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Comparative Analysis of IPv4 & IPv6: Intended for Learning Object Repository to Setup an E-Learning Environment

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Abstract

In the recent epidemic scenario of lockdown, everything has come to hold and businesses and transactions are moving online. Similarly in the education sector, classes and training are being conducted remotely and via the internet. Consequently, the audio and video streams either offline or in real-time generate additional traffic on the internet. For smooth coverage of the educational material, an additional setup is being established by keeping expansion and up-gradation in mind. The basic question is how to choose the IP-Suite. In this research study based on key performance parameter; security, multicasting, automation IPv4 and IPv6 has been compared. Three working environments; Windows, Linux, and Mac-OS have been tested for the results to be driven and compared under the results section of this research study. Achieved results must be given consideration whenever the end-user application needs to be deployed in the networks.

Index Terms: *E-Learning, Internet Protocol Version, Transmission Control Protocol, User Datagram Protocol, Windows/MAC-Operating Systems.*

I. INTRODUCTION

The terminology "E-Learning" has been around since 1999's when the word was initially used at a course of CBT systems seminar. Different words started to jump in looking for a precise definition, for example, "Internet Learning" & "Virtual Learning". Nonetheless, the E-Learning standards have been very much evolved since forever, and proof of this proposes that old types of E-Learning were here as early as the 1800s. Sometime before the existence of the web, separate certifications were being given to youngsters for training on specific subjects or abilities [1] and [2]. The E-learnedness hypothesis portrays the scientific discipline standards of powerful transmission learning exploitation electronic instructional innovation [3-5]. In the 1840s Isaac Pitman enlightened his understudies shorthanded by the medium of correspondence. This type of emblematic composing was focused to improve composing efficiency and was well known around different people like columnists and secretaries etc. who completed loads of writing or composition. With the evolution of personal computers and the Internet in the late 2000s, E-Learning apparatus and portrayal mediums extended. In the 1980's the principal MAC motivated people to have personal computers in their homes, fashioning it less tightened to be searched out regarding specific subjects and build up bind ranges of talent for them. At the point of that, in the upcoming decade, online learning began to genuinely flourish, with people hovering over associate abundance of E-Learning openings and online data. In the 20th century, organizations begin to use E-Learning to figure out how to prepare their workers. New ones and experienced ones, labors alike presently had the chance to groom their industry's database and extend their range of skills. People were allowed access to programs at home; those offered them the content to profits online degrees and grow their living styles through extended erudition. Today, E-Learning is more well-known than any time in history, with incalculable masses utilizing the advantages that internet learning is offering. Starting with cognitive burden theory as their persuading logical reason, set up inside the logical writing a lot of sight and sound instructional structure rules that advance viable learning [6] and [7]. Many of those principles are "field-tested" in everyday learning settings and located to be effective there further [8]. The collected data from students indicated the need for improvement in the quality and service of online learning. As it is seen, the internet world is shifting to Internet Protocol version 6 (IPv6) and making sure what protocol fits best for the need of the internet and will be adaptive to change. It was time to experiment with the online learning experience, its performance, its accessibility, and much more over the traditional IPv4 and the upcoming rival IPv6 briefly [9-11].

Figure 1, below highlights various forms of E-Learning used nowadays over the internet for distance education to be supported. Table 1, shows the basic difference between IPv4 and IPv6 in general.

