Progress in Engineering Application and Technology Vol. 4 No. 2 (2023) 1085-1097
© Universiti Tun Hussein Onn Malaysia Publisher's Office

PEAT

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/peat
e-ISSN : 2773-5303

Use of Internet Protocol version 6 to Provide Better Communication Networking System for Railway Operation

Alyah Amyrah Yusri[1], **Karthigesu Nagarajoo**[1]*, **Muhammad Nazrin Yahya**[2]

[1]Department of Transportation Engineering Technology,
Universiti Tun Hussein Onn Malaysia 84600 Pagoh, Johor MALAYSIA

[2]r2p Asia Sdn. Bhd.,Menara Suezcap 1, KL Gateway, No.2 Jalan Kerinchi, 59200 Kuala Lumpur, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/peat.2023.04.02.112
Received 29 June 2023; Accepted 12 July 2023; Available online 12 July 2023

Abstract: IPv4 was introduced in 1981 by Internet Engineering Task Force (IETF) with providing more than 4.3 billion IP addresses. However, after 25 years of deployment IPv4 connection start to exhausted as the number of IP address drained as year pass. IETF encounter this problem with providing new Internet Protocol (IPv6) who capable to provide at least 340 trillion addresses. With focus on providing better network communication system in railway, ping test and latency test being execute with application of CCTV live streaming. For this research i to prove effectiveness of IPv6 in term of latency. After execution of experiments, results show that, compared to IPv4, IPv6 have lower round-trip time (RTT) in the ping test. While for latency test, IPv6 shows efficiency of 72% in data transferring which it determines that IPv6 require lower latency. The efficiency of data transferring is taken from the outcome of each parameter of experiments (bandwidth and duration). This shows that IPv6 really provide better network communication that it will benefit railway industry in transferring data from trains to control center with shorter time taken to travel from sender to its destination. As conclusion, IPv6 have lower latency than IPv4 because of its features, thus, adapting IPv6 are really recommended as it will benefits railway industry either for railway players or rail transportation user.

Keywords: IPv4, IPv6, Latency, Live Streaming

**Corresponding author: karthi@uthm.edu.my*

1. Introduction

World revolution on communication, internet devices like mobile phones, routers and more have brought a new wave on internet connection, networking. Network is an interconnection of any devices that can exchange data and share information or resources with each other. These networked devices use a set of rules known as communications protocols, sometimes known as Internet Protocols, to communicate information over physical or wireless technologies (IP). IP is the best-known Layer 3 or Network layer protocol [1]. The Internet Engineering Task Force (IETF) developed the Internet Protocol version 4 (IPv4) standard, which is used to transport internet traffic and other packet-switched networks. IPv4 employs 32-bit address space, which gives around 4.3 billion usable unique addresses. As the globe pushed toward Internet-of-Things (IoT), the available number of addresses soon began to run out. The development of IoT has made the pattern on internet users increase day by day and at the end, IPv4 unable to provide more unique addresses to be used. To overcome this issue, the IETF published an Internet Protocol version 6 (IPv6) with its 128-bit address space that is able to provide up to trillion IP addresses.

When IPv6 comes into networking systems, it must bring new improvements that are able to solve IPv4 problems. The shift from IPv4 to IPv6 can be broken down into the following three phases [2]:

Phase I: IPv6 is an island in IPv4 ocean (IPv4 still dominant network)

Phase II: IPv4 become island while IPv6 is the ocean (IPv6 overcome IPv4)

Phase III: IPv6 become native in most networks (IPv6 new dominant network)

In each phase we see the application of IPv6 are slowly replacing the use of IPv4 in the network system. As application of IPv6 cannot apply all at once because there still devices that not supporting IPv6 system thus the best way is applying it by phase.

There are few differences between IPv4 and IPv6 that show IPv6 able to provide better networking systems such as the address space and format, network-address translation, Internet Security (IPSec), packet loss and recovery and more. IPv4 will need help from Network Address Translation (NAT) in order to transfer data to its destination. It will take longer to transfer data as NAT functions on translating IP from local private addresses to public addresses. In railway system, majority of the devices in a train are connected by Ethernet. Every device will have their own IP addresses. This IP will help it connect through other devices and the control center. When we said Ethernet are used in the train communication networking system, there is need of transferring data from one device to another device. Thus, Internet Protocol and Internet Router will help in sending packages of data to destination safely with taking best path. However, there are times that device unable to send data to another device or even to center as there are packet loss or needing more time to transfer the data because of the size or router protocol that being used for the device. This becomes major problem when a device unable to send warning of accident to center when they detect the problem. It will bring catastrophe or severe damage.

The project will discuss more on the latency of IPv4 and IPv6 in transferring data in live streaming of Closed-Circuit Television (CCTV) application. This will assist the railway player on transforming the use the better Internet Protocol to provide safety and efficient service to train user.

This research aims at understanding the different of features of IPv4 and IPv6 giving different efficiency and latency on communication networking system focus on railway transportation devices. To achieve the aim of this research, the following objectives have been set:

i. To investigate the features of IPv4 and IPv6 in terms of their influence on efficiency and latency of data transfer in the context of railway communication network system.

ii. To analyse the performance of IPv6 in data transferring capabilities of live streaming for railway communication network systems using iPerf3 software.

