Innovative and Development Migration between IPv4 and IPv6 Transition Mechanism as Professional Methods and Enhancing Packet Loosing

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Abstract: ***IPv4 which is the old type of Internet Protocol has a new one named IP Next Generation (IPng) or IPv6 Development by Internet Engineering Task Force (IETF). This new version is developed specifically to fix some problem like space addressing. The lack of address space, Weak protocol extensibility, security issues and quality services. This paper will focus the reasons why used two versions together for a long time. Therefore, we have to investigate and analysis transition mechanisms that we can use during transition period to achieve a transition with minimum problem. Also defines the basic information about compatibility transition mechanisms between IPv4-IPv6. Dual Stack is one of the IPv4-IPv6 compatible mechanism by execution both IPv4 stack and IPv6 stack in a single station. Second methods 6 to 4 tunneling mechanism allow encrypt IPv6 packets in IPv4 packets to make communications possible. The IPv6 tunnel connection endpoints are terminated via a Virtual Tunnel Interface (VTI) configured in each device. This has been configured using GNS3 Simulator or/and Packet Tracer (Last update) Dual Stack & Tunneling mechanisms were completely implemented to select best one used in network. This research examines transmission latency, throughput and delay from end to end, through empirical observations of both Dual Stack and tunneling mechanisms. The main issues in my paper, how to reduce the packet loose, I suggest new professional method but the packet tracer has limitation, theriacal and logical be accepted, any way my proposal in my new method can solve the big issue in router that can dropped the packet.***

Keywords: IPv4 to IPv6 Transition; Encapsulation; DoubleVirtual Tunnel Interface (VTI), Dual Stack

1. Introduction

In today's digital age, the increasing use of the Internet especially In COVID -19 pandemic has shown the potential that the Internet can change and improve different areas such as education, businesses or entertainment, etc. also appear smart city, house that will increased the number of addresses provided by them and it was thought that the number of addresses provided by the Internet Protocol version 4 (IPv4) were more than enough IPv4 developed in 1981 and was used to make interconnection between different networks. After three versions, IP got the name of next version number 4 and declared as IPv4 to the internet community. The first version of IPv4 was generally used to ensure that two computers or any two network devices could connect with each other. As there is an ever growing expansion and advancement in the network and internet mechanism, the requirement of unique addresses is increasing. Therefore, to solve the address limitation of current IPv4, several technologies have come out like Network Address Translation (NAT) and Dynamic Host Configuration Protocol (DHCP). However, while these technologies decrease the addressing shortage, they prevent IP level end-to-end security; reduce robustness, so they are not good solutions [1].

To solve problem, a modern internet protocol was created, which is called Internet Protocol version 6 (IPv6). This protocol was created by the Internet Engineering Task Force (IETF) with positive advantage to routing addresses and security. IPv6, actually is known as IP next generation (IPng), IPv6 is more effective, scalable, secure and routable than IPv4.As 5G communications and Internet of Things (IoT) affected in many industry sector, a scalable IP technology is required with no constraint in number of addresses and no connectivity constrain

2. Related Work

Many studies have been conducted to measure the progress of IPv6 deployment. For example, Colitti et al. developed a method for measuring IPv6 adoption [2]. Claffy provided amazing summary of the deployment of IPv6 and also identified areas that require further study. In the field of performance evaluation, on one hand there are several studies that evaluate the performance of IPv4 and IPv6 in different operating systems. Zeadally and Raicu [3] compared the performance of IPv6 in Windows 2000 and Solaris 8. An upper bound model to compute TCP and UDP throughput for IPv4 and IPv6, in a full-duplex point-to-point connection, was presented by Gamess and Surós [4]. Amazing study that measure Performance Analysis of Three Transition Mechanisms between IPv6 Network and IPv4 Network: Dual Stack, Tunneling and Translation[5]. Khadiri1 and Labouidya2.

