Assessment of IPv4 and IPv6 Networks with Different Modified Tunneling Techniques using OPNET

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***Abstract*—Currently, all the devices are using Internet protocol version 4 (IPv4) to access the internet. IP addresses of the IPv4 are now depleted from IPv4 pool announced by IANA (Internet Assigned Number Authority) in February 2011. To solve this issue Internet protocol version 6 (IPv6) is launched. But the main problem is current devices can't support directly IPv6 that causes various compatibility issues. Many researchers have proposed various techniques, but still, their efficiency and performance is a big challenge. This study examines several mechanisms of transition IPv6 the backbone of multiprotocol label switching (MPLS) to evaluate & compare their performances. It involves comparing different performance metrics and manual tunneling tunnel efficiency metrics. The main goal of this paper is to examine the dissimilar tunneling techniques and find out which tunneling method is better in all performance, which increases network performance. Experimental results show that ISATAP is better performance in all metrics.**

***Keywords*—ISATAP; tunneling techniques; IPv4; IPv6; network performance**

I. Introduction

Due to the rapid growth of population demand for IP addresses has increased more and more [1-3]. Eventually, IP addresses of IPv4 pool is completely exhausted. IANA announced on 3 February 2011 that no. of IPv4 addresses are almost exhausted. Many companies and organizations are moving towards IPv6 addresses. IPv4 is 32 bit long and supports an address of only 32-bit, meaning 4.3 billion. IPv6 is 128 bit long and includes an enormous amount of addresses, i.e. trillions of trillion addresses are now accessible. MPLS is a mechanism for packet labeling [4-7]. It is extremely scalable system and commonly utilized in transmission technology by internet service suppliers. It plays a vital role in the IPv4 backbone network for companies. MPLS examines the labels and forward data packets discovered on the label instead of searching for hard routing and examine the packets. Companies, use the backbone of MPLS to link offices and sites together remotely. The integration of IPv6 facilities in the MPLS infrastructure can be seen as ordinary progress by service suppliers and businesses using MPLS networks [8-10].The MPLS backbone provides the option of connecting IPv6 network, using the existing IPv4 network. When using the IPv4 MPLS backbone current, several ways to connect to IPv6 islands. Because the cost of updating the spine in whole or in part is greater and needs network updates, therefore transition mechanisms are deployed. The theory of MPLS is developed and considered as the hybrid technology of ATM and IP. This paper evaluates distinct techniques for clouting current IPv4 network MPLS additional IPv6 facilities lacking the need for backbone adjustments. These techniques are used to isolate IPv6 domains to interact on the present IPv4 MPLS backbone [11]. In the IPV6 tunnels among customer edge and customer edge CE-to-CE routers together with manual tunnels, ISATAP tunnels, 6to4 tunnels. IPV6 tunnels between supplier edge and supplier edge PE-to-PE routers along with manual tunnels, IPV4 automatic tunnels, ISATAP tunnels, and 6to4 tunnels. This paper analyzes performance parameters, i.e. delays in data packets, jitter, and throughput of the network above mentioned techniques and performs statistical analysis [12-15]. The purpose of doing this study is to investigate the various tunneling mechanisms which run both network IPv4 and IPv6. After the deployment of these mechanisms find out the best transition mechanism that provides the highest throughput with very low delay and jitter in the network. For better understanding, the scenarios are shown below in Fig. 1. The figure shows this research paper consist of four phases. Each phase provides the evaluation of the research intention is acclimated. The emulation is done by Graphical Network Simulator (GNS3) tool. Network simulation and data gathering are done by (OPNET) tool. In the last phase data analysis is conducted by MS-office 2013.

A. Contributions/ Findings

The findings of these studies and contributions described as follows:

- Proposed work covers the shortage of IPv4 addresses and provides full IPv6 connectivity.
- Proposed study assessment of a sequence of IPv6 multi-protocol label switching (MPLS) transition mechanisms.
- Analyzing the transition system and identifying which mechanism is best performed in terms of the smallest delay lowest jitter and the greatest performance.