As this research focus on analysing the latency of IPv4 and IPv6 in transferring data by using iPerf3 software, it will involve the use of CCTV live streaming which is the same CCTV system in railway industry. Start with execute ping test with 100 packets of data transferring for both IPv4 and IPv6 to analyse the round-trip time (RTT) of both IP and then continue with latency test using iPerf3. For latency test different size of bandwidth will be use which is 0.5 Mbits/sec, 1.0 Mbits/sec, 1.5 Mbits/sec, 2.0 Mbits/sec, 2.5 Mbits/sec and 3Mbits/sec and 3 different time taken of experiment execution, 10 s, 60 s and 180 s. iPerf3 will be able to show the latency of data transferring with several commands.

In IPv4 header format (Figure 1, Enache, D., & Alexandru, M., 2016) there are 6 rows which every row has their own roles in networking of IPv4. However, with modernization era move as year past, IETF recognize that IPv4 unable to support current demand in networking thus IETF also come out with several issues that IPv4 have in order to provide better internet protocol for future use. The issue of IPv4 include the IPv4 space and format, IP security and packet loss. With focus on duration of lag while transferring data while using IPv4 because of Network Address Translation (NAT) and Classless Internet Domain Router application, IETF suggested to move to IP version 6 who also call as IP next generation (IPng).

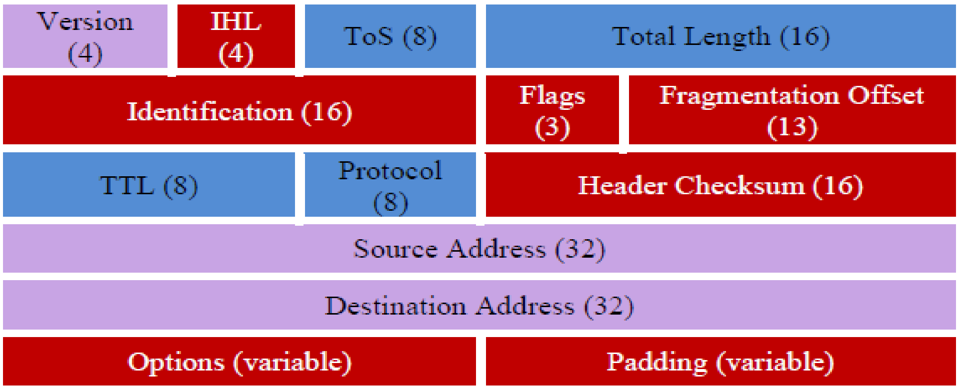

Figure 1: Internet Protocol version 4 (IPv4) Header Format

IPv6 built to solve the issue with the previous protocol. With the 128-bits address, IPv6 able to generate 2^{128} addresses. Unlike IPv4 that only use dotted decimal notation address format, IPv6 use hexadecimal values separated by colons and use of letter in lowercase, thus, it shows that IPv6 able to fulfill the demand of network user. With only 4 rows of header format, IPv6 able to give much better performance in data transferring especially in term of lower latency. Figure 2 shows the header format of IPv6 [3].

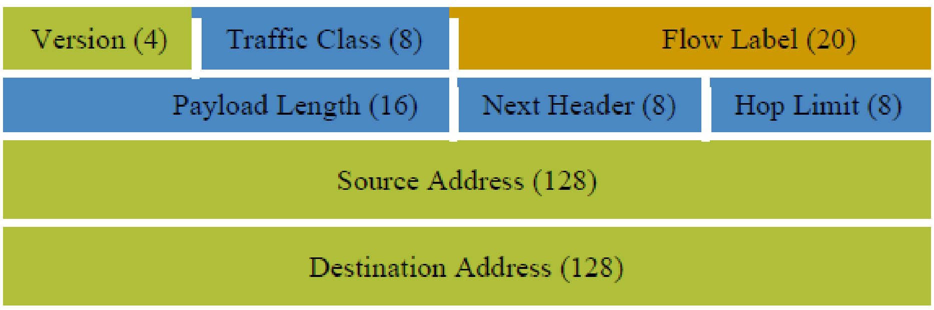

Figure 1: Internet Protocol version 4 (IPv4) Header Format

In the next chapter, will include procedures, parameters and explanation of the experiments that been execute for this research in order to answer the objectives of the research. Start with determining the resolution of CCTV system that being use for the experiment to the flow of the research, experiment setup and parameters for ping and latency test.

2. Methodology

2.1 Resolution of Live Streaming

There are several types of resolution use widely in any fields of job, Table 1 [4] shows those resolution list. In this project, resolution that will be used is 1920 x 1080. The selection of the 1920 x 1080 resolution is based on the maximum resolution offered by the CCTV system employed in the experiment.

Table 1: Resolution List

Resolution	Name	Aspect Ratio	Pixel Size
Standard Definition (SD)	480p	4:3	640 x 480
High Definition (HD)	720p	16:9	1280 x 720
Full HD (FHD)	1080p	16:9	1920 x 1080
2K video (Quad HD)	2K or 1440p	16:9	2560 x 1440
4K video or Ultra HD (UHD)	4K or 2160p	1:1.9	3840 x 2160
8K video or Full Ultra HD	8K or 4320p	16:9	7680 x 4320

1920 x 1080 resolution, often known as 1080p, is a sort of high-definition television that shows 1980 pixels horizontally and 1080 pixels vertically across a screen. 1080p is a popular streaming resolution on websites like YouTube because it provides high resolution without consuming too much internet connection to show quality. When comparing 1080p with 720p (1280 x 720), 1080p can produce a better, clearer image than 720p. When 1080p provides a better image, it will necessitate larger memory than 720p. To stream an hour of video in 720p, 1.86 GB is required, but 1080p takes 3.04 GB [5].