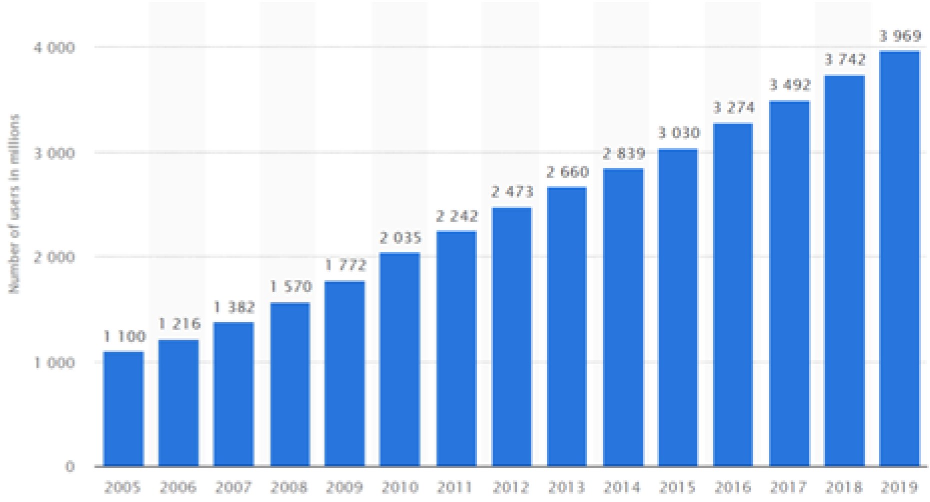

Figure 1: The number of users in word from 2005 -2019 in billion

2.1 Internet Protocol V4(Ipv4)

Internet Protocol version 4 (IPv4) is the fourth version in the development of the Internet Protocol (IP) and the first version of the protocol to be widely deployed. IPv4 is described in IETF publication RFC 791 (September 1981), replacing an earlier definition (RFC 760, January 1980). This tutorial will help you in understanding IPv4 and its associated terminologies along with appropriate references and examples [6]

Today, 4.72 billion people around the world use the internet in April 2021 – that's more than 60 percent of the world's total population. Most internet users (92.8 percent) use mobile devices to go online at least some of the time, but computers also account for an important share of internet activity. [7]

More than 70 percent of internet users in the world's larger economies go online via laptops and desktops for at least some of their connected activities. [7]

2.2 Internet Protocol V6(Ipv6)

To create a much larger address space for future shortage of IP addresses, IPv6 was developed. IPv6 addresses consist of 128 bits, instead of 32 bits, the 128-bit size gives approximately 1500 addresses per square foot of the earth's surface and include a scope field that identifies the type of application suitable for the address. IPv6 does not support broadcast addresses, but instead uses multicast addresses for broadcast. See figure 2 you can see the rate for using IPv6 since 2010 to 2021, Now 35%, I think the will increase in coming year, my opinion the curve is moving very slow

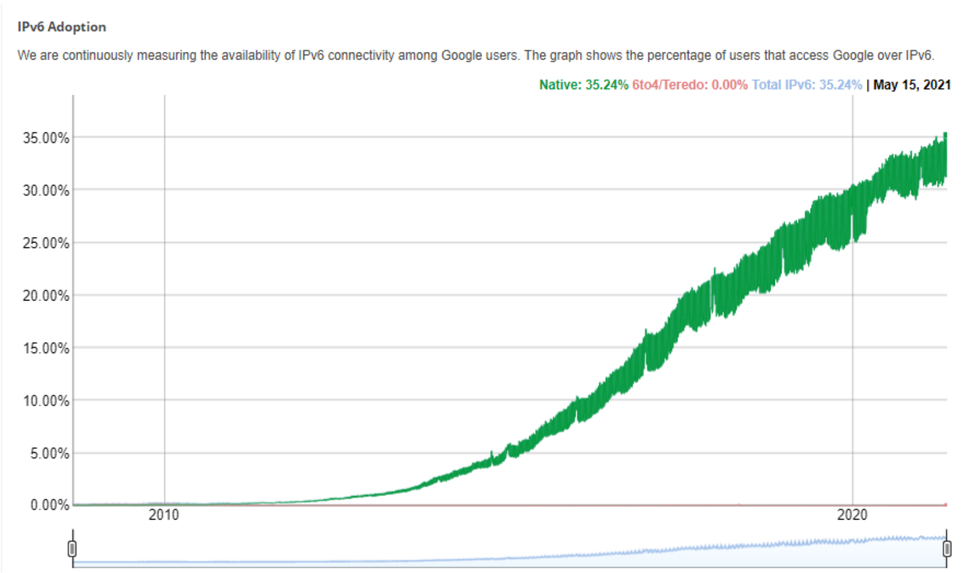

Figure 2: The percentage of users that access Google over IPv6

3. Transition Mechanisms

Transition strategies are methods that provide a means of connection between IPv4 and IPv6, as these two protocols cannot understand each other. Therefore, in order to transfer data, a special method is needed. The three strategies are:

- Dual-Stack: This method is used to understand simultaneously IPv4 and IPv6: regardless of which protocol is used, when the traffic is received the node is able to respond.

- Tunnel: This strategy is employed when there are two networks that are using the same IP version but are separated by another network that has a different IP. The tunnel method establishes a virtual link through the networks by providing a connection in the middle of them.
- Translation: This method is similar to NAT, as it changes the IP packet from IPv4 to IPv6 and vice versa, depending on the source and the destination [6]

a) Dual-Stack

The Dual Stack technique uses IPv4 and IPv6 together with same stack. The option of choosing of protocol is decided by the administrator, along with what kind of service is required and which type of network is used. This technology does not need any change to the packet header and at the same time does not make encapsulation between IPv4 and IPv6. This technology is known as native dual stack or Dual IP layer [8]