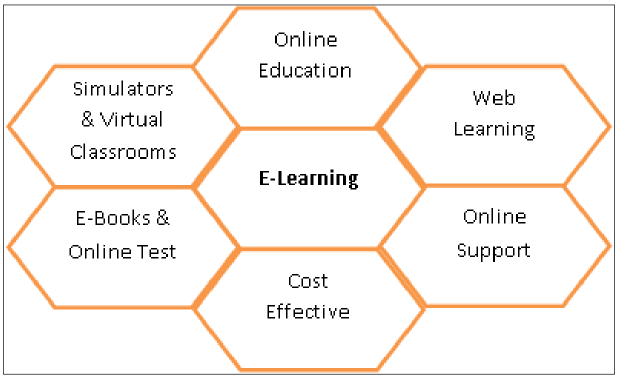

Figure 1: E-Learning Features

Table 1: IPv4 vs. IPv6

IPv4	IPv6
Invented 1981	Invented 1997
Has 32-bite (4-bytes) address space	Has 128-bite (16-bytes) address space
IPsec unnecessary	IPsec necessary
NAT Supported	NAT Doesn't Support
20-60 bytes	40 byte
Header with 12 Fields	Header with 8 Fields
TTL as Field Value	Hop Limit as Field Vale
Support Dotted Decimal Notation: 1.0.3.0.6.0.3.0	Support string Notation as Address Format: 1:A:2:4:E:1:3:7
It uses 127.0.0.1 as the loopback address	Its use::1 as the loopback address
224.0.0.0/4 for Multicast Transmission	FF00::/8 as Multicast Transmission
Support both DHCP and Manual Configuration	DHCP & Manual Configuration Not Supported it is plug-and-play
Support Broadcast Transmission	Support group / multicast Transmission
Data can't be prioritized	Data Prioritization Possible
IPv4 support mobile IP that ranges from 1G to 3G phones	IPv6 support mobile IP that ranges from 4G and above phones

II. BACKGROUND

The communication era till 1980 focuses on and uses IPv4 as the single communication protocol for reliable transmission. IPv4 supported five classes; A, B, and C are used for common use whereas class D is used for multicasting and class E is used for research environments. Currently, the invention of wireless networks and especially handheld devices that support both user and device mobility has changed the communication phenomenon. The trend of human-to-human communication is shifted towards machine-to-machine communication. Over the internet, one user has multiple wireless devices connected with his/her identity. That addresses limitation space drawback and ability support created a need for IPv6 protocol to overcome these issues.

Hierarchical Network Architecture:

- There will be no need for Network Address Translation (NAT) and the Application's Layered Gateway (ALG)
- Built-in security with Internet Protocol security (IPSec) implementation
- Auto-configuration and plug-and-play support
- Expanding the number of multicast addresses
- Improved support for Mobile IP and Mobile

The TCP protocol is always chosen for the transmission where we need surety of data delivery with proper acknowledgment. Reality is the key feature to adopt TCP protocol whereas whenever we need a multimedia transmission; audio, video to be forwarded so we prefer UDP protocol. In TCP reliability is achieved with a connection-oriented environment and acknowledgment mechanism of a three-way handshake between client and server always. Whenever the connection is interrupted so the packet will be resent again. In comparison with UDP which is a connection-less protocol and preferably used for multimedia transmission.

III. RELATED WORK

A group of researchers worked on 'efficiency in learning' and designed guidelines to manage the cognitive load [12], a test-bed is a setup that consisted of two identical computers that communicated via a cross-cable and having a different operating system for each run. The operating systems considered are Win XP, Win Vista, Win Server 2003, Win Server 2008, Ubuntu, and Fedora Linux. Data was collected first for IPv4 configuration than for clean IPv6 configuration while the protocol changed the rest of the configuration remained the same.

Distributed Internet Traffic Generator (D-ITG) application was used to generate traffic and measure the performance metrics: jitter, throughput, and delay and Central Processing Unit (CPU) usage for TCP/UDP. The throughput of TCP on IPv4 and IPv6 was measured against varying packets from 64 bytes to 1536 bytes. From the results, it was noted that for smaller packets all of the operating systems performed identically for both IPv4/IPv6. However, for larger packet size Linux distributions performed better than Windows.

Additionally, the performance of IPv6 was lower in most cases compared to IPv4. The throughput in the case of UDP showed similar behavior for both Linux distributions and Windows-OS for packet sizes between 384-1024. It was noted that both of the TCP/UDP throughput values showed similar behavior for all OS. Average delays for TCP and UDP showed peculiar behavior. Windows-OS performs better by showing close to zero delays while Linux distributions showing significant delays, thus performing poorly. In UDP for smaller packet sizes similar behavior is observed while for packet sizes over 384 bytes portray Linux distributions exhibiting as much as 4 times more delay than Windows-OS. Jitter in TCP for small packet size show similar behavior for all OS however for larger packet sizes slight difference is observed. Here Linux distributions showed higher jitter values than Windows-OS. For UDP Linux values are less than Windows- OS for most packet sizes however for the range 384-1024 bytes, a similar trend is observed. CPU usage for both sender and receiver portrays peculiar differences between operating systems. In most cases, it was observed that Windows-OS use more CPU resources than Linux, in some cases by as much as two times. For small packet sizes, the Linux senders seem to use more CPU than Windows-OS. On the receiver side, a similar pattern is observed for both TCP and UDP and in both instances, Windows Vista used more resources than the Linux Ubuntu [13].

