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(Hons) Computing (Computer Networks and Cybersecurity)**

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DECLARATION

I, Shaun Ross Holborow declare that I am the sole author of this Project; that all references cited have been consulted; that I have conducted all work of which this is a record, and that the finished work lies within the prescribed word limits.

This work has not previously been accepted as part of any other degree submission.

FORM OF CONSENT

I Shaun Ross Holborow hereby consent that my Project, submitted in candidature for the B.Sc. (Hons) Computing (Networking and Cybersecurity) degree, if successful, may be made available for inter-library loan or photocopying (subject to the law of copyright), and that the title and abstract may be made available to outside organisations.

1. Abstract:

With Internet Protocol v4 increasing in usage across the globe, the problems that plague the protocol such as space exhaustion and security are becoming more apparent. In this paper, a virtual scenario of networks has been created using the software GNS3 and Hyper V to test the overall performance of IPv4 and IPv6 using the routing protocols RIP, OSPF and EIGRP with the parameters of testing used being latency, end-to-end delay, throughput, packet loss and jitter. The tests done with this simulation scenario provide results that show IPv6 to be better than IPv4 in terms of overall performance based on all metrics used for testing.

B.Sc. (Hons) Computing (Computer Networking and Cybersecurity)

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3. Introduction:

The main aim of this study is to determine the general differences between IPv4 and IPv6 as well as to ultimately determine which one is deemed superior in terms of overall performance.

The main question being as for this topic is “What are the actual differences between IPv4 & IPv6?”.

To achieve the desired result of said study/experiment, 3 to 4 objectives had to be completed before the result could be achieved and a list of each objective is listed below as the following.

1. Analysis of each Internet Protocol (IPv4 and IPv6) as well as the routing protocols chosen for the experiment (RIP, OSPF, EIGRP) with their appropriate versions included.
2. To evaluate each of the protocols listed for experimentation as mentioned previously in their entirety using the parameters selected.
3. To design a suitable plan/model in handling and finding out the differences of each protocol.
4. To develop a viable solution in achieving the desired result based upon the hypothesis implemented for the test which was to create networks via simulation and then benchmark the results tests done using typical parameters for networks of today.

The expected outcomes/deliverables of this project will be a submission of recommendations based on the author's primary/secondary research as well as models and algorithms developed to address specific problems etc.

In addition to the above, the authors' own input with hard data provided from said experiment will be presented to give a better picture as to which Internet Protocol should be utilised as per the recommendation.

Studies are on-going in respect of this topic as the switch over to IPv6 instead of IPv4 has still not been fully implemented across the globe.

Prior to any real testing done or results achieved, research on various types of literature on the subject was done to paint a better picture of the topic as well as providing information that could help with improving the validity of the experiments taken.

Thus, the following literature review was taken with consideration of all the findings regarding or related to the topic at hand mainly being the differences between IPv4 and IPv6 with their general performance using typical parameters for network testing as well the more commonly used routing protocols in networks of today (RIP, OSPF, EIGRP).

Each piece of literature has been reviewed with various aspects in mind such as conclusions to the sources as well as the abstracts of said sources talking about the general points of the papers.

The project proposal chosen for this assignment was the Comparison of IPv4 and IPv6 in terms of general performance or parameters (latency, delay, packet loss etc.).

- The first chapter revolves around the research & review of all relevant literature found on the internet using certain databases like IEEE Xplore, ACM Digital Library as well as other less known sources.
- The second chapter involves the explanation of the research methodology used for this project or paper which in this case pertained to an experimental basis for relevance's sake for the topic at hand.
- The third chapter talks about the design and implementation utilised for the experiment regarding the use of software solutions and ideas.
- The fourth chapter presents the evaluation of the project with comparisons to the experiment with objectives set for the results found.
- The fifth chapter presents the conclusions made based on the literature review as well as the results obtained from the experiment done for the project with recommendations for things like improvements to performance testing being also presented.
- The sixth chapter presents a reflection of the overall project with potential future work planned or mentioned and a description as to what the author learned from the experience of doing the project.
- The final chapters present the references used for the project and report.

4. Research & Review of Literature:

In this section of the report, all research pertaining to the overall objectives of this project are referenced with the relevant information spoken of as follows.

- Differences between IPv4 and IPv6.
- Which is superior to the other.

The two objectives listed above have allowed me to focus my research in a more constructive & consolidated fashion with the opportunity to fine tune my investigations.