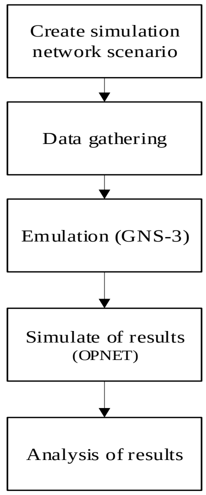

Fig. 1. Proposed Methodology Flowchart.

Our research paper is divided into six sections, the second section of the paper describes some existing techniques and drawbacks, the third section presents the methodology of the proposed analysis, and the fourth section is about the simulation results and their discussion. The fifth section is all about analysis of data through different statistical methods like ANOVA, F-test and T-test, in the last section is the conclusion.

II. Related Research

The various researchers have proposed different tunneling mechanisms, but there are some drawback is still in the network. Following Table I show some tunneling mechanisms and their drawbacks.

TABLE. I. Summary of Previous Work and their Drawbacks

S. No.	Author	Technique	Drawbacks
01	Dr vadym Kaptur	Tunneling, NAT, Dual-stack	Old technique and not ideal
02	Luke smith	Dual-stack and manual tunnel	A circumstance where point-to-multipoint tunnels
03	Zeeshan Ashraf	OSPF V3 in IPV6 tunneling methods	Only focus on OSPF protocol
04	M. S. Ali	Traffic sent from IPV4 network to IPV6 network and only method is used that is 6to4 method in OPNET tool	This research only focuses on one method, but other methods are remaining
05	Sami Salih	6vpe	Onlyfocused delay performance parameters.
06	Yashwin Sookun, Vandana Bassoo	ISATAP, 6RD and Dual Stack Performance Analysis of IPv4/IPv6 Transition Techniques	Network and traffic load is high
07	N. Chuangchunsong at al	DS-Lite, 4over6,	Metrics are not defined clearly
08	Mohammad Aazam et al	Teredo, ISATAP	Tunneling overhead in Teredo

III. Proposed Analysis

For simulation optimized network engineering tools (OPNET) has been used [16]. The Customer edge to customer edge (CE to CE) and the provider edge to provider edge (PE to PE) routers are placed. For configuration of routers well-known emulation is used, called graphical network simulator (GNS3) [17-19]. For simulation, all configurations are imported to the OPNET environment. External Border Gateway Protocol (EBGP) and Multiprotocol Border Gateway Protocol (MP-BGP) are used for PE routers, CE routers for remote access to PE router in MPLS whereas Interior Gateway Protocol (IGP) and Open Shortest Path First (OSPF) are used inside the MPLS. For suitable deployments configured for IPv4 and IPv6 networks, but it also depends on the transition mechanisms. MPLS cloud set to be in IPv4-enabled and IPv6-enabled customers and servers for the transition processes. If customers need to interact with servers on separate islands on each IPv6 island, they must cross the cloud of the IPv4 MPLS. Then a total of eight tunneling scenarios were configured for the various tunneling mechanisms shown in Table II. All customers and servers have IPv6 allowed configuration. These tunneling processes were used to traffic IPv6 throughout the current IPv4 network by encapsulating IPv6 packets in the IPv4 header. Data packet will be decapsulated at the end node of the tunnel, and it will be removed from the IPv4 packet header. An actual data packet of IPv6 transferred to Well-matched Tunnels, and it configured remaining four routers among provider edge routers.

