunneled traffic (depending on which row the data is placed in) for that particular application exhibited longer application response times than IPv4. A confidence interval with both negative upper and lower bounds indicates that we can say with 95% confidence that IPv4 exhibited longer application response times than IPv6 or tunneled traffic (depending on which row the data is

placed in) for that particular application. A confidence interval in which one bound is negative and the other bound is positive indicates that we do not have a 95% confidence level for the claim that there is a difference in application response time13. This is because the value of 0 is between the upper and lower bounds, indicating the possibility that there is zero difference between the two application response times. The confidence intervals are also indicative of the precision of the values. For example, the confidence interval for tunneled HTTP with 1000 concurrent connections ranges from 84.79 to 120.95. This indicates that we can say with 95% confidence that in our particular test environment tunneled HTTP with 1000 concurrent connections would exhibit longer application response type than IPv4 HTTP with 1000 connections by 84.97 to 120.95 milliseconds.

Table 6-1: 95% Confidence Intervals for Differences in Application Response Time

Protocol	Number of Connections	1	10	100	200	500	1000
HTTP	IPv6 (milliseconds)	0.93 to -2.67	0.96 to -2.10	6.43 to -0.81	N/A	16.32 to -3.66	24.28 to 16.94
	Tunneled (milliseconds)	5.78 to -1.70	2.81 to -0.47	13.71 to 3.35	N/A	57.71 to 34.55	120.95 to 84.79
FTP	IPv6 (milliseconds)	1.30 to -0.80	-76.30 to -459.08	628.45 to -3106.57	N/A	N/A	N/A

13 The confidence levels with which we can say one protocol exhibited longer application response times than the other are listed in section 3, namely, Table 3-2, Table 3-4, Table 3-6 and Table 3-8.

	Tunneled (milliseconds)	14.58 to -0.30	20.37 to -356.69	1200.06 to -3031.3	N/A	N/A	N/A
SMTP	IPv6 (milliseconds)	-15.47 to -48.07	211.25 to -156.99	1936.96 to 1093.52	N/A	12581.62 to 6990.24	N/A
	Tunneled (milliseconds)	-9.64 to -39.74	198.45 to -158.17	2506.87 to 1677.09	N/A	12630.12 to 7035.30	N/A
IMAP	IPv6 (milliseconds)	1.60 to -18.32	25.52 to -6.60	103.00 to -264.68	628.37 to 124.35	N/A	N/A
	Tunneled (milliseconds)	5.04 to -14.88	36.67 to 7.03	173.81 to -198.37	782.72 to 223.44	N/A	N/A

7 References

[1] Edward R. Dougherty, *Probability and Statistics for the engineering, computing and physical sciences*, Prentice Hall, Inc., 1990

[2] Raj Jain, *The Art of Computer Systems Performance Analysis*, John Wiley & Sons, Inc., 1991

[3] http://homepages.fh-regensburg.de/~jom30197/chapter3a.html