Name: The Performance of IPv4 and IPv6 in Terms of Routing Protocols using GNS 3 Simulator
Dalya Raad Al-Ania*, Ahmed Raad Al-Anib

Abstract:

The author of this paper considers IPv6 to be the answer to virtually all problems currently faced by IPv4, specifically highlighting examples such as space exhaustion and security. He then goes on to say that to test this theory, he created a virtual simulation of a network to

test the overall performance of both IPv4 and IPv6 with the focus being on the efficiency on sending messages from vendor to terminal with more focus on latency and end-to-end delay. Three different types of dynamic routing protocols were utilised, RIP (Routing Information Protocol), EIGRP (Enhanced Interior Gateway Routing Protocol) and OSPF (Open shortest Path First). The simulation used for this test with both IPV's showed a clear advantage of IPv6 over IPv4 in terms of the percentage of messages lost which was less with IPv6 and delivery of messages was found to be faster with IPv6 as well.

Conclusion:

The conclusion of this paper was that the performance of both IPV's had been thoroughly investigated using various factors, size of packets, routing protocols and the distance among the routers etc. The virtual environment consisted entirely of wired based network connections with said factors assembled at the same time to test the performance of both IPV's. Upon the author's getting the results, it was their opinion that with all these factors considered post-test that IPv6 was superior to IPv4. He mentions that the size of said packets can affect the amount of time it takes for it to reach its intended destination. He further provides an example of the RIP protocol used with IPv4 mentioning that when the packet is small it causes the effect of slowdown regarding its time to reach its destination whereas other routing protocols show instead that the small size of said packet will increase the speed of the packet itself.

His final input mentions the possible future of more routing protocols being used for testing with both wired and wireless networks.[1]

Name: Performance Evaluation of Different Routing Protocols in IPv4 and IPv6 Networks based on Packet Sizes Dipti Chauhana, *, Sanjay Sharmab

Abstract:

The author of this paper is convinced that IPv6 is the next generation of internet protocol and that it will replace IPv4 but says that they currently need to coexist with the issue being compatibility with different routing protocols being required for both IP versions with each one having differences in performance depending on the scenarios set on them.

Noting that routing is "a very challenging task" particularly in the case of wireless networks and in this paper, he evaluates the overall performance of each said IP via evaluation of their performance with the usage of specific routing protocols in this case being RIP, RIPng, OSPV2 and OSPFv3 in networks via Mobile Adhoc Networks.

These simulations were achieved by the author using the simulation software known as "Exata Cyber 1.1 Simulator" with the performance of each network being measured based on specific parameters (throughput, end-to-end delay, jitter, and packet delivery ratio with varying packet sizes of 256, 512, 1024 and 2058 bytes.

Conclusion:

The conclusion of this paper by the author was that performance on both IP versions was better the bigger the packet sizes were and consequently the better the overall performance of the network was while conversely smaller sized packets decreased performance particularly in the control overheads. Based on the author's results, the performance of RIPng was considered the best among all the protocols utilised with the justification by the

author being that it used maximum throughput and packet delivery ratio with minimum delay and jitter.

However, he appears to note that OSPF when used with IPv4 networks does not perform well and addresses the desire to further evaluate these protocols using wired and infrastructure-based networks as well as test the BGP protocol sometime in the future.[2]

Name: IPV4/IPV6 security and threat comparisons Emre Durda, Ali Buldub *

Abstract:

The author of this paper talks about the usage of the Internet continuing to increase rapidly, with him providing some brief background information regarding its inception. He states that it first came into existence in the form of communicating nodes, since this development has continued noting that Internet Protocol (IP) was made or used to allow said nodes to communicate correctly with the current version. The most widely used being Version 4 (IPv4).

He mentions that problems with the usage of the current Internet Protocol is its limited addresses which cannot meet the continuing growth of the Internet, thus IPv6 or Version 6 was created in 1995 to solve this problem while also providing security enhancements into modern day networks.

Then he finally mentions the tests and analysis made with IPv6 and IPv4 with Threat Comparisons of two stages with the first focusing on the attacks of IPv4 and IPv6 while the second focuses mainly on the attacks to IPv6 with new considerations.

Conclusion:

The conclusion of this paper by the author was that ultimately IPv6 will replace IPv4 with the reasoning being that every day more and more people are accepting the usage of the protocol throughout the global network.

Stating that IPv6 represents a considerable improvement when compared to the older IPv4 protocol stack with the new suite of protocols providing innumerable features that improve both the overall functionality as well as some specific security functions into a modern network.