TABLE. II. IPV6 Transition Mechanisms

Manual tunnel	
IPv4 MPLS backbone	Manual tunnel CE to CE
IPv4 MPLS backbone	Manual tunnel PE to PE
Automatic tunnel	
IPv4 MPLS backbone	Manual tunnel CE to CE
IPv4 MPLS backbone	Manual tunnel PE to PE
6to4 tunnel	
IPv4 MPLS backbone	Manual tunnel CE to CE
IPv4 MPLS backbone	Manual tunnel PE to PE
GRE tunnel	
IPv4 MPLS backbone	Manual tunnel CE to CE
IPv4 MPLS backbone	Manual tunnel PE to PE
ISATAP tunnel	
IPv4 MPLS backbone	Manual tunnel CE to CE
IPv4 MPLS backbone	Manual tunnel PE to PE

The CEs were intended to be allowed for IPv4 and IPv6 in the event of CE-to CE tunneling, and only IPv4 was configured for PE routers and all IPv6-enabled client and server configuration. After the encapsulating process of IPv6 data packets in the header of the IPv4 network, these tunneling procedures were used to traffic IPv6 across the existing IPv4 network. The packet will be decapsulated at the tunnel end node and the packet header IPv4 will be deleted. It will then forward the initial IPv6 packet to its final IPv6 place. Next, the

6PE, Native IPv6, and dual-stack transition devices were configured. The MPLS cloud is allowed for 6PE with PE routers supported by IPv4 and IPv6, CE routers supported by IPv6 and PE router supported by IPv4. The MPLS key infrastructure is unaware of IPv6 in the 6PE transition system and to support IPv4/IPv6; only PE routers are updated and 6PE. The 6PE routers use the MP-BGP over IPv4 to exchange accessibility information across the network in a transparent manner.

IV. Experimental Setup and Analysis

In our proposed technique, we have deployed IPv4 and IPv6 networks with MPLS technology. For the simulation of the network, OPNET simulator is used to verify both networks are working smoothly with five routers as shown in Fig. 2. For each of 11 situations, the model was run for five hours with three seeds. Every second, the metrics were set to be gathered, leading in 18000.

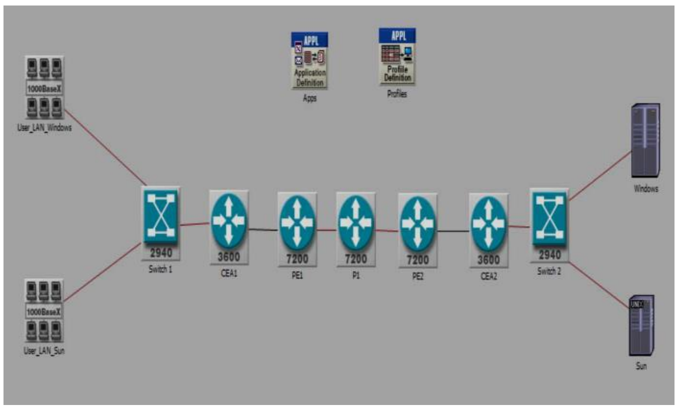

Fig. 2. OPNET Network Simulation.

V. Simulation Setup

The five thousand four hundred values gathered for every metric are highly greater, as shown in the statistics above the numbers are close to one another. As a consequence, the statistical investigation is conducted to define if the mechanisms for each performance metric have any statistically significant distinctions. The statistical analysis conducted to assess the information gathered is described in Section 4.

OPNET Average End-to-End delay for all scenarios as shown in Fig. 3. X-axis is total time in minute's total running time for simulation is 5 hours and Y-axis is time for delay measured in seconds.

OPNET Average End-to-End jitter for all scenarios as shown in Fig. 4. X-axis is total time in minute's, total running time for simulation is 5 hours and Y-axis is time for jitter that is delay that is IP delay variation is seconds.

OPNET average End-to-End Throughput for overall simulation as shown in Fig. 5. X-axis is total time in minute's total running time for simulation is 5 hours and Y-axis is time for throughput of the network that process how many packets can process in a given amount of time.