2.2 Live Streaming

To achieve the objective of the research on latency of data transfer between IPv4 and IPv6 in application of railway communication network system, Closed-Circuit Television (CCTV) live streaming will become the method of evaluation.

CCTV is the equipment that will be used to record and monitors condition of surrounding. CCTV widely use everywhere included in railway industry. Thus, with use of CCTV, the live streaming system will take part in the test. The reason why the live streaming being the method of evaluation for this research are because, the live streaming able to provide clear results in term of real-life data transferring and the use of CCTV are widely use in railway industry. The CCTV plays role in trains, driver cabs, stations and more either for recording and save for future reference or even for live streaming the real-life condition.

2.3 Methodology Flowchart

This research aims to understand the difference between IPv4 and IPv6 addresses through various sources and reviews two software tools: GNS3 and iPerf3. The test begins with a ping test of IPv4 and IPv6 addresses to determine the latency of IPv6 compared to IPv4. Ping is an internet program used to test and verify the existence of a destination IP address and its ability to accept requests in computer network administration. It is also used diagnostically to ensure the host computer is operating properly.

The testing continues with a latency data transferring test for live streaming using iPerf3 software with IPv4 and IPv6 addresses. The results are analyzed to determine if they follow the theory or against it. If not, a re-test will be conducted to verify the results. The justification of the test outcomes will be explained in the chapter results and discussion. The flow chart on the research plan is shown in Figure 3.

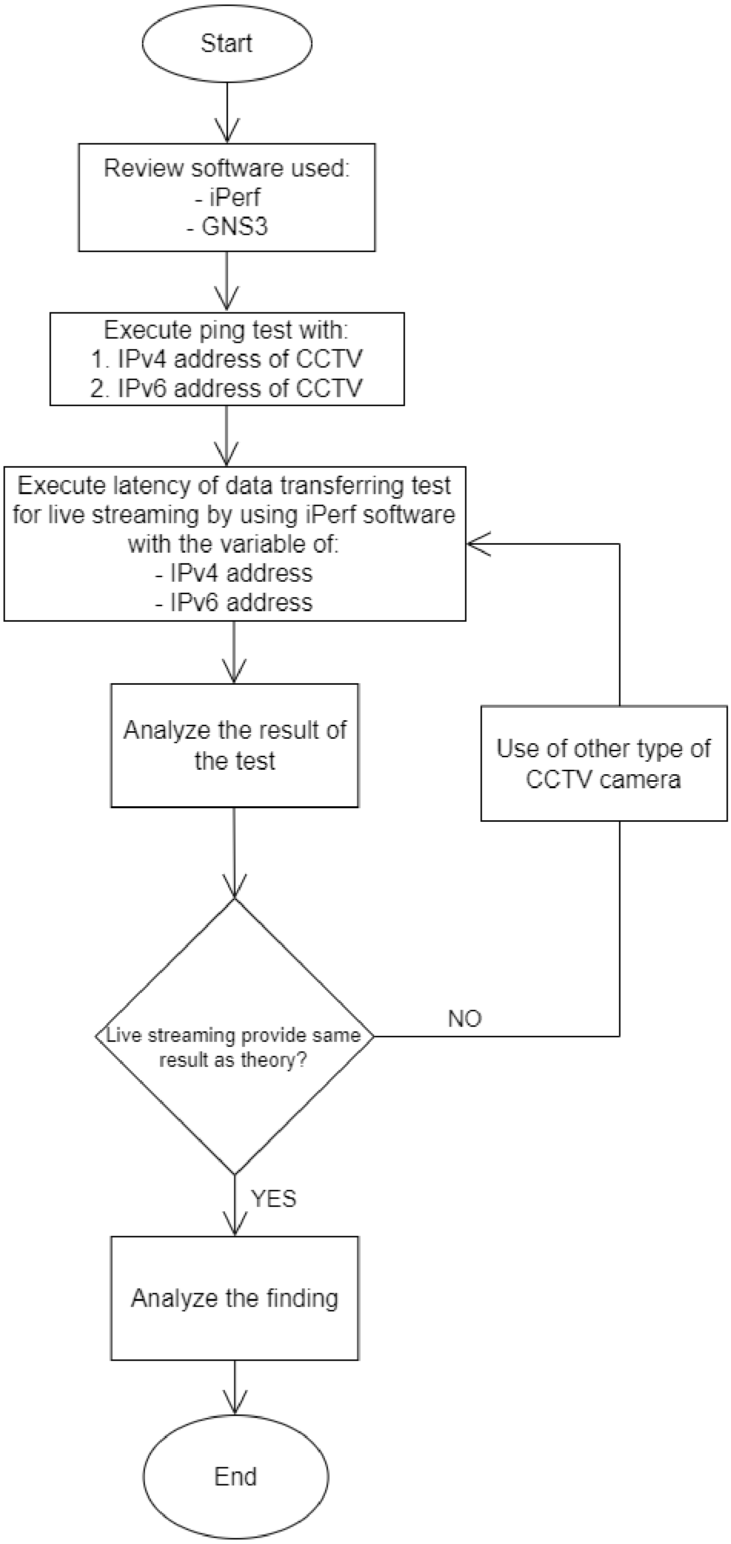

Figure 3: Research Flowchart

2.4 Experiment Flowchart

The setup of the experiment is shown in Figure 4. In this experiment, the use of two workstations were needed to assign a client and a server in iPerf3. The server workstation will wait for connections or data while client side will initiates sending data. The CCTV that being used in the test is an example of CCTV that being used by several train of Malaysia, thus, this experiment is compatible to be adapt in Malaysia's railway to provide better services in future. All equipment that been used in the experiment will be connected to switch. The switch will connect multiple devices to networks, it also enables connected devices to share information and talk to each other. The server workstation who plays VLC Media Player will stream the CCTV to show live streaming. While streaming is play in workstation 1, latency test will be executed at the same time. Which then the outcomes of latency will be shown in the iPerf3.