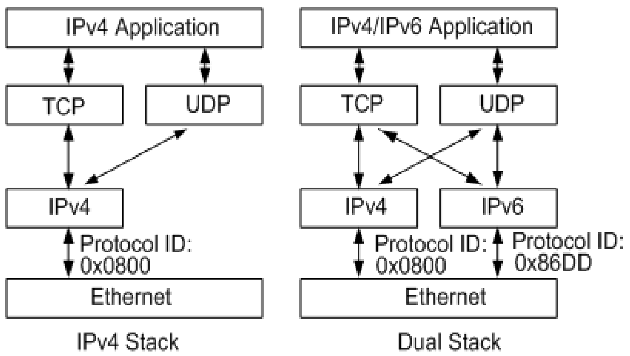

Figure 3: Dual Stack

b) Tunneling

Tunneling could be either manual or automatic. The connection for the manual is a point to point mode which is assigned the source and the destination address of the tunnel by the operator while the automatic connection is a point to multipoint where the source address is assigned by the operator and the destination address is found automatically. The tunnel idea works as a bridge to transfer packets between two similar networks over incompatible network [8]. In other words, the IPv6 will be as a part of IPv4, and the IPv6 data will flow by using IPv4 infrastructure, which will send it to the destination (IPv6) for processing; the tunnel is a virtual link between the two points to transfer data [9]

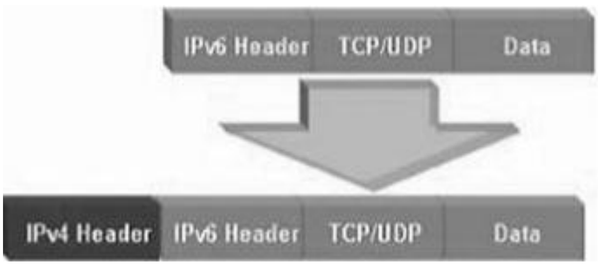

Figure 4: IPv6 over IPv4 Tunneling

- **Manual Tunnel**

The manual tunnel support a connection between the IPv6 networks over the IPv4 network as a static point-to-point tunnel. The IPv4 and IPv6 are manually assigned as the source and destination. This strategy provides a secure connection between two ends [10].

- **Automatic Tunnel**

Tunnel Broker

It is an external system, rather than a router that acts as a server on the IPv 4 networks and that receives requests for tunnelling from dual-stack nodes. Requests are sent over IPv 4 by dual-stack nodes to the tunnel broker using HTTP. End users can fill a webpage to request a configured tunnel The tunnel-broker sends back information over HTTP to the dual-stack nodes such as the IPv 4 addresses, IPv 6 addresses, default IPv 6 routes to apply for the establishment of a configured tunnel to a dual-stack router. Tunnel-broker remotely applies commands on a dual-stack router to enable a configured tunnel. Integration and o-existence [10]

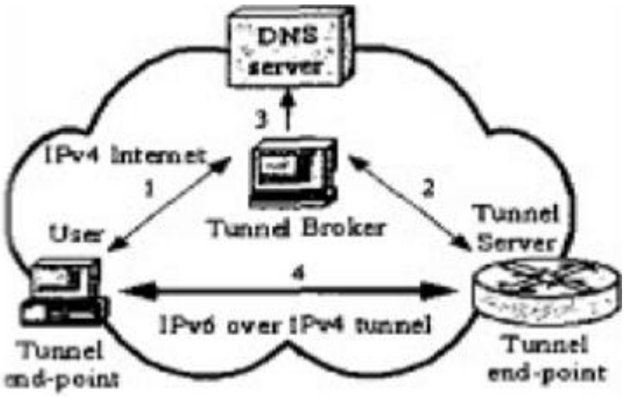

Figure 3: dual stack

6 to 4

6to4 is a technique that is able to connect IPv6 domains that are separated by an IPv4 network. The IPv4 network acts as a link between the IPv6 networks. 6to4 is an automatic tunnel. It uses the IPv4 infrastructure to transfer the IPv6 packet. Therefore, the IPv4 address is part of the IPv6address during the transferring of the packets until they reach the other side of the tunnel.

The IPv6 networks are connected together using the 6to4 router with the prefix 2002: IPv4address::/48. The IPv4 address (32 bit) is the 6to4 router address. The IPv6 destination will extract the encapsulation address. In addition to connecting the IPv6 network with the IPv6Internet through the IPv4 network, the prefix is the same and the 6to4 router will encapsulate theIPv4 destination for the 6to4 relay router [8]