Bringing more flexibility thus enabling the opening of security problems and despite many improvements made, it is noted by the author that potential security issues still exist in IPv6 as well as IPv4 with new ones emerging over transition with time and it is believed by the author that by fixing these security issues, wider acceptance and therefore usage of IPv6 can occur.[3]

Name: Performance Evaluation of IPv4 and IPv6 Routing Protocols on Wired, Wireless and Hybrid Networks Sonal Telang Chandel, Sanjay Sharma

Abstract:

The author of this paper talks about the definition of a routing protocol and that there are separate sets of protocols designed for IPv4 & IPv6 (RIP, OSPFv2, RIPng, OSPFv3, AODV etc.). He mentions that IPv4 is meant to be replaced by IPv6 but that they are not suitable for direct replacement, which has resulted in them having to coexist with each other.

In this paper the performance of each IP version (4 and 6) is tested through the testing of performance with various routing protocols over wired, wireless and a hybrid network and that these simulations were done using Exata Cyber 2.1 Simulator/Emulator.

Conclusion:

The conclusion found by the authors was that packet loss is caused by the size of buffers, radio range and router load. The results showed a clear performance winner with AODV with IPv4 with it having the maximum throughput, minimum delay in packet delivery ratio as well as little jitter.

The authors then go on to say that the rest of the paper shows the results of testing each protocol for the appropriate parameters and wish to extend their work for testing in this field of routing protocols sometime in the future.[4]

Name: Performance analysis of IPv4 / IPv6 protocols over the third-generation mobile network DANIEL ABAD CAMARERO

Abstract:

The author of this paper talks about IPv4 being heavily used by various groups, companies, and individuals currently with each requiring their own Ip address to talk to other machines across the internet and vice versa.

However, noting that with these entities being found to use multiple IP addresses at the same time when connected to the internet, this brings up the issue of IPv4 space exhaustion and discusses the reasoning for creation of IPv6 being exactly that.

The author states that the main aim of the project is to measure the differences performance wise between IPv6 and IPv4 in areas such as signalling or loading a web page etc. These tests were done in lab environment using smartphones to observe said behaviour with the results being that IPv6 provide savings in signalling however the IP data was shown to be larger due to the size of headers with a final note being made that work still needs to be done over a wider range of webpages as the tests were only done on applications or webpages with a high level of market penetration that operated the best with the IPv6 protocol.

Conclusion:

The conclusions made by the author was that signalling, and web loading time was less in IPv6 than IPv4 with variations in performance related to differences in optimisation in operating systems with implementation also being a factor.[5]

Name: Performance Analysis of Routing Protocols Based on IPV4 and IPV6 for MANET
Krishna Kumar Chandel, Dr. Sanjeev Sharma, Mr. Santosh Sahu

Abstract:

The authors of this paper talk about the Ad hoc network being used with MANET and routing protocols for helping communication between source nodes and destination nodes

mentioning also other authors using different types of routing protocols for testing such as AODV, DSR, DSDV etc.

In this case, he tests them using a simulator called "Qualnet5.0.2" with the performance metrics being throughput, jitter packet delivery ratio and total packets received.

Conclusion:

The conclusions made by the authors of this paper are that there were clear differences performance wise between each routing protocol (DYMO, AODV, OLSR) with the use of IPv4 and IPv6 and a conclusion made of IPv6 ultimately performing better than IPv4 overall.[6]

Name: Performance Comparison of Mobile IPv4 and Mobile IPv6 Protocols in Wireless Systems R. Gunasundari and S. Shanmugavel

Abstract:

The authors of this paper discuss the success of wireless being reliant on new technologies in the future, mainly in the successor to Mobile IPv4 being Mobile IPv6 with tests and results made from a simulation of networks using both protocols to make proper comparisons and conclusions.

Conclusion:

The conclusions made by the authors of this paper are that MIPv4 and MIPv6 differ performance wise when it comes to parameters such as end-to-end delay or TCP tests etc and that MIPv4 is better suited for VoIP while at the same time so is MIPv6 thus a solution is proposed by the authors that extensions be used for MIPv6 help mitigate said issues.[7]

Name: Performance Evaluation of IPv4 IPv6 Transition Mechanisms IPv4 in IPv6 Tunnelling Techniques Chuangchunsong N, Kamolphiwong S, Kamolphiwong T, Elz R, Pongpaibool P.

Abstract:

The authors of this paper talk of IPv4 address space being a problem that most internet service providers are aware of with tools and proposals made to fix the problem by making it possible to connect IPv4 with IPv6 with 4over6, DS-lite and 4rd with the parameter performance of said tunnelling tools being investigated with comparisons and results made.

Conclusion:

The conclusions made by the authors of this papers are that the tools mentioned have clear pros and cons with differences in performance of areas such as reliability, compatibility, and flexibility etc.[8]

Name: Comparison of RIP, OSPF and EIGRP Routing Protocols based on OPNET Justin Deng, Siheng Wu, Kenny Sun

Abstract:

The authors of this paper talk about the workings of transmission of data dependent on the routing protocol used with the typical ones used being RIP, OSPF and EIGRP. They claim that the aim of the project is to analyse the performance of these protocols using OPNET to simulate said protocols for attributes and performance.

