Impact of TCP Window Size on IPv4 and IPv6 Performance

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Summary
IPv4 will run out of address space soon and IPv6 will co-exist with IPv4 in IP network. This article highlights the impact of Transmission Control Protocol (TCP) Window Size for IPv4 and IPv6 performance. Multiple sizes of files from 100MB to 1000MB were transferred between two hosts by using multi size of TCP window. Five tryouts were made for every TCP window size and for every file size used for the test of both IPv4 and IPv6. Average from three consistent results from five tryouts was used to tabulate the performance graph. Other metrics such as packet drop, packet error, discarded input, discarded output and discarded IP datagram with route failure were monitored, while accurate Simple Network Management Protocol (SNMP) community name and version are configured to ensure high level of accuracy for the test. Further study of this research area will be carried out because there is a need for improvement in IP based network performance.
Key words:
IPv4, IPv6, performance, benchmark

1. Introduction

Studies in IPv4 and IPv6 area have been done [1], [2], but there is still a gap for improvement which can benefit to all users. IPv6 slow uptakes give us a hint that IPv4 and IPv6 will co-exist for a long time just like IPX for Novell computers. Performance of IPv6 network itself is one of the few reasons why migration of IPv6 is slow. IPv6 is an upgraded version of IPv4. Address features is the main changes between IPv4 and IPv6. The 128 bits address space in IPv6 was built to overcome IPv4 address space shortage. Theoretically, better network performance should be achieved after migrating to IPv6 network but the actual performance results still not clear [3].

The structure of this article is as follows. In Section 2, we briefly discuss about research background of this study at Section 3 explains about the test scenario. Results from the test scenario were explained in Section 4. In Sections 5 is discussion for the test results. Finally, conclusion for this article and proposed future works are in Section 6.

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2. Research Background

TCP is a reliable connection oriented protocol widely used in IP based networking and reviews from other articles [1-3] shows that there is a different in TCP performance between IPv4 and IPv6 network, but why and what caused the difference is unclear.

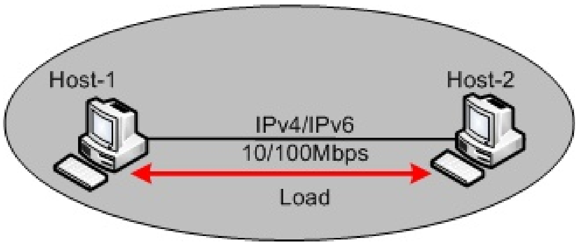

Fig. 1 **S**etup for baseline test [2].

Figure 1 is the test setup was done to compare IPv4 and IPv6 performance under controlled environment [2]. Performance different for the baseline test is small but we still need further exploration and see whether there is a room for improvement. There are few factor which can influence performance of IP based network which are; Jitter, buffer length, segment size and TCP window size. Jitter or delay variation is a measurement of a series of one-way latency, while buffer length is how much memory allocated to send and receive the network traffic packet, whereas maximum segment size is how much data is sent in each packet, but this article only focused on impact of TCP window size or how many packet are sent before receive window acknowledgement in both IPv4 and IPv6 network. The main tool use to perform the test is Jperf which is the frontend of Iperf written in Java programming language [4], [5]. Jperf can be considered as a modern and easy to use for measuring TCP and UDP performance test. Advantages of Jperf are;

- It is easy to use with GUI.
- Less time required for setting up process.
- Bandwidth calculation is automatic and can be shown at a certain interval (configurable).
- Sequential or concurrent test upload and download.

- Upload and download test with multiple parallel channels.
- Higher accuracy compared with manual file transfer and measurement by using separate tool.

Other tool used for this test is 3Com Device Manager, but it was mainly used for the switch configuration and monitor packet drop, error and discard during the test. Our focus for this test is on Jperf tool to see the output and compared it with other baseline test result [2]. Another tool used for this test is Wireshark. Wireshark is the world's foremost network protocol analyzer [6] which is open source, free to download and use. Wireshark was used to capture the network traffic data and perform offline packet analysis.