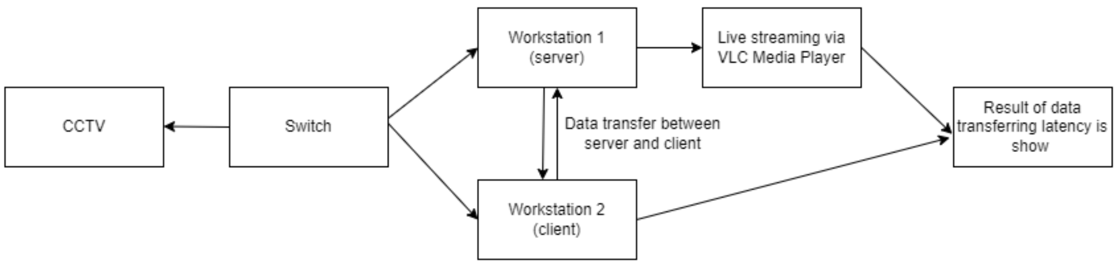

Figure 4: Experiment Setup

2.5 Experiment Execution

All equipment that being used in the test has been assigned with specific IP address for IPv4 and IPv6. Table 2 is the list of IP addresses of each equipment. Every equipment needs to have specific IP to ensures all connected devices can accurately send and receive data between themselves.

Table 2: List of IP addresses

Host	IPv4	IPv6
CCTV	192.168.50.239	2001:DB8:0000:0000:244:17FF:FEB6:D25D
Workstation 1 (server)	192.168.50.222	2001:DB8:0000:0000:244:17FF:FEB6:D22D
Workstation 2 (client)	192.168.50.213	2001:DB8:0000:0000:244:17FF:FEB6:D21D

First experiment will be the execution of ping test. For this project will be use parameter of 100 packet of data using each IP address of IPv4 and IPv6 of the live streaming. Table 3 shows on parameter of ping test. The number of Packet in ping test show as "-n" which it an option of sets the number of ICMP Echo Requests to send. Use of 100 packet will help to show exact application of data transferring with bigger echo requests in real-life situation.

Table 3: Parameter of Ping Test

Parameter	Values
Network Protocol	IPv4 and IPv6
Number of Packet	100

Latency test in this project will use several parameters with different conditions of testing such as different size of bandwidth and time taken. Details on the parameters and variable is shown in Table 4. Reason on the use of different size of bandwidth is because, the use of bandwidth in railway applications will be in variety of size as it will follow scope of the project that has been requested by owner of the railway operation. Thus, for better view on the outcome of IPv6 efficiency, use of bandwidth will use 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 Mbits/sec with different duration. As for duration, it use to determine how long iperf3 will measure the network performance in term of latency between client and server.

Table 4: Parameters of Latency Test

Parameters / Variables	Value
IP address of server	IPv4: 192.168.50.222 IPv6: 2001:DB8:0000:0000:244:17FF:FEB6:D22D
IP address of client	IPv4:192.168.50.213 IPv6: 2001:DB8:0000:0000:244:17FF:FEB6:D21D
Bandwidth (Mbits/sec)	0.5 Mbits/sec, 1 Mbits/sec, 1.5 Mbits/sec, 2 Mbits/sec, 2.5 Mbits/sec, 3 Mbits/sec
Time Taken (s)	10 s, 60 s, 180 s

3. Results and Discussion

This research had been conducted to achieve the two main objectives as stated in Introduction section. The results are presented to the two main areas of concern which is the effectiveness of IPv4 and IPv6 in daily use of network system and the area of application of IPv4 and IPv6 in live streaming of railway communication network system. The results for each area will be elaborated and discussed throughout this chapter.

3.1 Ping test

The ping test for this section are to verify that IPv6 require less time to transfer data rather than IPv4. The time taken of data transfer are shown at the bottom of result of ping test (approximate round trip times in milliseconds).

The result of the test of ping test is shown in Table 5. Based on Figure 5, it shows that maximum RTT of IPv4 higher than RTT IPv6 which in the first test IPv4 have maximum RTT at 6ms while IPv6 maximum RTT for the first test is 2 ms. Not just the first test show IPv4 have higher maximum RTT, it shows in second and third test, 11 ms and 4 ms respectively. Low maximum RTT of IPv6 shows that it takes lesser time to deliver data packet to its destination and lesser time taken on acknowledgment packet sent from destination to the source.