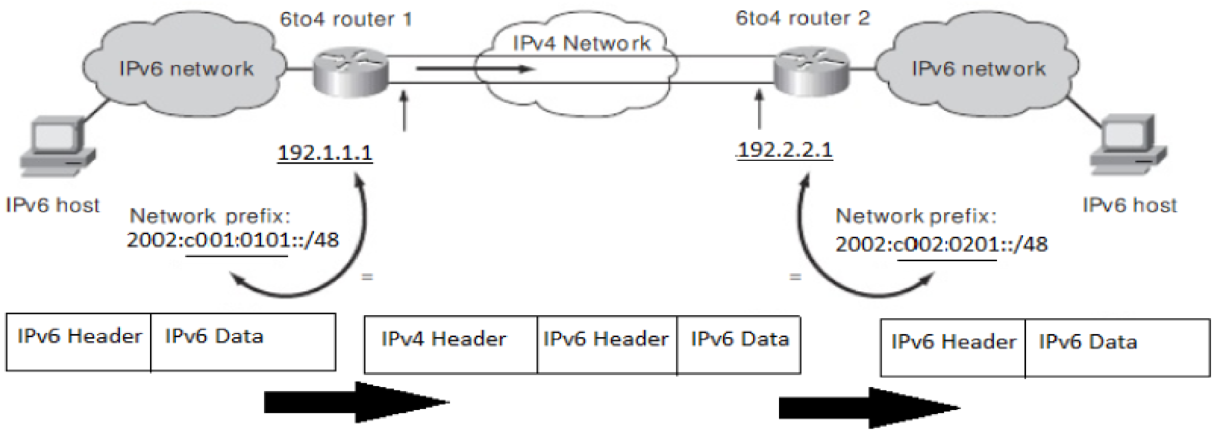

Figure 4: 6 to 4 tunneling

c) Translation

This mechanism of transition changes the header format from IPv4 to IPv6 format and vice versa. This scheme translates the packet from both the addresses. By using this translation, IPv6only hosts can communicate with IPv4only hosts. Translation methods are of two types, such as stateless and stateful. The stateless translation, the packets are not interrelated to each other while the stateful translation is interrelated to each other

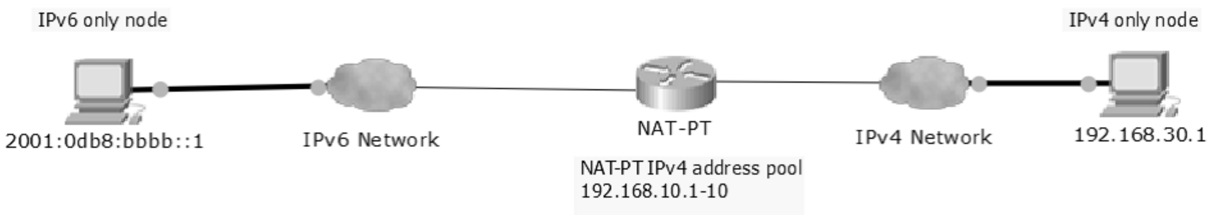

Figure 5: 6 to 4 tunneling

Implementation of the Transition

I will do implementation between "headquarters" and "branch office" of a company over public network. three sample models were experimented in the simulator environment to evaluate the successful and pros and cons of each method. My experiment is done in three scenarios by implementing three ways such as 6to4 tunnel and Dual stack and NAT-PT

Scenario 1(Dual stack)

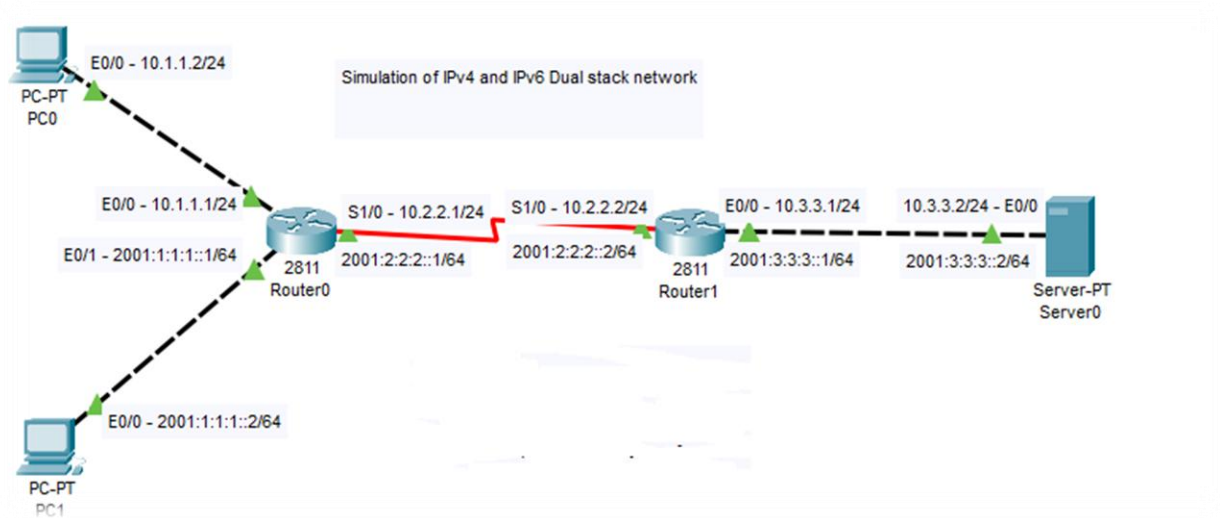

Figure 7: Simulation of ipv6 and ipv6 Dual stack network

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Device Name	*IP Address*	*Gateway*
PC0	10.1.1.2/24	10.1.1.1
PC1	2001:1:1:1::2/64	2001:1:1:1::1
R1-E0/0	10.1.1.1/24	N/A
R1-E0/1	2001:1:1:1::1/64	N/A
R1-S0/0/0	10.2.2.1/24	N/A
R1-S0/0/0	2001:2:2:2::1/64	N/A
R2-S0/0/0	10.2.2.2/24	N/A
R2-S0/0/0	2001:2:2:2::2/64	N/A
R2-E0/0	10.3.3.1/24	N/A
R2-E0/0	2001:3:3:3::1/64	N/A
Server	10.3.3.2/24	10.3.3.1
Server	2001:3:3:3::2/64	2001:3:3:3::1