The creators proposed to set up three distinctive proving ground arrangements for our analyses [14]. The test lab comprised of three. We installed Server 2012, FreeBSD 11, and Red hat 7.5 on the systems. The 100 Mbps Ethernet interface was utilized for every one of the tests. Proving ground I utilize a solitary framework that goes about as a circle back interface to play out the investigations. This proving ground is utilized to keep away from our trial from outside elements, for example, data transfer capacity, link clamor and impact, middle-of-the-road hubs, and so forth. In the Test Bed-II configuration, we connected two systems using an Ethernet Hub. In the Test Bed-III configuration, we connected two systems using the router. Data was collected first for IPv4 configuration than for IPv6 configuration while the protocol changed the rest of the configuration remained the same. Standard metrics i.e., Round-Trip Time (RTT), throughput, socket creating time, number of connections established, and CPU usage; were used for protocol evaluation. RTT of TCP for packet sizes from 32-1500 bytes was evaluated in different OS.

Windows 2003 performed lower than FreeBSD and Red hat. Throughput test for both TCP and UDP for the same packet range show that Windows 2003 performed badly while FreeBSD was comparatively better but was still behind Red hat. For socket creation time FreeBSD performed best, Red hat showing similar results but Windows 2003 showed poor performance. It was also noted that TCP sockets need 10 % more time for creating than UDP sockets. For TCP connection time again Windows 2003 gives the worst performance taking 44% more time than FreeBSD and Red hat. When tested for several connections per second it was observed that Red hat proved best while Windows 2003 being worst and Red hat in between. The RTT for smaller packets sizes shows similar behavior while for larger packets Windows 2003 perform comparatively better than the other two.

Throughput of UDP and TCP for packets smaller sizes shows similar behavior but Red hat gives better performance. For larger packet sizes UDP shows overlapping behavior while in TCP Windows 2003 performs significantly better than the other two. In TCP connect time Windows 2003 perform poorly while FreeBSD and Red hat show similar behavior. When checking for the number of connections per second Red hat supports maximum followed by FreeBSD while Windows 2003 lagged behind. RTT for all operating systems showed similar behavior, however, for larger packets, Windows 2003 performed poorly. Throughput for TCP and UDP showed comparable performance by all operating systems. For TCP connect time Windows 2003 took almost twice the time to connect than the other two operating systems. Red hat supported the maximum number of connections per second followed by FreeBSD while Windows 2003 lagged behind.

As described by few investigators who undertake performance evaluation of TCP/IP over Windows-OS and establish laboratory exercise for such [15]. Net monitor, ping, traceroute and modified version of Netperf tools were used for benchmarking the efforts. Using the packet trace analysis it was found that Windows 2000 performed better over Windows NT for various segment sizes. It was found that for smaller windows size better throughput was achieved. During the RTT evaluation, it is noted that UDP performs considerably well over the TCP counterpart. Same experiments were performed using IPv6 and it was noted that IPv4 performed comparably better in overall performance. Various configurations and modifications can be applied to implement different lab tests for the students and various parameters be evaluated.

The researchers experiment to measure the throughput, round trip latency, CPU utilization, Web Client Server Simulation and TCP connection time on, Solaris and Windows, operating systems [16]. The test-bed was configured and the experimental results were obtained. Throughput in case of TCP small message size it is noted that IPv4 is three times better than IPv6 for Solaris and the difference decreases if the size of a message is increased. On the other hand, for Windows, it is noted that the results are similar for small messages, and greater size IPv4 yield 11 % greater throughput. For UDP throughput the same result was noted as for TCP on Solaris and Windows yield similar results. For TCP, messages up to 1kB, round-trip latency of IPv6 was noted 30% worse than IPv4 on Windows 2000 and for Solaris, a 5% increase was noted.