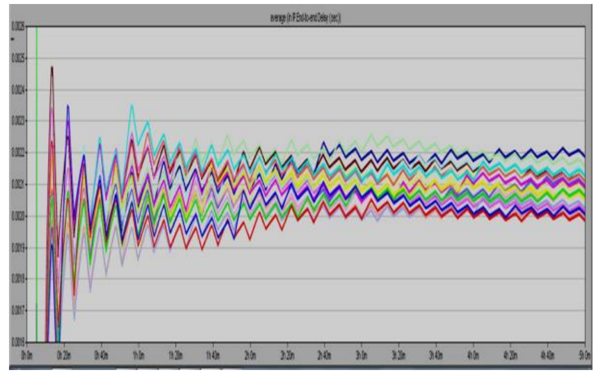

Fig. 3. OPNET Average End-to-End Delay for All Scenarios.

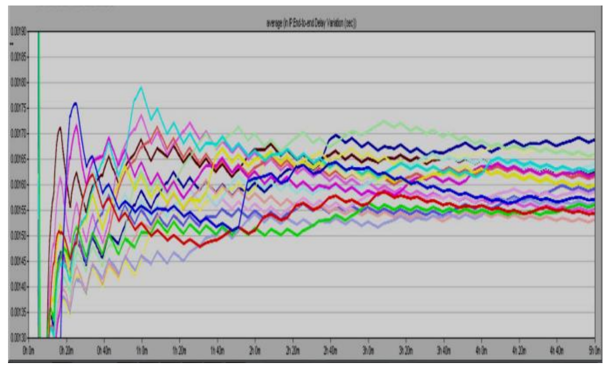

Fig. 4. OPNET Average End-to-End Jitter for All Scenarios.

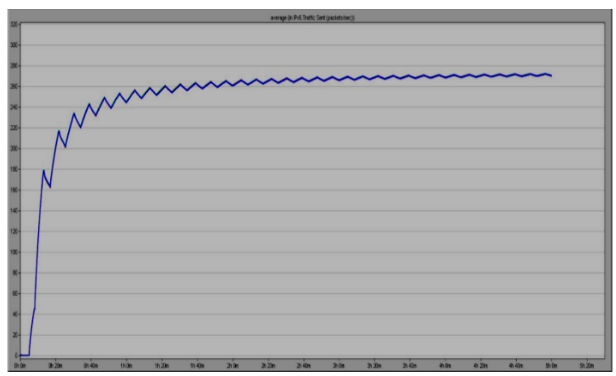

Fig. 5. OPNET Average Throughput for All Scenarios.

VI. Analysis of the Results

Investigation of the collected data and evaluated the resultant data. Methods Below were used to perform the statistical analysis.

- Analysis of variance (ANOVA)
- F-TEST
- T-TEST

ANOVA was used to determine if there is statistically significant difference in means among the scenarios F-Test was used to determine whether modifications were equivalent and whether the mean of one system differed from the mean of the other. Finally, either two sample T-test using degree of freedom was used to determine if the mean of one mechanism is different from the mean of another mechanism.

A. Scenario. 01 Customer Edge to Customer Edge (CE-to-CE)

To calculate significant variations between the metrics of IPv6 CE-to-CE tunneling processes (delay, jitter, throughput) and Calculate which method is the best.

1) Analysis of delay: For ANOVA, the hypothesis below has been recognized. • Null Hypothesis (H0): delay implies equivalent to CE-to-CE tunneling processes Alternative Hypothesis (H1): for CE-to-CE tunneling processes, at least one delay implies different from other means.

TABLE. III. ANOVA RESULTS FOR DELAY CE-TO-CE TUNNEL

ANOVA: Single Factor				
Specified group	***Total***	***Sum (Quantity)***	***Average***	***Difference***
Manual CE-CE	51699	107.4725336	0.0020970	2.44585
Auto CE	51762	106.4065222	0.0020822	2.44083
GRE CE-CE	51758	109.4823187	0.0031417	2.5934
6to4 CE-CE	51792	108.815763	0.0034448	2.53934
ISATAPCE-CE	51750	105.403224	0.0030568	2.33172

(contd.)