5. Addressing Table

A. Router1 Configurations

R1 Router Configuration
Router1#configure terminal
Router1(config)#interface fastEthernet 0/0
Router1(config-if)#ip address 10.1.1.1 255.255.255.0
Router1(config-if)#no shutdown
Router1(config-if)# interface fastEthernet 0/1
Router1(config-if)#ipv6 address 2001:1:1:1::1/64
Router1(config-if)#no shutdown
Router1(config-if)# interface Serial1/0
Router1(config-if)#ip address 10.2.2.1 255.255.255.0
Router1(config-if)#ipv6 address 2001:2:2:2::1/64
Router1(config-if)#no shutdown
Router1(config-if)#exit
Set IPv4 and IPv6 Routes
Router1(config)#ipv6 unicast-routing
Router1(config)#ip route 0.0.0.0 0.0.0.0 10.2.2.2
Router1(config)#ip route ::/0 2001:2:2:2::2

B. Router2 Configuration

Router2#configure terminal
Router2(config)# interface Serial1/0
Router2(config-if)#ip address 10.2.2.2 255.255.255.0
Router2(config-if)#ipv6 address 2001:2:2:2::2/64
Router2(config-if)#no shutdown
Router1(config-if)# interface fastEthernet 0/0
Router1(config-if)#ip address 10.3.3.1 255.255.255.0
Router1(config-if)#ipv6 address 2001:3:3:3::1/64
Router1(config-if)#no shutdown
Router2(config-if)#exit
Set IPv4 and IPv6 Routes
Router2(config)#ipv6 unicast-routing
Router2(config)#ip route 0.0.0.0 0.0.0.0 10.2.2.1
Router2(config)#ipv6 route ::/0 2001:2:2:2::1

Scenario 2 (IPv6 over IPv4 Tunneling)