Table 5: IPv4 and IPv6 Round Trip Time Result

IP version	Maximum RTT (ms)		
IPv4	6	11	4
IPv6	2	7	3

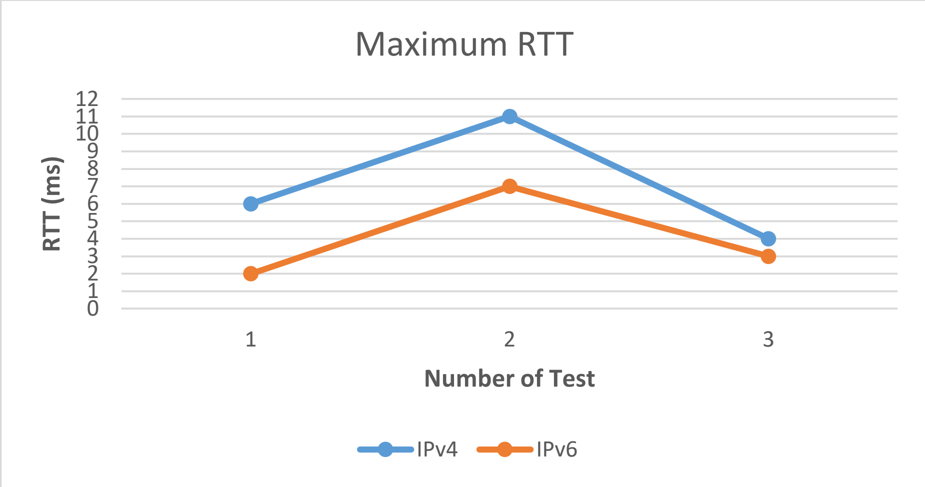

Figure 5: IPv4 vs. IPv6 RTT (ms)

3.2 Latency Test

Latency is the amount of time it takes for a data packet to move from one location to another [6]. Network latency may be calculated by calculating the RTT for a data packet travelling to and from a destination. High network latency may significantly increase page load times, disrupt video and audio streams, and render an application inoperable [6]. Latency test in this project will use several parameters with different conditions of testing such as different size of bandwidth and time taken. Details on the parameters and variable is shown in Table 4 below.

Table 6 shows the average latency result for IPv4 and IPv6 with the first variable of time taken, 10 s and all size of bandwidth. As can be seen in Figure 6, with bandwidth of 1.0 Mbits/sec to 3.0 Mbits/sec the average latency of IPv4 higher than IPv6 except for bandwidth of 0.5 Mbits/sec. Bandwidth 0.5 Mbits/sec the IPv6 require longer time in data transferring with difference of 0.239 ms between IPv6 (1.6044 ms) and IPv4 (1.3654 ms). The 1.0 Mbits/sec IPv4 have higher latency than IPv6 with number of 1.0861 ms and 0.9009 ms respectively. The high latency of IPv4 also can be see in 1.5 Mbits/sec test which IPv4 need 1.1248 ms meanwhile IPv6, 0.8712. For size of 2.0 Mbits/sec IPv4 and IPv6 have different of 0.0885 ms with IPv4 need 0.7527 ms to transfer data in 2.0 Mbits/sec with time of 10 seconds meanwhile IPv6 will only need 0.6642 ms to transfer data of the live streaming. The difference of average latency of IPv4 in 2.5 Mbits/sec a bit higher to compare to 2.0 Mbits/sec. In 2.5 Mbits/sec, IPv6 and IPv4 have difference of 0.24 ms which IPv4 require 0.9944 ms time taken while IPv6 0.7544 ms. The last size of bandwidth that being test (3.0 Mbits/sec), IPv4 and IPv6 only have slightly different (0.01 ms). The test of 10 seconds time taken for six size of bandwidth majorly shows that IPv6 have lower latency than IPv4, it shows that the facts of IPv6 will need less time to transfer data is true in this case.

Table 6: Latency Result of IPv4 and IPv6 of 10 seconds

Bandwidth (Mbits/sec)	Average Latency IPv4 (ms)	Average Latency IPv6 (ms)
0.5	1.3654	1.6044
1.0	1.0861	0.9009
1.5	1.1248	0.8712
2.0	0.7527	0.6642
2.5	0.9944	0.7544
3.0	0.6921	0.6821