Conclusion:

The conclusions made by the authors of this papers are that EIGRP was considered the best choice performance wise for small and large networks where as OSPF was found to only be good for large networks and RIP had the worst performance of them all particularly when utilised in a large network but had performance almost on par with EIGRP when utilised in a small network.[9]

Name: Evaluation of OSPF and EIGRP Routing Protocols for IPv6 Alex Hinds, Anthony Atojoko and Shao Ying Zhu

Abstract:

The authors of this paper talk about IPv4 addressing space being a problem with support from IPv6 being required to solve the issue. A study comparison was made of each IPv protocol using the two of the most popular routing protocols OSPF and EIGRP with the changes of each edition being noted in said paper.

Conclusion:

The conclusions made by the authors of this paper are that EIGRP has the advantage in certain key areas but is apparently held back by its proprietary nature and costs.[10]

Name: Performance Comparison of IPv4 and IPv6 in Peer-Peer and Client Server Local Area Networks Samad Salehi Kolahi, Burjiz K. Soorty, Navneet Chand, and Zhang Qu

Abstract:

The authors of this paper talk about the performance of IPv4 and IPv6 when compared with both Client-Server and Peer-Peer networks

Conclusion:

The conclusions made by the authors of this paper are that there were clear differences between each server type in areas such as throughput and packet size with IPv4 seemingly being superior to IPv6 in this instance.[11]

Name: Network Performance Evaluation of Internet Protocols IPv4 and IPv6 on Operating Systems Shaneel Narayan, Peng Shang, Na Fan

Abstract:

The authors of this paper talk about IPv4 having a standard to network infrastructure and a hindrance to growth in changes to said infrastructure with IPv6 being the solution to various problems found with IPv4 and the authors setup a test involving six operating systems to test each Internet Protocol under these systems for differences in performance metrics with typical parameter for said tests used.

Conclusion:

The conclusions made by the authors of this paper are that the performance of each Internet Protocol depends entirely on the operating system utilised.[12]

Name: PERFORMANCE EVALUATION OF RIP AND OSPF IN IPV6 USING OPNET 14.5 SIMULATOR Rajneesh Narula, Pallavi Aggarwal

Abstract:

The authors of this paper talk about the importance of routing protocols in the modern era of the internet with RIP and OSPF being mentioned as examples followed by them stating that in the paper, they evaluate the performance of routing protocols like RIP and OSPF for IPv6 using the typical parameters for testing networks.

Conclusion:

The conclusions made by the authors of this paper are that the best performance output for IPv6 in this scenario is a combination of RIPng and OSPFv3, but individual routing protocol performance was better with OSPFv3 over RIPng.[12]

Name: Performance Analysis of IPv4 to IPv6 Transition Mechanisms Sheetal Singalar, EM Banakar

Abstract:

The authors of this paper talk about the apparent issue of IPv4 addressing space with the need for complete transition over to IPv6, some techniques are mentioned as options for potential in helping transition of IPv4 systems to IPv6 and these techniques are analysed using cisco packet tracer.

The results showed dual stack to be better in performance compared to tunnelling method.

Conclusion:

The conclusions made by the authors of this paper are that while dual stack and tunnelling are both good performance wise in their own ways, its ultimately found that dual stack is better performance wise compared to tunnelling.[14]

Name: Evaluating the performance of IPv6 with IPv4 and its Distributed Security Policy
Vineeth. M. V, Rejimoan. R

Abstract:

The authors of this paper talk about issues that IPv6 could solve with its introduction to replace IPv4 and that an analysis was done of the various security vulnerabilities, network security improvements and other things within or related to IPv6 with the recommendation that more security policies be made for both IPv4 and IPv6.

Conclusion:

The conclusions made by the authors of this paper are that any security policies present need to be improved and any new polices made need to be implemented.[15]

Name: Implementing of IPv6 Protocol Environment at University of Kuala Lumpur
Measurement of IPv6 and IPv4 Performance Mohd Nazri Ismail, Zaheera Zainal Abidin

Abstract:

The authors of this paper talk about the benefits of IPv6 integration for their university with multimedia capabilities (Video, Audio) as the sole focus with comparisons of performance between IPv4 and IPv6 using video conferencing as a benchmark.