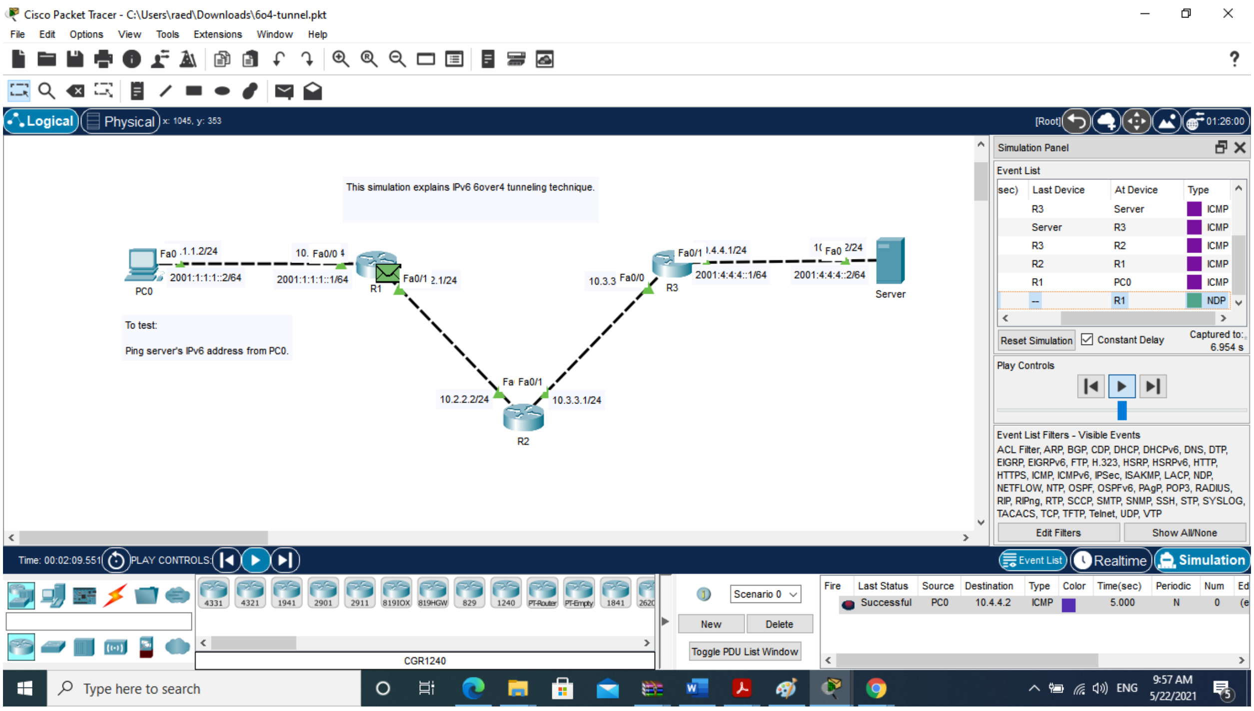

Figure 8: Simulation of IPv6 over IPv4 Tunneling

7. Addressing Table

Device Name	*IP Address*	*Gateway*
PC0	10.1.1.2/24	10.1.1.1
PC1	2001:1:1:1::2/64	2001:1:1:1::1
R1-E0/0	10.1.1.1/24	N/A
R1-E0/1	2001:1:1:1::1/64	N/A
R1-S0/0/0	10.2.2.1/24	N/A
R1-S0/0/0	2001:2:2:2::1/64	N/A
R2-S0/0/0	10.2.2.2/24	N/A
R2-S0/0/0	2001:2:2:2::2/64	N/A
R2-E0/0	10.3.3.1/24	N/A
R2-E0/0	2001:3:3:3::1/64	N/A
Server	10.3.3.2/24	10.3.3.1
Server	2001:3:3:3::2/64	2001:3:3:3::1

1) R1 Router Configuration

Router1#configure terminal
Router1(config)#interface fastEthernet 0/0
Router1(config-if)#ip address 10.1.1.1 255.255.255.0

Router1(config-if)#ipv6 address 2001:1:1:1::1/64
Router1(config-if)#no shutdown
Router1(config-if)#interface fastEthernet 0/1
Router1(config-if)#ip address 10.2.2.1 255.255.255.0
Router1(config-if)#no shutdown
Router1(config-if)#exit
Set IPv4 Route
Router1(config)#ip route 0.0.0.0 0.0.0.0 10.2.2.2
Enable IPv6 Routing
Router1(config)#ipv6 unicast-routing
Configure Tunnel
Router1(config)#interface tunnel 0
Router1(config-if)#tunnel mode ipv6ip
Router1(config-if)#ipv6 address 2001:2:2:2::1/64
Router1(config-if)#tunnel source fastEthernet 0/1
Router1(config-if)#tunnel destination 10.3.3.2
Router1(config-if)#exit
Set IPv6 Routes over tunnel
Router1(config)#ipv6 route ::/0 2001:2:2:2::2

2) R2 Router Configuration

Router1#configure terminal
Router1(config)#interface fastEthernet 0/0
Router1(config-if)#ip address 10.2.2.2 255.255.255.0
Router1(config-if)#no shutdown
Router1(config-if)#interface fastEthernet 0/1
Router1(config-if)#ip address 10.3.3.1 255.255.255.0
Router1(config-if)#no shutdown
Router1(config-if)#exit
Set IPv4 Routes
Router1(config)#ip route 10.1.1.0 255.255.255.0 10.2.2.1
Router1(config)#ip route 10.4.4.0 255.255.255.0 10.3.3.2

3) R3 Router Configuration

Router1#configure terminal
Router1(config)#interface fastEthernet 0/0
Router1(config-if)#ip address 10.3.3.2 255.255.255.0
Router1(config-if)#no shutdown
Router1(config-if)#interface fastEthernet 0/1
Router1(config-if)#ip address 10.4.4.1 255.255.255.0
Router1(config-if)#no shutdown
Router1(config-if)#exit
Set IPv4 Routes
Router1(config)#ip route 0.0.0.0 0.0.0.0 10.3.3.1
Enable IPv6 Routing
Router1(config)#ipv6 unicast-routing
Configure Tunnel
Router1(config)#interface tunnel 0
Router1(config-if)#tunnel mode ipv6ip
Router1(config-if)#ipv6 address 2001:2:2:2::2/64
Router1(config-if)#tunnel source fastEthernet 0/0
Router1(config-if)#tunnel destination 10.2.2.1
Router1(config-if)#exit
Set IPv4 Routes
Router1(config)#ipv6 route ::/0 2001:2:2:2::1

Scenario 3(NAT-PT)