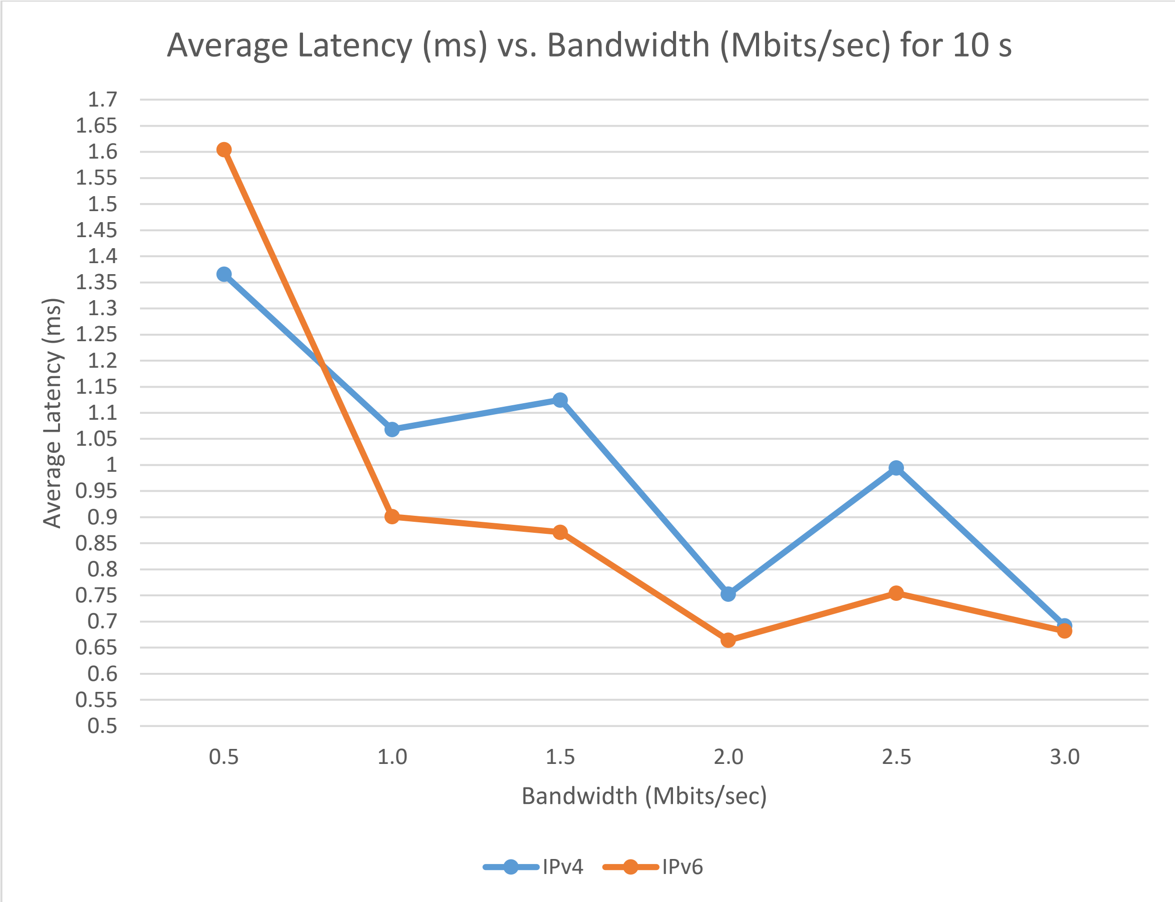

Figure 6: IPv4 vs IPv6 Latency of 10 seconds

Next test will use time taken of 60 s with same parameters. Table 7 shows on the result of average parameters for IPv4 and IPv6 in each bandwidth sizes while Figure 7 visualize the outcomes based on the Table 4.5. In this case of testing, IPv6 shows high latency in bandwidth of 1.0 Mbits/sec, 2.5 Mbits/sec and 3.0 Mbits/sec. In 1.0 Mbits/sec, IPv6 required 0.9184 ms while IPv4 only need 0.8818 ms, 2.5 Mbits/sec shows IPv6 require of 0.8201 ms difference of 0.1622 ms from IPv4. Meanwhile in 3 Mbits/sec bandwidth, IPv6 have average latency of 0.7969 ms and IPv4 only 0.7055 ms. This result shows that IPv4 have lower latency than IPv6 in the condition of 60 s time taken that may cause by network infrastructure in the experiment. A network infrastructure is the combination of hardware and software that makes up a specific network. Network infrastructure can be in the form of a physical or virtual network, and it provides users with the ability to complete activities via the many applications and services that operate on the network [7]. Servers, network cables, switches, and other network infrastructure components are common. Majority of the components are used in the experiment thus, the uncertainty result of the IPv6 latency may cause by the unsupported IPv6 system in Malaysia network system. As deployment of IPv6 in Malaysia still below half [8] and it more focus on telecommunication sections [9], it shows that Malaysia still not ready to adapt IPv6 system in for railway industry applications.

Table 7: Latency Result of IPv4 and IPv6 of 60 seconds

Bandwidth (Mbits/sec)	Average Latency IPv4 (ms)	Average Latency IPv6 (ms)
0.5	1.2731	1.0470
1.0	0.8818	0.9184
1.5	2.1998	0.8041
2.0	0.6508	0.6351
2.5	0.6568	0.8201
3.0	0.7055	0.7969