Conclusion:

The conclusions made by the authors of this paper are that IPv6 had low throughput compared to IPv4 while used with workstations or servers whereas both Internet Protocols behaved the same performance wise when used for streaming activities.[16]

Name: VoIP network performance evaluation of operating systems with IPv4 and IPv6 network implementations Shaneel Narayan, Matthew Gordon, Chad Branks, Li Fan

Abstract:

The authors of this paper talk about VoIP implementation being more commonplace in the modern era compared to more traditional telephone network systems used in the past. They used testing method of VoIP CODECS with Windows operating systems to see performance differences with metrics like jitter, latency, throughput etc.

Conclusion:

The conclusions made by the authors of this paper are that there was only a slight difference in performance between each network using IPv4 and IPv6 with the difference dependant on the CODEC or operating system used etc. [17]

Concluding this reviewed literature, various software is used to test the performance/reliability of the internet protocols with wired application in mind, using GNS3, Hyper V etc.

5. • Research Methodology

The planned research methodology of this project was through experimentation as well as reliability and validity with the reasoning being mainly from the topic or nature said project plan.

The data collected from said experiment is in the form of observations followed by documentation of said data which mainly contains the information based on benchmarking of throughput, delay, packet loss, jitter etc.

The risks found were little to non-existent in this scenario with limitations however being the accuracy of testing as it was done using virtual simulation of networks using the required IP versions and routing protocols required.

All the data obtained from the experiment was obtained through GNS3 with pinging which was then compiled into an Excel spreadsheet to provide a better overview of the data retrieved from the experiment. It was then taken and used for averaging or in creating bar graphs to provide a better picture for any other viewers of the project to see more easily. The clear differences were observed in things such as latency which was one of the main parameters used for testing.

'Ping' is a very widely used command in the IT industry. It provides an effective method of not only ensuring that we have a connection at the TCP layer but gives a good indication of the return trip time between a source and target. For this experiment it was a good measuring tool with consistent and reliable results. Its simplicity as a tool allows it to be easily executed and relied upon.

The lower the round trip Ping time the more stable the network & the lower the end-to-end delays.

The reason why this research methodology was used for this project was because it was deemed as the most appropriate or relevant form for the tasks required by the author to be undertaken, this was under experimentation of each IP (IPv4 and IPv6).

The advantages of using this form of methodology are that it involves the use of equipment and techniques that have already been utilised previously by said author thus experience helped with the setup of this project with the use of equipment such as Hyper V and GNS3 as well as the addition of prior work in the field involving the testing and analysing of various network in the real work, mainly in the form of cisco networks or universities etc.

The disadvantages of this approach in methodology are that it is virtualised, meaning all the problems potentially present are still not fully accounted for. In addition, the issues relating to the setup of these programs in the first place may not be fully compatible or powerful enough to efficiently use said programs, thus halting any progress that could have otherwise been made.

The experimental hypothesis of this project is that IPv6 is better than IPv4 in terms of general overall performance, both internet protocols however are each better in some areas more than others. For example, one of the reasons IPv4 is considered better than IPv6 is that it is simpler to understand with its 32-bit dotted decimal structure which is much smaller and simpler than IPv6's hexadecimal numbers. This simplicity is easier for humans to read.[13]

The hardware used for the project was the author's own personal computer using the following specs ensuring optimal performance requirements were for the tasks required.

- GPU: EVGA NVIDIA GeForce RTX 2060 KO GAMING, 06G-P4-2066-KR, 6GB GDDR6, Dual Fans, Metalplate
- CPU: Intel CORE I5-9600K 3.7 GHZ SKT1151 9MB CACHE BOXED - BX80684I59600K
- CPU Fan/Cooler: Cryorig CR-H7A Tower Cooler For AMD/Intel CPU
- Motherboard: MSI Z390-A PRO Motherboard ATX, LGA1151, DDR4, LAN, USB 3.1 Gen2, Type-C, M.2, RGB Mystic Light, VGA, DVI-D, Display Port, Intel 8th and 9th Gen
- RAM: Corsair Vengeance RGB PRO 16 GB (2x8 GB) DDR4 3200Mhz C16 XMP 2.0 Enthusiast RGB
- Storage: Western Digital WDS500G2B0A WD Blue 3D NAND Internal SSD 2.5 Inch SATA, 500 GB
- Case: Corsair C-9011077-WW Carbide Series 100R Silent Mid-Tower ATX Computer Case - Black
- PSU: Corsair VS650 650 W Active PFC 80 PLUS Certified Power Supply Unit - Black
- Optical Drive: Portable

The software used for this was Microsoft Word, Excel, GNS3, Hyper V and other software although used more sparingly and not of considerable importance.

This experiment is valid because it involves the investigation and conclusion of a topic that is still ongoing as of 2021 with various studies still being made though most admittedly were from many years back regarding IPv4 and IPv6.

