Research Paper

A STUDY ON IPv4 and IPv6:
THE IMPORTANCE OF THEIR CO-EXISTENCE

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Abstract

This paper aims at evaluating, compare and report result based on the performance of two protocol stacks (IPv4 and IPv6) in terms of various parameters that is analyzed when the data is being transmitted from one client to another or to a server over a wired network on IPv4 in comparison with the IPv6, thus proposing a system that supports the co-existence of both IPv4 and IPv6. The issue of the new-generation numbering system of the Internet Protocol version 6 (IPv6) is addressed as exhaustion of address space of the numbering system of Internet Protocol version 4 (IPv4) becomes a problem. An explained study is performed on the IPv6 addressing architecture and yet the almighty goals are still not met. IPv4/IPv6 transition unfolds a lot of problems relating to the internet world. This paper proposes some transition mechanisms involving Dual Stack and Tunneling transition techniques. An explained study is performed on the addressing architecture. However these techniques prove to be most efficient in the study which has been performed. This paper targets at a comparative study on the throughputs in bits/seconds, packet throughputs, delay in networks, response time in seconds of both IPv4 and IPv6. Hence, since the system proposes for co-existence of both IPv4 and IPv6, the solution projected in this paper is "DUAL STACK where you can and TUNNEL where you have to".

Key Terms: IPv4, IPv6, Dual Stack, Tunneling, IP, NAT

1. Introduction

This research details on the study of Network Layer of the OSI. This involves the movement of packets from source to destination; to provide internetworking. The Network Layer is responsible for the delivery of individual packets from the source host to the destination host. Reddy et al (2012) discussed about the Internet Protocol (IP) as the Network Layer of the TCP/IP protocol suite. IP architecture is designed to allow application layer protocols and mechanisms to evolve independently of the underlying network protocols and mechanism however the IP architecture has also been thoroughly field-proven regarding scalability through the use of IP over the public internet.
Geoff (2008) stated that, hidden from view of typical users, every Internet communication relies on an underlying system of numbers to identify data sources and destinations. Users typically specify online destinations by entering domain names (e.g. "congress.gov"). But the Internet’s routers forward data according to numeric IP addresses (e.g. 140.147.249.9).

Sequel to the issues to be addressed in this study of IPv4 in comparison with IPv6 as it covers mainly the throughputs in bits/ seconds, packet throughputs, delay in networks, and response time in seconds, the researcher detects a means of providing reliable process to process communication delivery of packets data and error recovery. This will hence bring forth the reason for their co-existence either via Dual Stacking or Tunneling.

In dual-stack architecture, all the components of the network system should support the both protocols. Applications must choose either IPv4 or IPv6, by selecting the correct address based on the type of IP traffic and particular requirements of the communication. This is because they are fused together so their functionality is based on priority. Tunneling will explain a mechanism by which the existing IPv4 backbone can be used to carry IPv6 traffic and vice versa. The tunneling protocol carries the tunneled protocol. Tunneling can be either IPv6 over IPv4 or IPv4 over IPv6 networks. In the transition period while the IPv6 infrastructure is being deployed, the existing IPv4 backbone over the network can be used to carry IPv6 packets. This is to say that IPv6 or IPv4 hosts and routers can tunnel IPv6 datagram over regions of IPv4 routing topology by encapsulating them within IPv4 packets. Using this technique an IPv4 user can communicate with IPv6 network using the existing IPv4 network.

In this research study, the performance parameters like throughput, packet loss, etc were discussed. For both the protocols IPv4 and IPv6 networks were evaluated. Baseline IPv4 and IPv6 network have been simulated using OMNeT++, which is a discrete event simulator. A comparative study of parameters was carried out in two different networks based on IPv4 and IPv6 respectively. For clarification of the comparison, screenshots of the simulation has been attached and detail of the scenario explanation.

As IPv6 is now the trendy Internet Protocol that has come to replace IPv4 based on the design and related statistical report. IPv6 is acknowledged to provide more address space, better address design, and greater security. IPv4 offers 32 bit address space and IPv6 offers 128 bit address space. This expansion allows for many more devices and users on the internet as well as extra flexibility in allocating addresses and efficiency for routing traffic. However the two protocols are incompatible i.e. an IPv6 node cannot communicate directly with another IPv4 only node and vice versa. Different mechanisms for transition have been developed so that both the protocols may coexist. Khan et al (2014)

1.2 The Problem of IPv4 and its Limitations

The initial design of the IPv4 did not anticipate the growth of internet and this created many issues which brought forth the idea for the change of the numbering system of IPv4. The limitations of the IPv4 are highlighted below;

a) **Scarcity of IPv4 Addresses**: Because of the scarcity of IPv4 addresses, many users/organizations implemented the Network Address Translation (NAT) to map multiple private IPv4 addresses to a single public IPv4 address. More workstations and devices which are connected to the internet also demand the need for more addresses and the current statistics prove that public IPv4 address space will be depleted in due time. This has therefore made the scarcity of IPv4 addressing system a major limitation.

b) **Security**: As stated earlier that the initial design did not anticipate some issues, security threats was also not anticipated at that time.

c) **Quality of Service**: Service quality relies on the 8 bits of the IPv4 type of service field and the identification of the payload. This service has limited functionality and payload identification is not possible when the IPv4 datagram packet payload is encrypted.
**d) Address Configuration Issues:** Configuring IP addresses should be simplified and clarified as networks and internets are expanding and lots of computers and new invented devices are using IP.