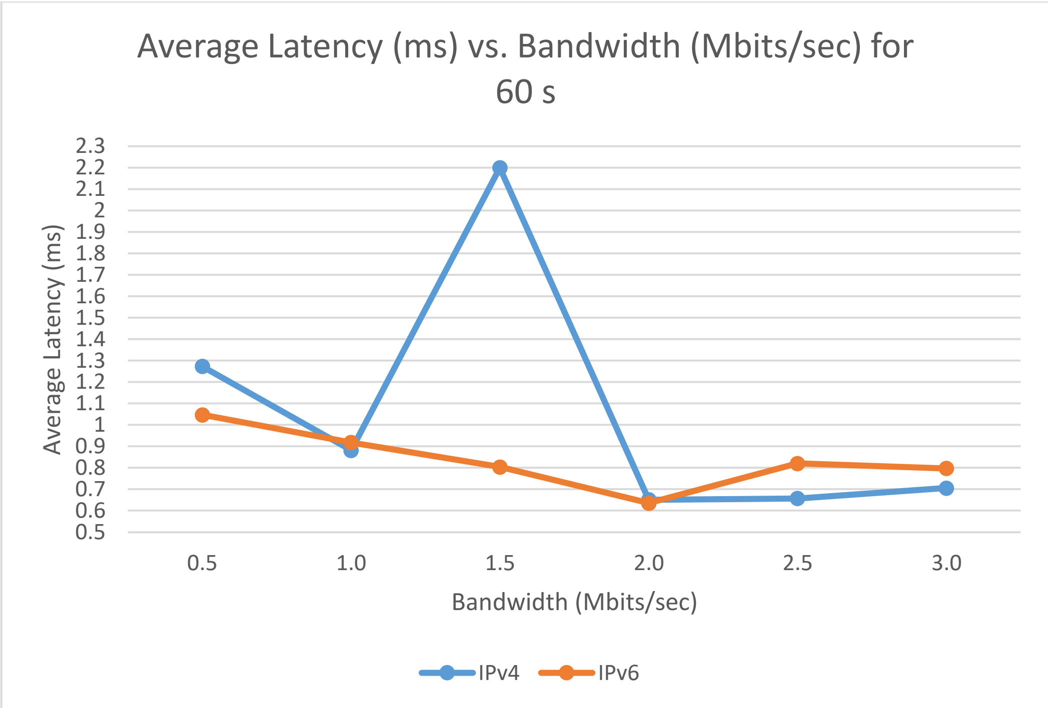

Figure 7: IPv4 vs IPv6 Latency of 60 seconds

Last test use time taken of 180 s, the results shown in Table 8 while Figure 8 visualize the results. For the 0.5 Mbits/sec IPv6 shows higher latency compared to other bandwidths. the 0.5 Mbits/sec IPv6 is 1.4644 ms while IPv4 only 1.2344 ms. Latency for 180 seconds (1.0 Mbits/sec) of time taken is 0.8229 ms (IPv4) which it higher than IPv6 (0.7116 ms). The difference of 0.2385 ms, 0.3447 ms and 0.2201 ms between IPv4 and IPv6 for 1.5 Mbits/sec, 2.0 Mbits/sec and 2.5 Mbits/sec respectively shows IPv4 require more time to transfer data in longer time taken. Last bandwidth of 3.0 Mbits/sec, IPv4 have average latency of 0.7307 ms while IPv6 only have average latency of 0.7251 ms. Conclusion of test of 180 s time taken, IPv6 have lower latency compared to IPv4 except for 0.5 Mbits/sec.

Table 8: Latency Result of IPv4 and IPv6 of 180 seconds

Bandwidth (Mbits/sec)	Average Latency IPv4 (ms)	Average Latency IPv6 (ms)
0.5	1.2344	1.4644
1.0	0.8229	0.7116
1.5	1.1189	0.8804
2.0	1.0011	0.7179
2.5	0.8894	0.6693
3.0	0.7307	0.7251

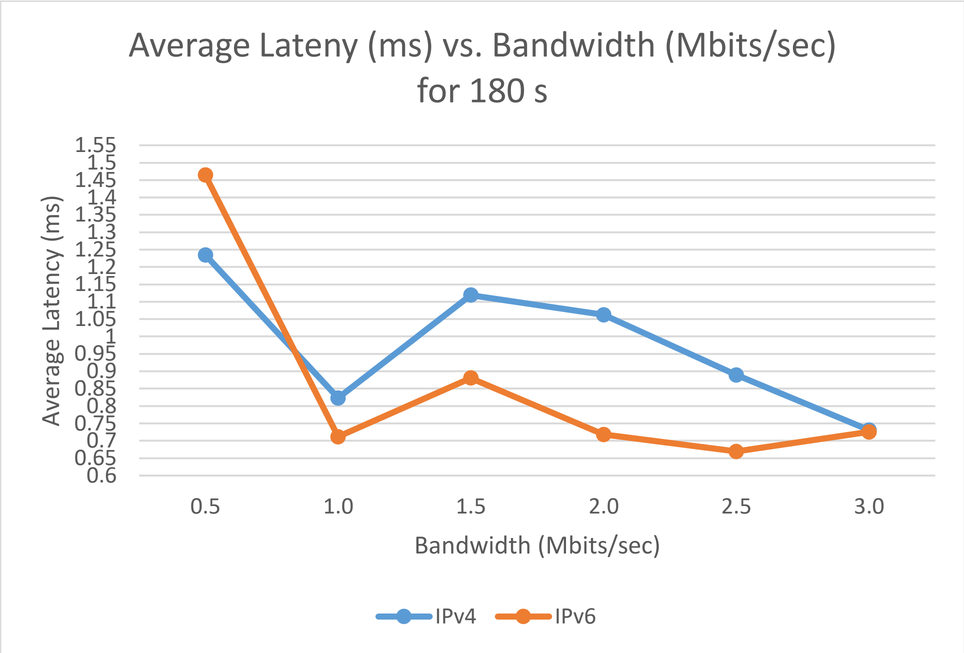

Figure 8: IPv4 vs IPv6 Latency of 180 seconds

Efficiency of IPv6 in data transferring is shown in Table 9 with visualization of the outcome in Figure 9. Efficiency in this case is the efficiency on data transferring by IPv6 with lower latency as per the experiment that have been done in time taken of 10 s, 60 s and 180 s and different size of bandwidth (0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 Mbits/sec). The efficiency of IPv6 in 0.5 Mbits/sec are lowest with percentage of 33%. For the 1.0, 2.5 and 3.0 Mbits/sec, all three bandwidth have efficiency of 67%. Lastly for remaining 1.5 and 2.0 Mbits/sec, both obtain 100% of efficiency in data transfer of IPv6. Overall, IPv6 obtain 72% of efficiency in data transfer based on the experiment of this project, which it shows that the use of IPv6 is valid in order to have lower latency and better network communication with focus on railway industry.