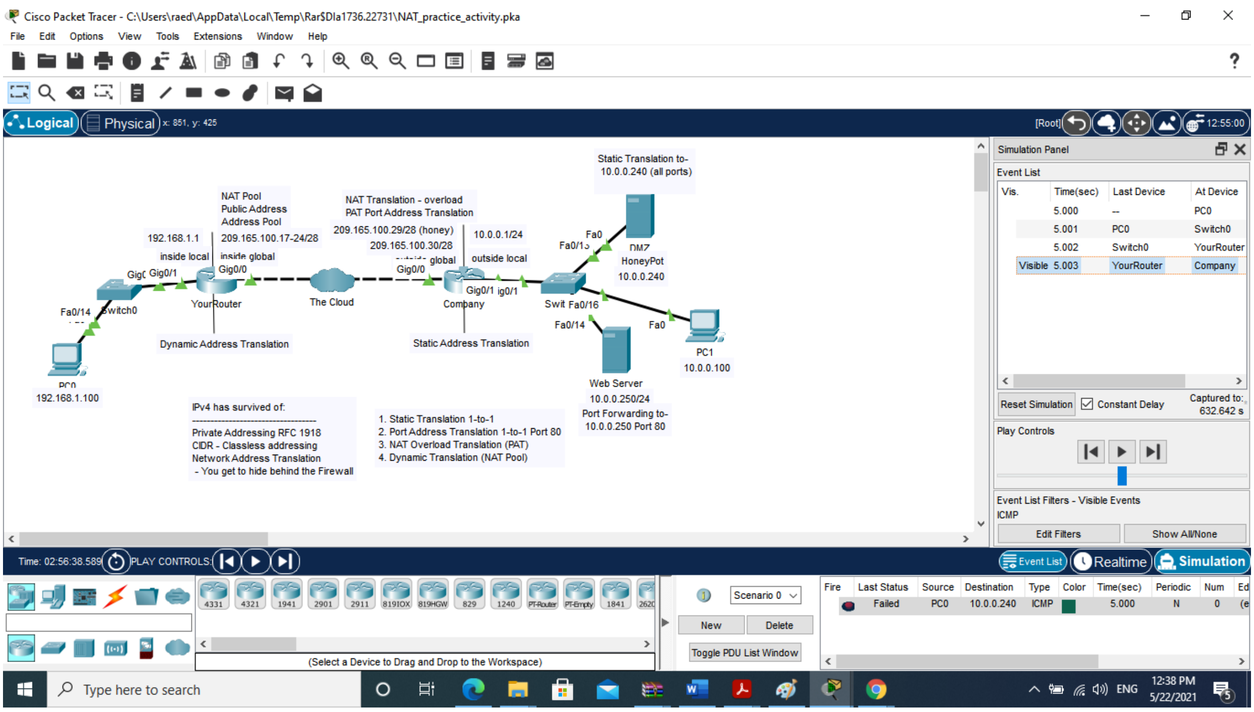

Figure 9: (NAT-PT)

8. Discussion and Results

In this three methods, I compare all network performance with three area (latency time, throughput, pack loose)

1) Latency time: is a measure of delay. In a network, latency measures the time it takes for some data to get to its destination across the network and
2) Throughput= size packet / time consumed for transmission

I used cisco packet tracer 2021 to analysis three method and compare between them, the best one used to transmit between nodes, After deploying the above topologies of the transition mechanisms, some complex Protocol Data Unit (PDU) have been transferred from one host to another host, ICMP packets have been transferred with various sizes packet. In latency time,, the latency analysis, the throughput analysis and the packet loss analysis have been done. In this analysis, . After observing the packet transmissions, the following results have been found, all data are collected used excel 2020 to create diagrams:

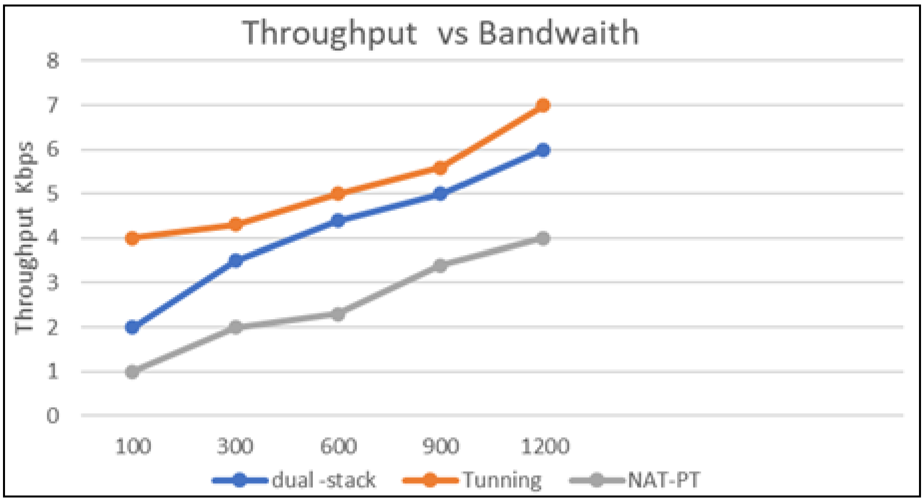

Figure 10: (NAT-PT)