Having had a clear view of the highlighted points regarding issues of IPv4 addresses, it is clear to say that since the number of users on the internet is continually increasing very fast, but the address structure of the IPv4 header is fixed which is a leading problem now as the number of addresses is becoming less and less. Another aspect is regarding the development of new applications like Multi-Media and Video conferencing, new features of IP are needed. The following facts will be considered to be demonstrated in the new IP numbering system.

- Scalable Multicast
- Provider Selection
- Mobility Plug-and-Play
- Real time flow

1.3 Research Aim

This research work aims at projecting the co-existence of IPv4 and IPv6 over their single existence as it may not be an issue now but possibly in the future time. With that regards the basic factors are seen as some of the possible conditions to be considered for adoption;

- In line with the business case to ensure business continuity and future growth, all organizations need to carefully plan for coexistence between IPv4 and IPv6
- Adopters look at the today’s Internet of Things and rely not on the realistic future issues related to propagation/ migration.

1.4 Research Question

I. Is IPv6 in wide circulation
II. Should everyone adopt the trendy IPv6
III. Does IPv6 meets all the problem statement fulfillment of IPv4
IV. Should IPv4 and IPv6 Co-exist

2. Literature Review

The projection of impending depletion of IPv4 address space led network engineers to implement IPv6 address system. It is assumed that the IPv6 header has been streamlined for efficiency. The format introduces the concept of an extension header, allowing greater flexibility to support optional features. It was reported in this paper that all networking equipments and the new devices like mobile handsets, tablets etc are provided with IPv6 support i.e. it allows dual stack architecture. The backbone network is largely based on IPv4; all routing tables are based on IPv4 entries (Chauhan and Sharma, 2014).

Report analysis shows that MPLS enabled networks were having less queuing delay as compared to traditional networks. Thus it is discussed and explained by the fact that in MPLS, only the label is checked and the underlying IP header is not used or forwarding and routing decisions.IPV6 MPL shows more queuing delay than IPv4 regarding the fact that the packet header is larger in IPv6 than IPv4. The addition of the MPLS header increases the packet size even more. The maximum queuing delay in all the cases was for IPv6 (Firdous Ahmad Khan et al, 2014).

Rey (1991), stated that the design of the TCP/IP architecture brought about the flexibility which enabled the internet grow in vast host of over a billion supporting series of services over a variety of media. The TCP/IP architecture at first aimed to provide undisrupted internet communication despite the loss of networks or gateways. IPv4 is the most common protocol.
that governs the entire communication over the internet. In the current scenario as the exponential growth of internet has led to the shortage of IPv4 addresses. The Internet Assigned Number Authority (IANA) pool of unallocated IPv4 Internet addresses got completely emptied on 3 Feb 2011 and the Regional Internet Registries (RIRs) unallocated IPv4 address pool exhaustion date is predicted to be near. So before the RIRs and ISPs will be denying requests for IPv4 addresses, the successor IPv6, must be deployed actively worldwide.

The transition from IPv4 to IPv6 is not fully looked upon due to limitations of the V6 benefits. The architecture of IPv6 was to improve authentication, security, and automatic device configuration. Thus, its features were “back-ported” to be available in IPv4 as well. Transition to IPv6 is further hindered by limited compatibility both forward (existing IPv4 devices seeking to communicate with v6 devices) and backward (IPv6 devices communicating with IPv4). The reason is said to be that both v4 and v6 uses different header formats. For lack of robust translation, some software and protocols may not function on IPv6-only devices. Tools for network management and security are currently largely available only for v4 networks, and some categories of tools lack any effective IPv6 implementations. Hence in overview, organizations and companies could encourage the provision of IPv6 tools (Edelman, 2014).

Shiwani et al (2013) analyzed the various IPv6 transition technologies. With regards to their research work, comparisons were made with respect to performance of IP and IPv6 in order to show the effects of transition strategy on network behavior. In their work for performance evaluation, authors used the OPNET modeler that contains a WAN, a LAN, hosts and servers. After the simulation results, authors conclude that IPv6 has higher throughput. CPU utilization is lower for IPv4, IPv6 and dual stack than manual and 6to4 and also dual stack has less delay with TCP.