Source of variation	***SS***	***DF***	***MS***	***F***	***P-VALUE***	***F-critical***
Between Groups	0.000127451	4	4.24835	16.96009107	5.2	2.37 F test > F critical Reject null Hypothesis
Within Groups	0.519426123	259211	2.50491			
Total	0.519553573	259215				

The result for delay performance metrics from CE-to-CE tunnel is shown in above Table III. where F test>F critical for Seeing that null hypothesis is rejected that reason it is enough evidence that at least one delay mean is different from other delay mean for all scenarios.

2) F-Test for delay CE-to-CE tunnel: F test was used to evaluate if the variances are equal using the hypothesis given below.

Null hypothesis (H0)= delay variance i= delay variance

Alternative hypothesis (H1) = delay variance i=<delay variance j.

The result shown in Table IV since F0>F α n1-1, n2-2 is not true then null hypothesis is not rejected and it is enough evidence that delay variances are equal in that condition we will perform T-test to find which delay mean is less than the others.

3) T-Test for delay CE-to-CE tunnel: The results are shown in Table V, since t0<-tα, n1-1, n2-2 then the null hypothesis was rejected and hence it is enough evidence that delay means of Manual CE-to-CE and Automatic CE-to-CE is less than the 6to4 CE-to-CE and GRE CE-to-CE. Additionally ISATAP CE-to-CE tunnel is less than the GRE CE-to-CE tunnel.

TABLE. IV. F-TEST RESULT FOR DELAY CE-TO-CE TUNNEL

F-TEST	**n1,n2 is the degree of freedom f0=S12/S22**		
Transition Mechanisms	***F α, n1-1, n2-2***	***F0***	***Test if F0>F α n1-1,n2-2***
Auto CE & 6to4 CE	one	0.961206111	Negative
Auto CE & GRE CE	one	0.941160555	Negative
Auto CE & ISATAP CE	one	0.801237	Negative
Manual CE & 6to4 CE	one	0.963112573	Negative
Manual CE & GRE CE	one	0.943143	Negative
Manual CE & ISATAP CE	one	0.85365	Negative
6to4 CE & GRE CE	one	0.979155778	Negative
6to4 CE & ISATAP CE	one	0.89125	Negative

TABLE. V. T-TEST RESULT FOR DELAY CE-TO-CE TUNNEL

Two Sample T-Test			
Transition mechanism	***tα n1+n2-2***	***t0***	***Test if t0<-tα , n1+n2-2***
Auto CE & 6to4 CE	1.63	-4.25017473	YES
Auto CE & GRE CE	1.63	-6.06411939	YES
Auto CE & ISATAP CE	1.63	-3.638063334	YES
Manual CE & 6to4 CE	1.63	-5.453454824	YES
Manual CE & GRE CE	1.63	-1.820066369	YES
Manual CE & ISATAP CE	1.63	-2.639061371	YES
6to4 CE & GRE CE	1.63	-3.999067322	YES
6to4 CE & ISATAP CE	1.63	-2.638067771	YES

4) Analysis of jitter: Jitter is also analyzed using similar techniques. The ANOVA results in Table VI were obtained.

TABLE. VI. ANOVA RSULTS FOR JITTER CE-TO-CE TUNNEL

ANOVA: Single Factor				
Groups	***Count***	***Sum***	***Average***	***Variance***
Manual CE-CE	51753	82.6607	0.001597	4.05
Auto CE-CE	51864	82.52443	0.001591	4.14
GRE CE-CE	51858	85.79141	0.001654	4.28
6to4 CE-CE	51892	84.85763	0.001635	4.37
ISATAPCE-CE	51850	81.33167	0.001568	4.28

(contd.)