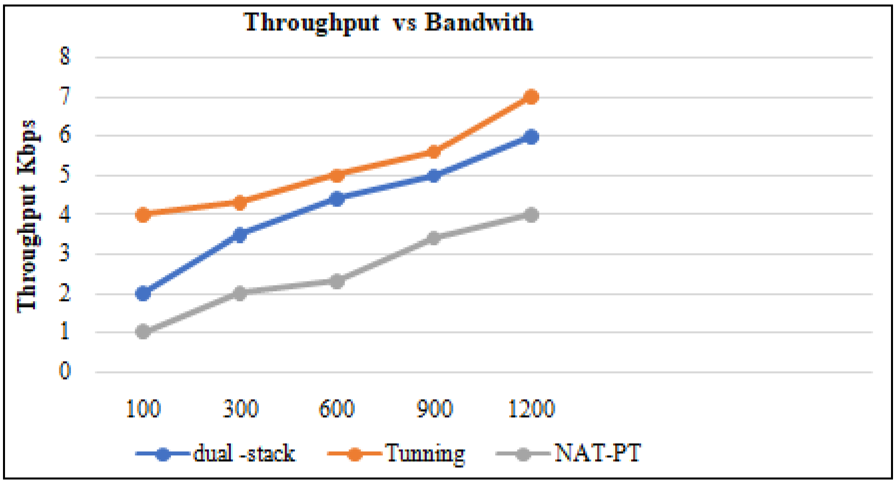

Figure 11: Throughput vs Bandwidth

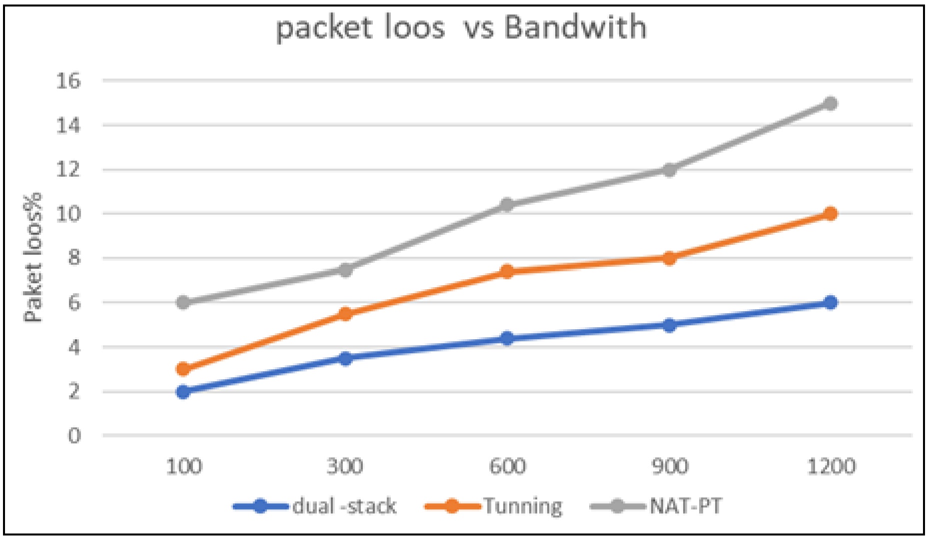

Figure 12: Packet loose vs Bandwidth

From the Figure10, it has been found that the NAT-PT transition gives the highest latency, while Dual stack provides the moderate and the Tunneling mechanism provides the lowest latency.

The throughput from the scenario, it is found that Tunneling views the highest throughput rate than the other and the NAT-PT method provides the lowest. From Figure12, it is found that NAT-PT transition mechanism experiences highest percentages of packet loss due to its delay time. But, tunneling has the lowest packet lost experience. Any way the tunnel channel has many issues that will:

- The main issue packet loose
- The tunnel entry and exit points need time and CPU power for encapsulating and decapsulating packets [11]
- Exiting Single Points of Fail [11]
- Troubleshooting gets more complex [11]

Challenges of packet loose

The main issue of tunneling technique packet loosing, when I do my experiment of my tunneling scenario, I register my results but I want to reduce the losing to increased my network performance.

My proposal methods to decrease packet losing

I suggest double trunk line between two end point (nodes), each one can transmit the data MTU=1280, will reduce packet size 1280

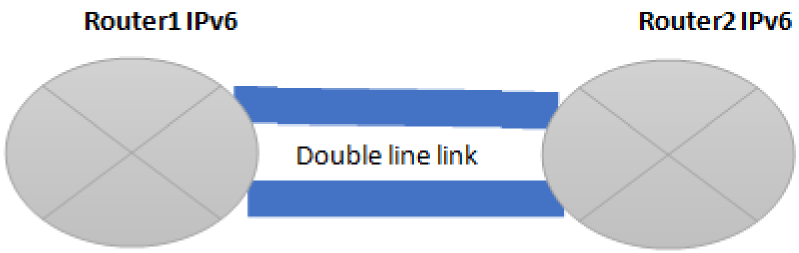

Figure 12: Double link

When divided the translation between two channel the packet lose will decrease between two channels. All router can deal with one channel, that have limitation so, I cant apply my ideal with the router.

9. Conclusion

In this paper, the three mechanisms of the IPv6 to IPv4 transition have been discussed, analyzed. It has been that three mechanisms have found Advantages and these advantages of transferring the data within the network. The best transition will be chosen for the network based on various parameters like the bandwidth, packet loss the availability of the latest devices, the cost, the security concern and so on. Some of them have been focused on this paper with the simulation results. If latency, throughput and packet loss are considered then tunneling method is the best choice while the NAT-PT is the worst. Due to the limitation of Packet Tracer, our comparisons were also limited to few application layers services. I suggest new idea to reduce packet losing but can't apply because limitation of packet tracer theriacal can apply with good advantage.

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