Table 9: Latency Result of IPv4 and IPv6 of 180 seconds

Bandwidth (Mbits/sec)	0.5	1.0	1.5	2.0	2.5	3.0
Efficiency of IPv6	1	2	3	3	2	2
Percentage of Efficiency	33%	67%	100%	100%	67%	67%

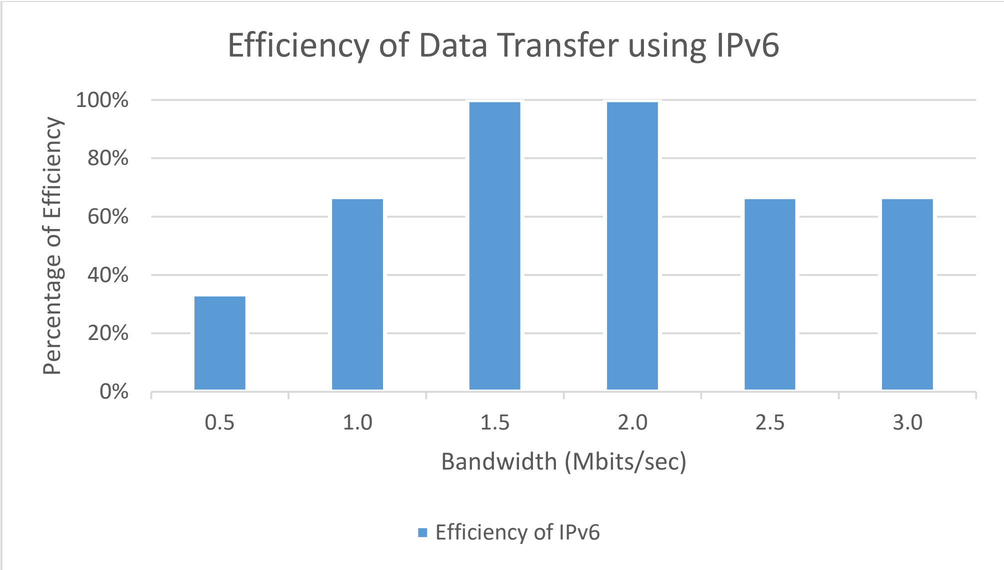

Figure 9: Efficiency of Data Transferring using IPv6

4. Conclusion

In the start of the report, explanation on how features of IPv4 and IPv6 different make a different outcome in network data transferring. As IPv4 lack of new IP addresses, no IPsec and tend to have packet loss, IPv6 being introduced to encounter all the issues based on IPv4 structure. The discussion on the features of IPv4 and IPv6 and effect of each conditions shows that even with simpler header format, IPv6 able to provide better data transfer with lower latency. In order to answer second objective of this research, ping and latency test has been executed with several parameters by using command prompt and iPerf3 respectively. The result of this research show that the RTT of IPv6 were lower than IPv4 while in the test of latency, there are several outcomes from the test. IPv6 proves to require lower latency in most of the experiment parameters. However, in certain bandwidth and time taken, IPv6 shows contradicts result from the theory and this may because of of deployment of IPv6 is far from stable. According to Google's statistics (Google. Google IPv6 Statistics.), from 2011 to 2020, the adoption of IPv6 increased drastically (30% of deployment) while in 2023 the deployment has reach up to 40% [8], thus, adaption of IPv6 need to be in fast pace in order to have better data transferring in every sector involve of networking system.

The project result help railway industry player to plan transition of IPv4 to IPv6 to provide better quality of services and better communication networking system for railway operation. If railway industry keeps on using IPv4 as their choice of internet protocol, there will consequence on safety, services, communication and more. As example, when there is emergency information that need to be send to OCC but if the information requires more time to transfer from train to center, it will surely cause worse after effect. Thus, we really encourage adaptation of IPv6 in railway industry in future. Even the deployment of IPv6 still not fully adopt in network systems yet, there are need of planning for future applications.

After trend of deploying IPv6 networks increase as year past, further research should be performed in four to five years. This will help strengthen the objective of application of IPv6 in railway industry will bring good outcomes.

Acknowledgement

This research was made possible by funding from research grant provided by the Ministry of Higher Education, Malaysia. The authors would also like to thank the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia for its support.

References

[1] CV, R. K., & Goyal, H. (2019). IPv4 to IPv6 Migration and Performance Analysis using GNS3 and Wireshark. 2019 International Conference on Vision Towards Emerging Trends in Communication and Networking (ViTECoN). https://doi.org/10.1109/vitecon.2019.8899746

[2] N. Chuangchunsong, (2014). Performance Evaluation of IPv4 / IPv6 Transition Mechanisms: IPv4-in-IPv6 Tunneling Techniques. pp. 238–243, 2014

[3] Enache, D., & Alexandru, M. (2016). A Study of The Technology Transition from Ipv4 to Ipv6 for An ISP. Review of the Air Force Academy, 14(1), 117–122. https://doi.org/10.19062/1842-9238.2016.14.1.17

[4] CircleHD. (2019). How to Accurately Calculate Video File Size (Plus: Bonus Glossary). CircleHD. https://www.circlehd.com/blog/how-to-calculate-video-file-size

[5] What is the difference between 1080 p and 720 p resolution? (2023, January 10). DEXON Systems- Visual Quality Innovation. https://dexonsystems.com/blog/1080-p#:~:text=Picture%20quality%20%2D%20Although%20there's%20very,sharper%20clearer%20image%20than%201080p.

[6] Gillis, A. S. (2020). latency. WhatIs.com. https://www.techtarget.com/whatis/definition/latency

[7] Carklin, N. (2022, August 25). What is Network Infrastructure? Parallels Remote Application Server Blog - Application virtualization, mobility and VDI. https://www.parallels.com/blogs/ras/network-infrastructure-definition/

[8] IPv6 – Google. (n.d.). https://www.google.com/intl/en/ipv6/statistics.html

[9] Azalan, M. M. (2023, March 19). Telekom Malaysia’s IPv6 readiness journey | APNIC Blog. APNIC Blog. https://blog.apnic.net/2023/03/17/telekom-malaysias-ipv6-readiness-journey/