For messages greater than 1 kB the increase was noted in latency rate. For UDP, 30 % higher latency was noted on Windows 2000, and on Solaris 5 % higher latency was noted. The CPU usage was measured during experiments at sending host using windows task manager; it was observed that TCP over IPv6 used 20 % higher CPU resources than TCP over IPv4. For both TCP and UDP socket creation under Solaris socket creation time had no difference between IPv4 and IPv6. And for TCP and UDP socket creation time of IPv6 was increased 31 and 13 percent respectively than IPv4.

During testing, the obtained result was 430 and 404 connections per second for IPv4 and IPv6 respectively under Solaris, and on Windows 147 and 115 connections were created per second for IPv4 and IPv6. The researchers experimented to measure the throughput and round trip latency of TCP/UDP over IPv4 and IPv6 using

Windows 7, 8, 10, and Debian-based Linux, having payload sizes varying between 50 to 10000 bytes [17]. The result of the experiment revealed that the throughput was almost the same on smaller payload sizes on all operating systems, whereas IPv4 had higher throughput on larger payload sizes over IPv6 for both TCP and UDP. Results revealed that the delay of IPv6 was higher than the IPv4 in all operating systems for smaller and larger payload sizes for both TCP and UDP.

As explained by the authors who described that the E-Learning is a piece of a new and unique element that describes instructive frameworks, toward the beginning of the 21st century [18]. Like society, the idea of E-Learning is liable to consistent change. Moreover, it is hard to think of a solitary meaning of e-discovering that would be acknowledged by most mainstream researchers. The distinctive understandings of E-Learning are conditioned by particular professional approaches and interests. A universal venture, in light of the support of specialists around the globe, was attempted to concur on the meaning of E-Learning. To this end, two principles investigate exercises were done. Initially, a broad survey was directed of the writing on the idea of e-picking up, drawing from friend inspected diaries, specific site pages, and books. Second, a Delphi study was conveyed to assemble the feelings of perceived specialists in the field of instruction and innovation in regards to the idea of E-Learning with the end goal of achieving the last accord.

IV. MATERIALS AND METHODS

In this research, a personal experiment environment containing one server and three clients are set up. On the server-side Windows Server 2016, is installed whereas for the three clients different OS (i.e. one client each for Windows, Linux, and Mac-OS Sierra) was set up. The proposed methodology adopted for the implementation is shown in figure 2.

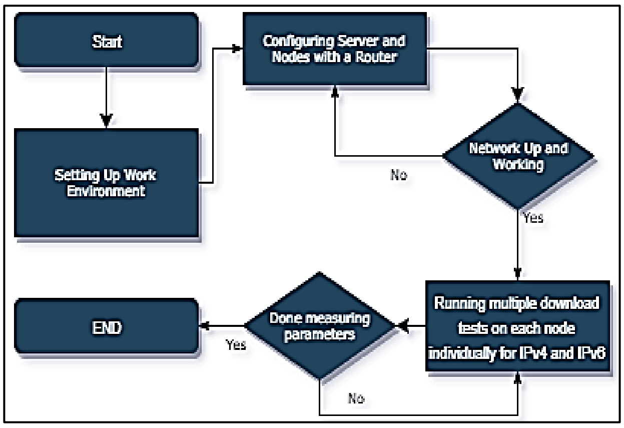

Figure 2: Proposed Methodology

As shown in figure 3 we have chosen varying payloads of sizes i.e. 32, 700, and 1200 bytes to ensure our configurations were working properly. Furthermore, we have considered averaged results of three experimental runs, with different payloads.