Source of variation	***SS***	***Df***	***MS***	***F***	***p-value***	***F-critical***
Between Groups SSB	0.000143	3	4.77	113.4597	2.8	2.604952 F test > F critical Reject Null Hypothesis
Within Groups SSW	0.087257	207363	4.21			
Total SST	0.0874	207366				

5) F-Test for jitter CE-to-CE tunnel: The results shown in Table VII says that there is enough evidence to support that end-to-end jitter means of different tunneling Manual CE-to-CE and Automatic CE-to-CE are less than 6to4 CE-to-CE and ISATAP CE-to-CE tunnel, and 6to4 CE-to-CE has lower mean jitter than ISATAP CE-to-CE.

6) T-Test for jitter CE-to-CE tunnel: The results shown in Table VIII says that there is enough evidence to support that end-to-end jitter means of different tunneling Manual CE-to-CE and Automatic CE-to-CE are less than 6to4 CE-to-CE and ISATAP CE-to-CE tunnel, and 6to4 CE-to-CE has lower mean jitter than ISATAP CE-to-CE.

B. Scenario. 02 Provider Edge to Provider Edge (PE-to-PE)

1) ANOVA results for delay PE-to-PE tunnel: The result for delay PE-to-PE performance parameters are shown in Table IX. Since Ftest >Fcritical therefore the Null Hypothesis is rejected and there is enough evidence to demonstrate that at least one delay mean is different from other delay means among the all scenarios.

TABLE. VII. F-TEST RSULTS FOR JITTER CE-TO-CE TUNNEL

F-TEST	**n1,n2 is the degree of freedom f0=S12/S22**		
Transition Mechanisms	***F α, n1-1, n2-2***	***F0***	***Test if F0>F α n1-1,n2-2***
Auto CE & 6to4 CE	one	0.945501655	Negative
Auto CE & GRE CE	one	0.967344952	Negative
Auto CE & ISATAP CE	one	0.922723464	Negative
Manual CE & 6to4 CE	one	0.945787554	Negative
Manual CE & GRE CE	one	0.976769838	Negative
Manual CE & ISATAP CE	one	0.944407759	Negative
6to4 CE & GRE CE	one	0.956819337	Negative
6to4 CE & ISATAP CE	one	0.945066522	Negative

TABLE. VIII. T-TEST RSULTS FOR JITTER CE-TO-CE TUNNEL

Two Sample T-Test			
Transition mechanism	***tα n1+n2-2***	***t0***	***Test if t0<-tα , n1+n2-2***
Auto CE & 6to4 CE	1.63	-10.88907171	YES
Auto CE & GRE CE	1.63	-15.68834028	YES
Auto CE & ISATAP CE	1.63	-11.22907883	YES
Manual CE & 6to4 CE	1.63	-9.441690775	YES
Manual CE & GRE CE	1.63	-14.25657544	YES
Manual CE & ISATAP CE	1.63	-8.88922133	YES
6to4 CE & GRE CE	1.63	-4.672126496	YES
6to4 CE & ISATAP CE	1.63	-9.889071761	YES

TABLE. IX. ANOVA RSULTS FOR DELAY PE-TO-PE TUNNEL

Summary				
Groups	***Count***	***Sum***	***Average***	***Variance***
Auto PE	52022	107.5243	0.001591	2.45
Manual PE	52022	107.5243	0.001597	2.45
GRE PE	51938	108.4176	0.001654	2.39
6to4 PE	51938	108.4080	0.001635	2.39
ISATAP PE	52010	106.5133	0.001568	2.57

(contd.)

Source of variation	***SS***	***df***	***MS***	***F***	***p-value***	***F-critical***
Between Groups SSB	0.000127451	3	4.24835E-05	16.96009107	0.029644	2.604952 F test > F critical Reject Null Hypothesis
Within Groups SSW	0.519426123	207363	2.50491E-06			
Total SST	0.519553573	207366				

2) F-Test results for delay PE-to-PE tunnel: The result is shown in Table X, since F0>F α n1-1, n2-2 is not true then null hypothesis is not rejected and it is enough evidence that delay variances are equal in that condition we will perform T-test to find which delay mean is less than the others.