3. Test Scenario

The objective of the testbed scenario is to measure and compare impact of TCP Window size for both IPv4 and IPv6 performance setup under controlled environment.

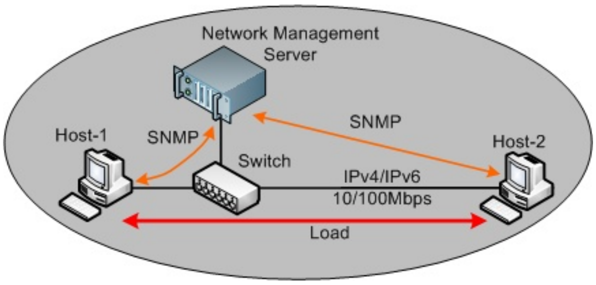

Fig. 2 Test setup

Hardware and software configurations for the testbed setup are as follows;

- Hardware - PC with 2.6 GHz dual core AMD CPU, 160GB HDD, 2GB RAM, Gigabit Network Interface Card (NIC).
- Software - Windows Vista Ultimate Operating System, Jperf and 3Com Device Manager.
- Network Cable - Unshielded Twisted Pair (UTP) Category 5 Enhanced cable.
- Network switch - 24 ports x 10/100/1000Mbps, IPv4 and IPv6 manageable L2L3 support.

Test scenario setup and procedure;

- Setup and configure the same operating system on both host-1 and host-2. Make sure both hosts use the same hardware component and setting.
- Use two Gigabit NIC for the Network Management Server (NMS). One for data communication and the other for network traffic capturing process to ensure 0% or reduce the packet drop, error and discard.
- Set up and configure IPv4 address on all PCs, network switch and server.
- Connect all hosts by using UTP Cat5e cable to a network switch.
- Configure the switch default VLAN and IP to enable communication and management between the switch and the network management server.
- Configure the ports connected to host-1 and host-2 to operate in 100Mbps, to emulate and enable result comparison with 100Mbps Internet or Wide Area Network connection.
- Double check the connection speed between host-1, host-2 and the switch by checking the color of blinking LED on the switch.
- Restart the network port on the switch or at both host-1 and host-2 if the speed still unchanged to 100Mbps.
- Use ping test to ensure connection is working.
- Set up and configure all software on host-1, host-2 and server.
- Do a pre-test by transferring 100MB, 200MB, 300MB, 400MB, 500MB, 600NB, 700MB, 800MB, 900MB, 1000MB of load from host-1 to host-2 and vice versa.
- Monitor packet drop, error, discard and make sure there is no duplex mismatch for all connection.
- Check the physical condition of the UTP cable and RJ45 connector and make sure the packet drop, error and discard counter statistics not increase.
- Run the actual test and collect the data when there is no packet drop, error and discard.
- Disable IPv4 address on all hosts.
- Configure IPv6 address on all hosts.
- Transfer 100MB, 200MB, 300MB, 400MB, 500MB, 600NB, 700MB, 800MB, 900MB, 1000MB of load from host-1 to host-2 and collect the data again.

Other precautions to increase level of accuracy of the test are by ensuring;

- Zero % packet drops, TCP segment packet error, discarded input IP datagram, discarded output IP datagram and discarded IP datagram with route failure before running the test.
- Double check the packet drop, error and discard from 3Com device manager and Windows NETSTAT command line shell from all hosts.
- Make sure SNMP community name and version was configured correctly.
- Avoid running other application on host-1 and host-2 during the test.
- Avoid pressing the F5 button or refresh key during the test.
- Make sure there is no other software or operating system update running in the background process.

4. Result

This section presents the output result from the test. As mentioned earlier, multiple file size from 100MB to 1000MB were used for the test. We also use multiple sizes of TCP windows range from 8KB to 64KB for every file size test.