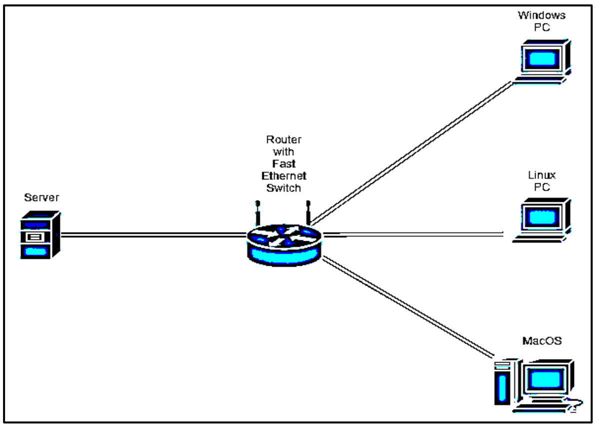

Figure 3: Experimental Environment

V. PERFORMANCE PARAMETERS

A. Throughput

Throughput was tested on each operating system having IPv4 and IPv6 configured in downloading the payload of size 32, 700, and 1200 bytes. Throughput did increase on all operating systems when larger payloads were downloaded.

$$Throughput \leq \frac{RWIN}{RTT} \quad (1)$$

Where:
RWIN is the TCP Receive Window and RTT is the round-trip time for the path.

B. Delay

Delay was tested for each payload on each operating system configured with IPv4 and IPv6 noted and averaged the results for better discrimination among the delays of each operating system with each technology. Further in the next section results achieved after testing has been illustrated via figure 4.

$$D_T = \frac{N}{R} \quad (2)$$

Where:
$\mathbf{D_T}$ is the transmission delay in seconds
N is the number of bits, and
R is the rate of transmission (say in bits per second)

C. CPU usage

CPU usage was analyzed for both IPV4 and IPV6 to transfer the payload towards the respective client connected with the server. The results were averaged to get a better overview of the usage of each operating system with IPv4 and IPv6. Further in the next section results achieved after testing has been illustrated via figure 5.

VI. RESULTS DISCUSSION AND ANALYSIS

As the environment was already set up, This work started by performing tests from Windows 7, 8, and 10 from Windows client computer, and then after that the same tests were performed on Ubuntu and Mac-OS Sierra. The task was to access the lecture video and download it for offline use, using both the TCP and UDP over IPv4 and IPv6. We have then averaged the tested values from three tests performed on each operating system with IPv4 and IPv6 configured. The final results were analysed.

A. Throughput

Throughput as shown in figure 4 is found almost the same for TCP and UDP, though UDP is showing slightly higher values. For IPv4 and IPv6 comparison of accessing and downloading the file, Windows performed best of all as its throughput was higher than all other operating systems, Ubuntu topping in some IPv6 tests, but for all other operating systems, the results were almost identical having slight ups and downs.

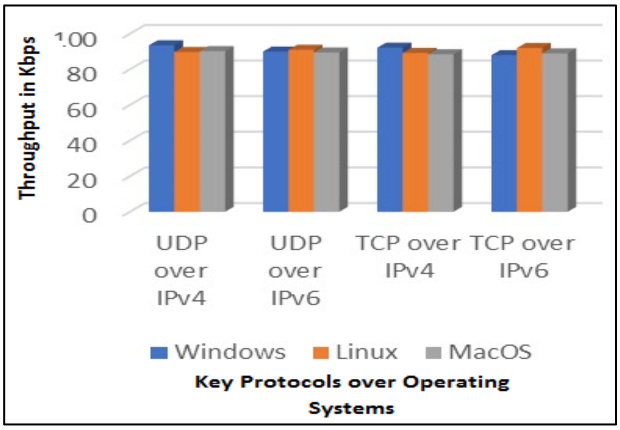

Figure 4: Average Throughput Comparison

B. Delay

In TCP as illustrated in figure 5 below the delay was much higher than the UDP, for IPv4 and IPv6; IPv4 handled delay quite efficiently on all of the operating systems. Delays for Windows operating systems were higher than the Linux and Mac-OS delay in downloading the file.