3) T-Test results for delay PE-to-PE tunnel: The result is shown in Table XI, since t0<-tα, n1-1, n2-2 then the Null Hypothesis was rejected. Therefore there is enough evidence to support that end-to-end delay mean of Manual PE-to-PE and Automatic PE-to-PE are less than the 6to4 PE-to-PE and GRE PE-to-PE. Additionally it demonstrates that ISATAP PE-to-PE tunnel is lower delay mean as compare to GRE PE-to-PE tunnel.

TABLE. X. F-TEST RSULTS FOR DELAY PE-TO-PE TUNNEL

F-TEST			
Transition mechanism	***Fα n1-1 n2-1***	***F0***	***Test if F0 > Fα n1-1 n2-1***
Auto PE & 6to4 PE	one	1.024523462	YES
Auto PE & GRE PE	one	1.024800865	YES
Auto PE & ISATAP PE	one	1.02525635	YES
Manual PE & GRE PE	one	1.024523462	YES
Manual PE & ISATAP	one	1.024800865	YES
Manual PE & 6to4 PE	one	1.024785256	YES

TABLE. XI. T-TEST RSULTS FOR DELAY PE-TO-PE TUNNEL

Two sample T-TEST			
Transition mechanism	*Tα ,a*	*t0*	*Test if t0<-t α ,a*
Auto PE & 6to4 PE	1.63	-2.10904	YES
Auto PE & GRE PE	1.63	-2.1273	YES
Auto PE & ISATAP PE	1.63	-2.13886	YES
Manual PE & 6to4 PE	1.63	-2.10904	YES
Manual PE & GRE PE	1.63	-2.12737	YES
Manual PE & ISATAP	1.63	-2.11678	YES

4) ANOVA Results for jitter PE-to-PE tunnel: The result is shown in Table XII, since Ftest<Fcritical the Null Hypothesis was accepted. Therefore there is enough evidence to show that there is no statistically-significant difference among the jitter means of PE-to-PE tunneling mechanisms.

5) ANOVA results for overall throughput: The result of throughput of overall system is shown in Table XIII that shows there is not a significant difference among all the mechanisms.

TABLE. XII. T-ANOVA RSULTS FOR JITTER PE-TO-PE TUNNEL

Summary				
Groups	*Count*	*Sum*	*Average*	*Variance*
Manual PE	52021	83.55317109	0.001606143	4.47442
Auto PE	52021	83.55317109	0.001606143	4.47442
GRE PE	51937	83.54239534	0.001608533	4.09939
6to4 PE	51937	83.59333751	0.001609514	4.09323
ISATAP PE	52010	83.40317009	0.001603592	4.09221

(contd.)

Source of variation	*SS*	*df*	*MS*	*F*	*p-value*	*F-critical*
Between Groups SSB	4.56307E-07	3	1.52102E-07	0.354921286	0.785586345	2.604951992 F test <F critical Accept Null Hypothesis
Within Groups SSW	0.089101094	207912	4.28552E-07			

TABLE. XIII. T-ANOVA RSULTS FOR JITTER PE-TO-PE TUNNEL

Summary				
Groups	*Count*	*Sum*	*Average*	*Variances*
Auto PE	54000	1.40654	2604703	4.27
GRE CE	54000	1.40721	260533	4.3
GRE PE	54000	1.40671	2605027	4.31
Manual CE	54000	1.40645	2604539	4.34
Manual PE	54000	1.40654	2604703	4.27
6to4 CE	54000	1.40616	2603998	4.31
Auto CE	54000	1.4059	2603527	4.32
6to4 PE	54000	1.40671	2605027	4.3
ISATAP CE	54000	1.41517	2613775	4.32
ISTAP PE	54000	1.41622	2632852	4.36

(contd.)