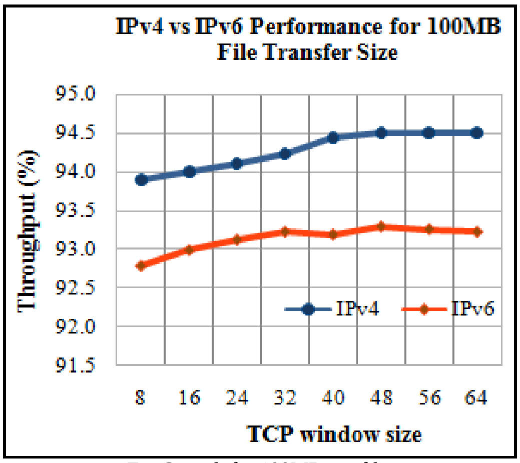

Fig. 3 result for 100MB test file.

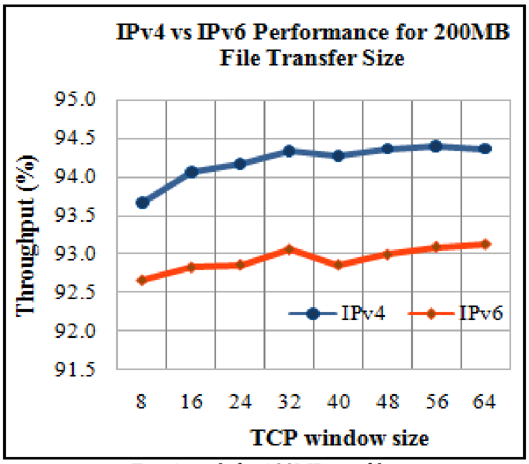

Fig. 4 result for 200MB test file.

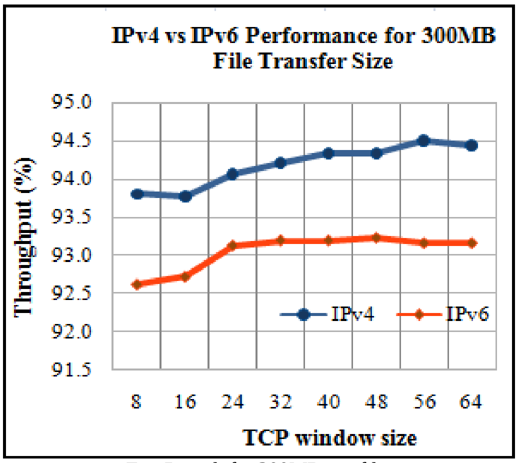

Fig. 5 result for 300MB test file.

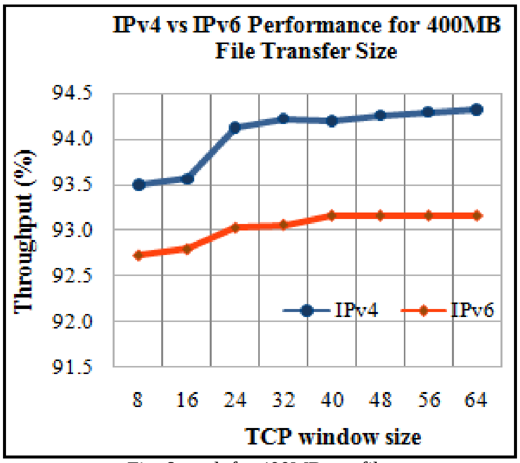

Fig. 6 result for 400MB test file.

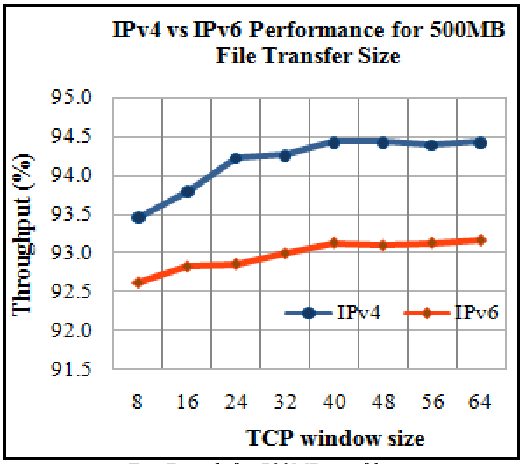

Fig. 7 result for 500MB test file.