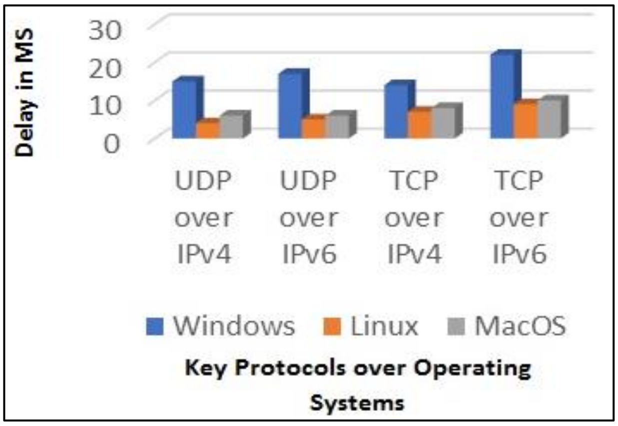

Figure 5: Average Delay Comparison

C. CPU usage

CPU usage results on both TCP and UDP upon Windows operating systems were higher than the Mac-OS and Linux as expressed via figure 6.

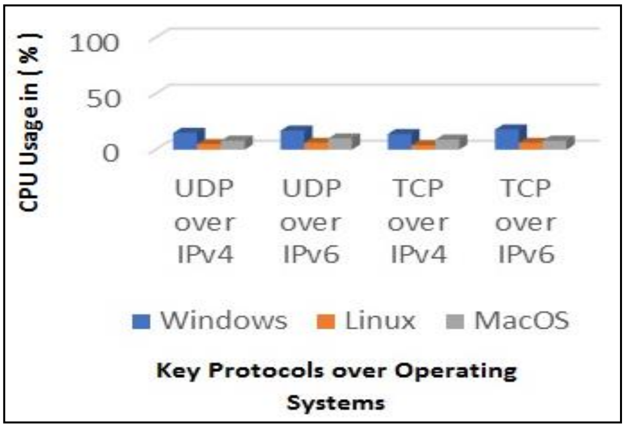

Figure 6: Average CPU Usage Comparison

D. Results Analysis

From the results discussed above, it is obvious that the Linux system had the best throughput performance over IPv6 on both the TCP/UDP protocols reaching 91 Mbps and 92 Mbps for UDP and TCP while staying neck to neck with Windows in IPv4 reaching 89.7 Mbps and 89.2 Mbps for UDP and TCP. whereas, Windows took the lead in IPv4 transmission over TCP/UDP protocols reaching 93.5 Mbps and 92.2 Mbps for UDP and TCP while striving in IPv6 with its other competitors reaching 90Mbps and 88Mbps for UDP and TCP, Lastly, Mac-OS remained an average platform among its other competitors reaching 90.2 Mbps and 88.5 Mbps for UDP and TCP over IPv4 while 89.6 Mbps and 89Mbps for UDP and TCP over IPv6. In figure 3, the Average delay was enlightened for all of the platforms, which clearly shows Linux was the winner averaging 7–9 ms delay times overall scenarios while Mac-OS remained at 2nd position having 8–10 ms delay time followed by Windows at last position having 15–22 ms delay time. In figure 5, displayed is the result value of CPU usage while performing the test, it can be observed that Linux is the winner here having the least amount of CPU usage averaging around 5–6 % for all the tests, while Mac-OS remained at 2nd utilizing CPU about 9–10 % for all the tests followed by Windows at the end with 15–18 % CPU usage while performing the tests.

VII. CONCLUSION

It is concluded and evaluated from the results achieved in this study that a suitable protocol for setup an E-Learning environment is IPv6 for windows, Linux, and Mac-OS. However, IPv6 was almost neck to neck with the IPv4's performance having slightly topping results in Ubuntu. There is still are need for improvements in IPv6 to make it faster more reliable and overcome its issues to fully replace IPv4 with IPv6 in the upcoming future of the Internet with billions of users and terabytes of bandwidth exist. The paper focused and covered the offline aspect of E-Learning, in the future the above-mentioned performance parameters of E-Learning may be tested for real-time audio and video streaming.

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Authors Contribution

The Idea and methodology to conduct this research work was proposed by Khurram Shahzad and Ahthasham Sajid. The framework was prepared by Imranullah Khan. The technical implementation was done by Nauman Mehmood, Faraz Ahsan, and Raja Asif

Conflict of Interest

All the researchers declare no conflict of interest.

Data Availability Statement

The testing data is available in this paper.

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