Source of variation	*SS*	*Df*	*MS*	*F*	*p-value*	*F-critical*
Between Groups	2.49	10	2.49	0.005791	1	1.83072 FTEST<FCRITICAL Accept Null Hypothesis
Within Groups	2.55	593989	4.3			
Total SST	2.55	593999				

C. Summarized Result

The statistical analysis for delay, jitter, and throughput was performed to identify if there is a statistically-significant difference among these scenarios and if so to determine which one(s) are the superior methods, in the order of best to worst. The detailed analysis is described in the above Analysis.

The results for delay including the ordinal ranking values are shown in Table XIV.

1) Lowest to highest delay ipv6 transition mechanism: The results for delay including ordinal ranking values are shown in Table XIV shows that ISATAP PE having lowest delay and 6to4 CE is highest delay.

2) Lowest to highest jitter ipv6 transition mechanism: The results for delay including ordinal ranking values are shown in Table XV shows that ISATAP PE having lowest jitter and 6to4 CE is highest delay.

For throughput, the analysis shows that there is no statistically significant difference among the all mechanisms. Next the main objective of this research is analyzed, which is to rank the aforementioned IPv6 transition mechanisms from best to worst as shown in below Table XVI. The best mechanism offers lowest delay, lowest jitter, and highest throughput.

3) Best to worst overall ipv6 transition mechanism: The result shows that ISATAP PE has the best overall performance metrics with lowest delay lowest jitter and highest throughput.

TABLE. XIV. LOWEST TO HIGHEST DELAY IPV6 TRANSITION MECHANSIM

IPv6 Transition Mechanisms in Order of Lowest to Highest Delay	**Ordinal Ranking Value**
ISATAP PE Delay (0.00204793) jitter (0.001603592) Throughput (2632852)	1
Manual PE-to-PE and Automatic PE-to-PE	2
6to4 PE-to-PE and GRE PE-to-PE	4
Manual CE-to-CE and Automatic CE-to-CE	6
6to4 CE-to-CE and ISATAP CE	8
6to4 CE (0.002133757)	10

TABLE. XV. LOWEST TO HIGHEST JITTER IPV6 TRANSITION MECHANSIM

IPv6 Transition Mechanisms in Order of Lowest to Highest Jitter	**Ordinal Ranking Value**
ISATAP PE (0.001603592)	1
Manual CE-to-CE and Automatic CE-to-CE	2
Manual PE-to-PE, Automatic PE-to-PE, 6to4 PE-to-PE, and GRE PE-to-PE	4
6to4 CE-to-CE and ISATAP CE	8
GRE CE (0.001654)	10

TABLE. XVI. BEST TO WORST OVERALL IPV6 TRANSITION MECHANISM

Overall (including delay, jitter, and throughput) IPv6 Transition Mechanisms in Order of Best to Worst	**Ordinal Ranking Value**	**Overall Ranking**
ISATAP PE Delay (0.00204793) jitter (0.001603592) Throughput (2632852)	1	1
Manual PE-to-PE and Automatic PE-to-PE	13	6
Manual CE-to-CE, Automatic CE-to-CE, 6to4 PE-to-PE, and GRE PE-to-PE	14	7
6to4 CE-to-CE , ISATAP CE	21	10
GRE CE-to-CE	23	11

VII. CONCLUSION

This paper has two phases of contribution, i.e., connectivity of IPv4 and IPv6; secondly, test performance of different tunneling techniques. From the above simulation test result, ISATAP PE is best because of the high throughput and lowest jitter during data packets transmission. Whereas GRE CE is worst due to its high jitter and lowest throughput in the network. The main objective is to provide IPv6 connectively and test which tunneling technique is better to have better performance than others. Future work can extend in payload of the network. Additionally security of these tunneling techniques can be analyzed.

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