This experiment is reliable because it provides hard data or at the very least relevant data that can be used to thoroughly or at least support the arguments made for and outside said project to help with further understanding the topic and making any further changes for future reference. Also, the reliability factor mainly is increased from the usage of tested and tried network simulation software (GNS3 with Hyper V) to measure the packets for things like latency or packet loss etc.

This experiment was conducted using research of various other papers using similar techniques to gain results and answers for their questions on the topic and software like GNS3 and Hyper V to analyse the results.

The protocols RIP, EIGRP and OSPF were used to simulate the conditions required for appropriate results of differences between IPv4 and IPv6.

This experiment is generalisable.

The experiment was conducted using the software GNS3 and Hyper V. Using these tools, networks or topologies were created that were tested under the internet protocols IPv4 and IPv6 with both each using the three main routing protocols chosen for the experiment (RIP, OSPF, EIGRP).

After these networks were setup, tests were done by measuring pings or capturing packets to measure the parameters chosen for use in testing which were latency, end-to-end delay, throughput, packet loss, and jitter.

Upon testing each of these parameters, the results were obtained and compiled into an Excel spreadsheet where the results of each were recorded for reference and to create graphs presenting the results.

These results are then compared with each other, providing a conclusive answer to the questions asked of the project.

6. Design & Implementation

6.1 Design

Regarding the design of the experiment/project, various decisions had to be made such as how it was going to be approached and what software was used etc.

Various ways were chosen in handling the project, such as possibly using Cisco Packet Tracer for network simulation instead of GNS3 with Hyper V however this idea was abandoned early due to issues with getting suitable test results that could be compared with IPv4 and IPv6 etc.

Also, the usage of VMware and Virtual Box was discontinued due to compatibility issues potentially related to my system type.

Certain protocols were left or unused due to being deemed unnecessary or not appropriately applicable to the task at hand for the project.

The factors most important for the project was what software was used, how it was used, what tests were done and providing an overall result to the main question.

Factors that were chosen to be ignored were mainly things like protocols used for Wireless networks which were not deemed applicable to the task required.

The design I had chosen for this project was to revolve around the use of tool/simulator called GNS3 to create the network topologies and configs and Hyper V to use with GNS3 to create the virtual operating system of the systems or routers, switches, pcs etc to use the Cisco Systems for creating said networks.

It was decided to use a group of small, easily configurable networks for the testing process. This philosophy ensured that factors involved in the outcome were related directly to the objectives and not influenced by unknown issues such as network congestion or configuration.

As for the parameters and routing protocols utilised, the parameters chosen for using with this experiment on the project were mainly latency, end-to-end delay, and packet loss. The routing protocols used for this experiment were RIP, EIGRP and OSPF.

It is with these parameters and protocols used that implementation for the experiment was possible.

6.2 Implementation

As for implementation, this was done using various methods and software to accomplish the main goals of the project.

Regarding the tools and techniques used for the project, as mentioned previously GNS3 with Hyper V were used to simulate the virtual networking environment. The inbuilt Cisco system were used for each network topology. Parameters such as latency, which were tested using the built-in systems on the virtual networking nodes allowed for command consoles to ping pcs from separate subnets. This was to test the milliseconds of each ping response from source to destination, which with the results then being averaged, to find the overall response time of each system and test made.