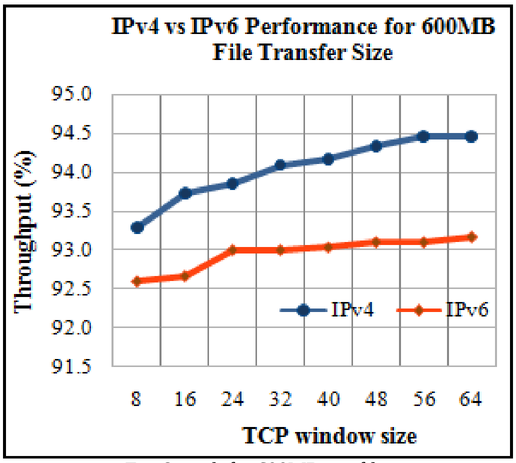

Fig. 8 result for 600MB test file.

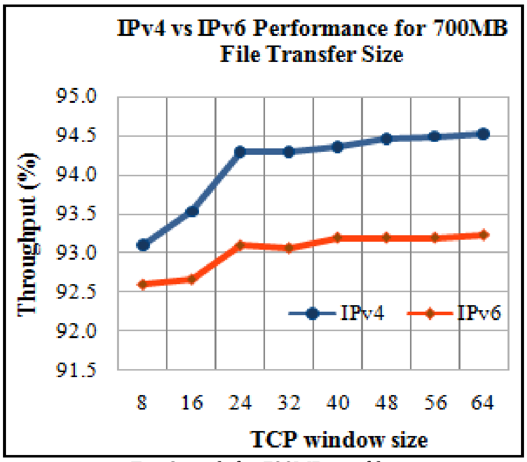

Fig. 9 result for 700MB test file.

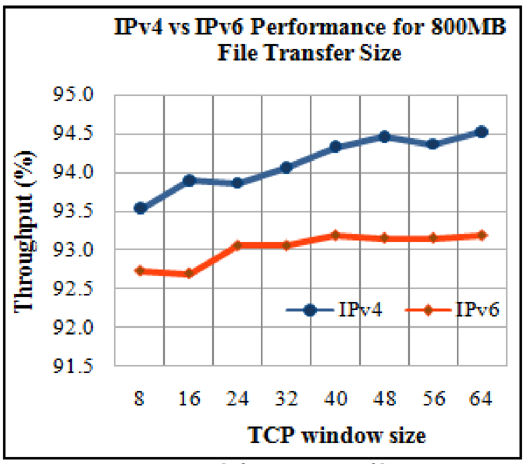

Fig. 10 result for 800MB test file.

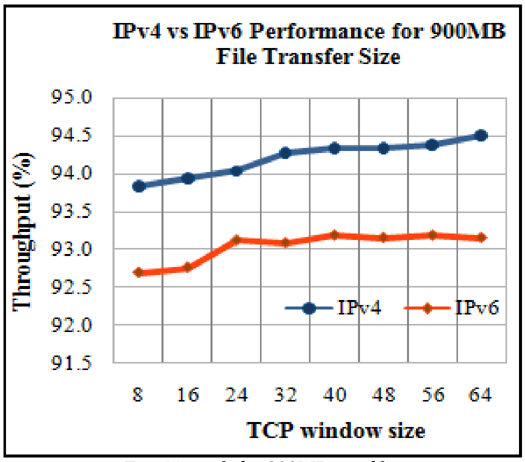

Fig. 11 result for 900MB test file.