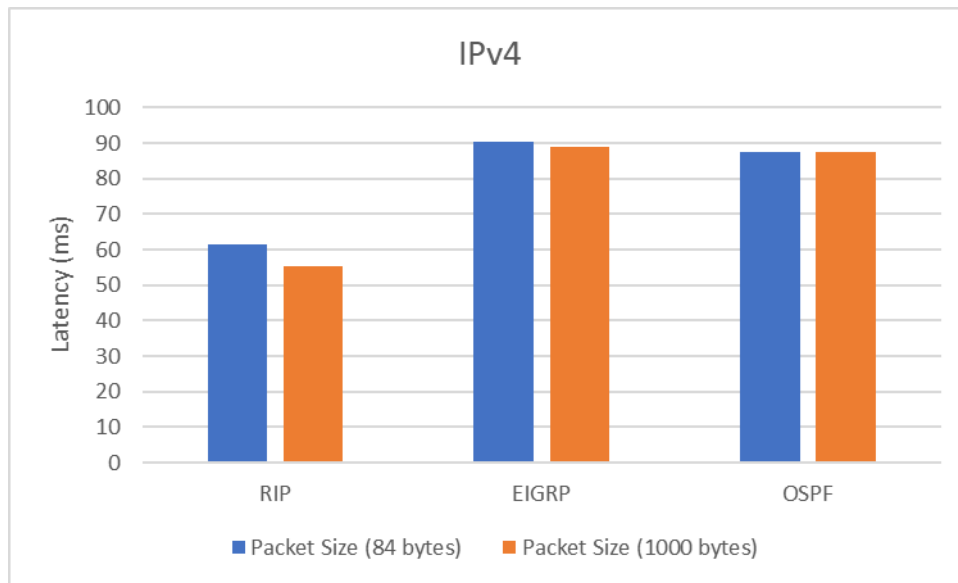
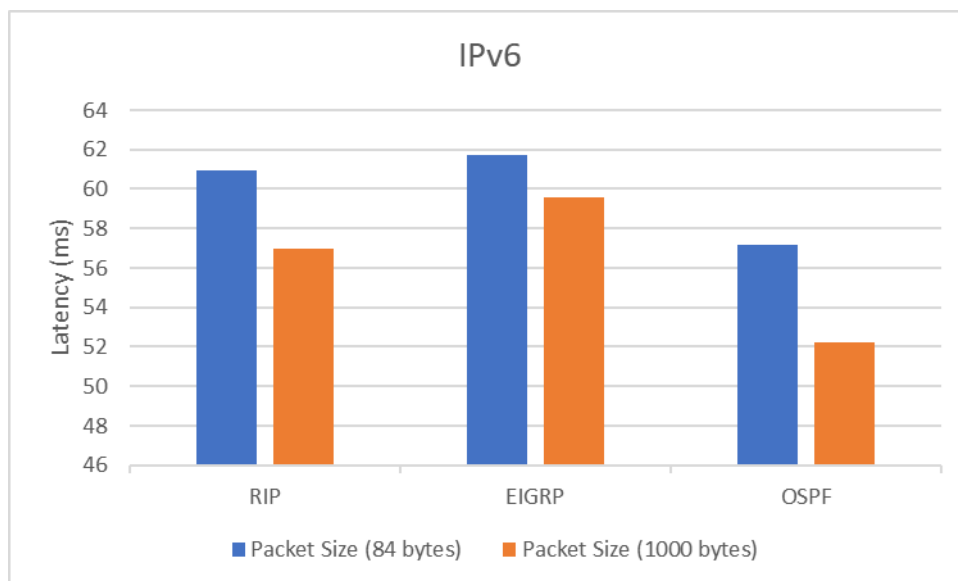
There were difficulties along the way of development and implementation of the experiment some of which being were compatibility issues with the software or tools themselves as well as difficulty in finding the methods required for the tests needed.

A lot of these difficulties were overcome (though not all) through research or looking for information on how to use or install said tools/techniques correctly either through books, websites, or videos mainly on the internet.

7. Result

7.1 Analysis of the result

The results of the experiment and tests done show clear evidence of varying latencies for each IP version including the packet sizes tested.

**Figure 1 - IPv4 Latency Test****Figure 2 - IPv6 Latency Test**

As shown here in the data and graphs, there is a clear distinction in the response time or milliseconds of each internet protocol using the following routing protocols with different byte sizes used to test for differences in latency with small and big packet sizes.

The results in general show that overall, the latency is much more manageable regardless of size when using IPv6 with said routing protocols while IPv4 is shown to take considerably more time in sending the packets regardless of size.

Besides this, tests with other parameters were done with end-to-end delay being found to exist but on no perceptible level, throughput although briefly tested was deemed non applicable overall along with jitter and packet loss due to the nature of the experiment with

packet loss being found to be of no issue with the network setup used for each routing protocol.

The results were mostly what was expected from the tests made with a few exceptions though mainly showing the IPv6 is indeed all-around superior to IPv4.

Some results however were not expected but the reasoning behind this could simply be due to the nature of the project or setup used to tests these things one of which was the lack of if any noticeable difference regarding jitter, end-to-end delay, throughput, and packet loss.

This mainly links back to the literature review made because it shows similar or nearly identical differences between each internet protocol when using these routing protocols and parameters for testing.

No real interesting correlations were made aside from what was already known or seen in previously mentioned literature sourced with the expectation being of latency with results showing similarities as to what has been discusses in various other papers researched.

Overall, the results provided answers that were mostly expected with a few notable exceptions because of the nature of the tests done and environment used for said tests.

8. Evaluation

The conclusion drawn from this data is that overall IPv6 is better than IPv4 in terms of general performance. However, differences exist between each internet protocol based on the tests done and related to the parameters and routing protocols used.

The results also show that they can and are still used interchangeably depending on the nature of their use and hence show the pros and cons of both currently or in relation to the modern era of the internet and networking with status changing overtime as IPv6 begins to overtake IPv4.

The data received from the tests done backed some of the literature research found, but not all. This may be due to relevance or lack of data in certain areas.