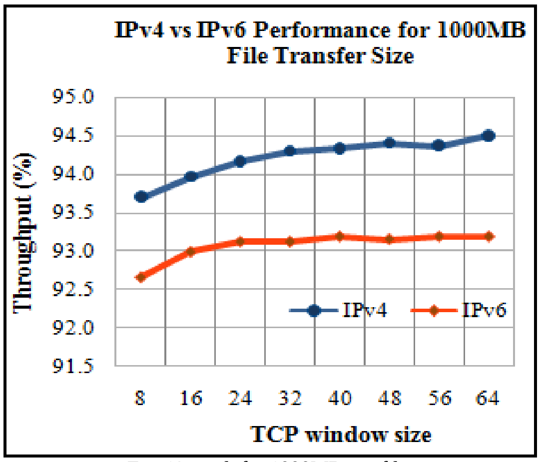

Fig. 12 result for 1000MB test file.

All graphs from Fig.3 to Fig.12 show that the maximum throughput for the entire test is not 100%. The maximum throughput is 94.5% or 94.5Mbps was achieved by using 64KB TCP window size with IPv4 address configuration. Most of the throughput for IPv6 address configuration is around 1% lower compared with IPv4 address throughput. The throughput also seem to increase when the TCP window size increase.

5. Discussion

Throughput is the main performance metrics proposed for this test scenario. Proposed tool to measure the throughput is Open Source based tool which is Jperf. It is because Jperf is also one of the network measurement tools widely accepted by network professionals. Other metric monitored are packet drops, TCP segment packet error, discarded input IP datagram, discarded output IP datagram and discarded IP datagram with route failure. It is important to monitor these metrics because it determines accuracy of the test and affect the performance result. The test setup was design in such way to get accurate comparative result of end-to-end IPv4 an IPv6 network performance under controlled network environment. The network switch was configured to operate at 100Mbps to mimic lower Wide Ares Network (WAN) throughput and see it from end user perspective.

Metrics and tools for the test setup also determine the accuracy of the measurement process. If the measurement for the test uses Multi Router Traffic Grapher (MRTG) the throughput result will be a bit higher. This is because MRTG use SNMP protocol to get the result and this situation will get the throughput which may includes network traffic from other layer such as Address Resolution Protocol (ARP), broadcast traffic and virtual tunnel traffic. While for Jperf it will not includes the other network traffic. If there is another file transfer process running during the test result from Jperf test will be much lower. So Jperf is a network measurement tool which is very useful tool to benchmark file transfer process.

6. Conclusion

Result from the test shows that, the different in performance between IPv4 and IPv6 for testbed is around 1% or 1Mbps. Small TCP window size will result lower throughput for both IPv4 and IPv6. The maximum throughput is 94.5% or 94.5Mbps was achieved by using 64KB TCP window size with IPv4 address configuration. While small test file (eg.100MB) does not have any impact on performance when the measurement was made by Jperf. This situation is different if the measurement was made by MRTG. With MRTG small file size will result lower maximum and average throughput of both IPv4 and IPv6. During the tools evaluation process we discover that average throughput is unchanged even when the tool (Jperf) reach steady state condition or a large file size such 8GB was transferred for high queue/repetitive number. Finally we also discover by Wireshark that the actual IPv4 and IPv6 maximum throughput for 100Mbps link will not reach the maximum 100Mbps due to Transmission Control Protocol (TCP) overhead during file transfer process, ARP traffic, broadcast/multicast traffic and the nature of Jperf tool itself.

Ongoing and future research area that we will embark on are a test scenario which involve a test bed with a multi service router and live experiment of IPv4 and IPv6 end to end network performance test. Once all data from test scenarios have been collected and analyzed, detail characteristic will be applied in the next simulation process. Simulation model will be design based on detail information gathered from tested scenarios. Simulation result will be evaluated with tested scenarios' result. Then accurate model and simulation process will be use for network extrapolation or network performance prediction in large scale implementation.

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[6] http://www.wireshark.org/about.html

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