Most of the objectives were met with little to no issues though some had to be abandoned such as getting more obvious packet loss data as readings in this area were not possible or were virtually non-existent.

As for the aim, this was successfully achieved, as any issues that were encountered such as software compatibility were quickly rectified by finding other more suitable alternatives.

Overall, the answers gained from the experiment were mostly to be expected outcome wise, with a few exceptions.

If required to do this experiment or project again, it would be done differently in a few ways one of which being to create and test networks using wireless connections instead of just wired ones while also trying out different routing protocols and methods for testing said protocols as well as perhaps do a simulation of the networks with real physical machines to get more potentially useful data that could be further applied to the networks of the world.

In addition, it may have been useful to test the difference between the IP versions under heavier traffic loads using perhaps some large consistent file transfers between source and target PC's.

9. Conclusions & Recommendations

To summarise everything done in this report, an experiment was done to find the differences between IPv4 and IPv6 as well as see which one is superior in terms of general performance based on the parameters typically and currently used for testing networks of today.

There were some possible other avenues for potential research and experimentation mainly in wireless networks, tunnelling methods with these protocols as well as the use of other routing protocols old or new with IPv4 and IPv6.

There was always an option to extend the experiment to include a larger more complex network, maybe including a connection to the Internet. However, this was excluded on the grounds that the said connection was not under test-controlled conditions with many external factors possibly causing inconsistent test results.

Recommendation wise, if anyone uses or wishes to use similar or the same software and hardware utilised in this study, make sure that there are no compatibility or performance issues when attempting to use or install GNS3 and Hyper V etc as certain functions of these tools requires a decent system to run efficiently and correctly.

One recommendation for anyone using GNS3 to create virtual networks is to always save the configs of said nodes (routers, pcs etc.) after you are finished using the networks as otherwise the program will restart without the configs which are needed for all inputs (IP addresses, routing settings etc.) made thus losing any progress made in implementing the correct IP addresses and router settings for the networks created.

There are various tutorials out there that can help anyone if required who do not understand the process as setting up these programs can be complicated depending on the specs of the system used as well as the skills of user attempting to set them up.

10. Reflection

Things learned mainly from this project were how networks might function when using these tools and protocols, particularly in a real-life scenario.

This changed the author as a person by presenting him with a better idea as to how these networks work, how much more complex they are than initially thought, and how they help us all in our daily lives. In relation to this complexity, I have more respect for the ISP's and the quality of the day-to-day provision of Internet access to the end user as without all these measures taken and put into account of actual application of use, the usage of these networks would be potentially disastrous or chaotic for the general user making them unsuitable for use.

The project could have been potentially done better. However, by doing more research and perhaps using different tools, software, or techniques, this could have helped with the experiment therefore increasing productivity overall.

Regarding any potential successors in the future, they should instead possibly use alternative software, different methods of handling protocols however it should be noted that the ones used for this project were just as viable as most available to the public of today.

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12. Appendices

Project Requirements specifications document

The project requirements specifications are as follows:

Software

- GNS3
- Hyper V

Hardware

PC Specs:

- GPU: EVGA NVIDIA GeForce RTX 2060 KO GAMING, 06G-P4-2066-KR, 6GB GDDR6, Dual Fans, Metalplate
- CPU: Intel CORE I5-9600K 3.7 GHZ SKT1151 9MB CACHE BOXED - BX80684I59600K
- CPU Fan/Cooler: Cryorig CR-H7A Tower Cooler For AMD/Intel CPU
- Motherboard: MSI Z390-A PRO Motherboard ATX, LGA1151, DDR4, LAN, USB 3.1 Gen2, Type-C, M.2, RGB Mystic Light, VGA, DVI-D, Display Port, Intel 8th and 9th Gen
- RAM: Corsair Vengeance RGB PRO 16 GB (2x8 GB) DDR4 3200Mhz C16 XMP 2.0 Enthusiast RGB
- Storage: Western Digital WDS500G2B0A WD Blue 3D NAND Internal SSD 2.5 Inch SATA, 500 GB
- Case: Corsair C-9011077-WW Carbide Series 100R Silent Mid-Tower ATX Computer Case - Black
- PSU: Corsair VS650 650 W Active PFC 80 PLUS Certified Power Supply Unit - Black

- Optical Drive: Portable

Project Test Environment:

6 networks are created, 3 for each Internet protocol (IPv4 and IPv6), for each of the three networks they use the routing protocols RIP, OSPF and EIGRP.

IPv4

- RIP Network
- OSPF Network
- EIGRP Network

IPv6

- RIP Network
- OSPF Network
- EIGRP Network

Parameters used for tests:

- Latency
- End-to-end delay
- Packet Loss