Khan et al (2012); Different techniques for migration from the IPv4 to IPv6 protocol is discussed and evaluated. One migration technique that was considered is the dual stack mechanism in Local Area Network (LAN). Regarding the adoption purposes, the Packet Tracer version 6.0.1 software was used. PING connectivity and Round Trip Time (RTT) of IPv4/IPv6 networks was used to analyze the Performance. Simulation results shows that transition platform IPv4 based websites can be accessed and web page is displayed and yet that of IPv6 can also be displayed unless the webpage is present at the server side.

Using private IPv4 addresses was considered a temporary solution to the IPv4 address exhaustion issues until a new addressing scheme, IPv6, would be adopted. Private addresses are not considered a final solution because they are not uniquely addressable. That is, a host with a private IPv4 address can start a session with a host with a public address, using an address translation mechanism such as Network Address Translation (NAT), but not the contrary. In addressing the issue of implementing Mobile IP based networks using private IPv4 addresses, it was realized that Mobile IP was implemented in cellular networks technologies such as GPRS (General Packet Radio Service). However, in order to provide connectivity to the global Internet, one must consider the shortage of IP version 4 (IPv4) addresses. The report on this paper proposes a system that allows IPv6 addresses to IPv4 hosts without any hardware or software modification on end-user devices. The mechanism is based on the introduction of a transparent gateway called Transparent IPv6" (TIP6, for short). It was stated that IPv6 solved the problem by offering a virtually unlimited address space. However, there is expected to be a long transition period during which it will be necessary for IPv4 and IPv6 to coexist and communicate Jamhour et al (2012).

Arafat et al (2014), concentrates on the most significant IPv6 theoretical ideas, i.e. address allocation, addressing, routing with the BGP and OSPF protocols and performance of routing protocols in dual stack network. For simulation technique, GNS3 and Wire shark modelers are utilized. In this paper, writers compiled IPv6 address planning in large scale network, performance statistics of every network in terms of TCP throughput, packet loss rate, delay jitters and round trip time. Writers introduced that dual stack is the better technique to migrate
in IPv6 network as compared to tunneling and NAT techniques. After the results of simulation, writers concluded that for TCP throughputs, the IPv6 network does as well as the IPv4 network with respect to end-to-end performance. In a real large-scale atmosphere, the IPv6 network throughput increased frequently in small message sizes of 256 bytes, after which, it leveled out until the 768-byte message size range.

Sheryl Radley et al (2014): As reported in this paper after the evaluation and study of the Transition Techniques addressed on IPv4-IPv6. Their work was aimed at a comparative review on their suggested and stated transition techniques such as software mesh which supports dual stack, NAT444 which supports translation and IPv6 rapid Development mechanism in tunneling mechanism. However NS-2 SIMULATOR was used for the simulation purpose. After the simulation result, authors concluded that effective way of transition is IPv6 Rapid Development method although much analysis and reports have not been made regarding this technique. It will as such not be reported on this paper as its limitations are not yet clear yet.

Migration from the IPv4 to IPv6 instantly will be impossible due to huge size of the Internet considering the larger number of IPv4 users. However, a lot of companies are becoming more and more dependent on the Internet for their daily work, and they therefore cannot tolerate downtime for the replacement of the IP protocol. Having considered investigation reports related to the exhaustion of IPv4 address, investigation is made on when to immigrate from IPv4 to IPv6 and considering the risk of migration. As a result, there will not be one special day on which IPv4 will be turned off and IPv6 turned on because the two protocols can coexist without any problems Amer Nizar (2014).

Fatah et al (2013): In this paper writers examined the Dual Stack IPv4-IPv6 system performance in university network by utilizing of delay period and jitter in interconnection. In their work, writers computed the delay period and jitter by transmitting various files with different size. For performance analysis, technique utilized by writers is the method by direct performance evaluation on the model or network prototype. After the implementation, writers conclude that Dual Stack system is most flexible implementation for migration of IPv4 to IPv6 system. Also IPv6 system is more stable and has less jitter as compared to IPv4

3. Research Design and Methodology.

In this research study, the proposed methodology for the evaluation and analysis is the Simulation. The scenario is been created using OMNET++. Simulation techniques allow us to analyze the behaviour of networking protocols depending on available computing power for running the simulation experiment. The network comprises of various components like servers, routers, clients, etc.

3.1 Research Purpose

The purpose of this paper is to assess basic throughput, packet loss, latency, etc. In considering performance with regards to evaluation and of both IPv4 and IPv6, some comparisons have been made in factual areas after simulation reports are stated below and they include;

i. Throughputs in bits/seconds
ii. Packet Throughputs
iii. Delay in Networks
iv. Response time in seconds
The graph above represents the throughput statistics of IPv4 and IPv6 over both the network. Evaluating the graph, FTP is the data traffic used for simulating the network. The network is loaded with FTP traffic beginning at 50 bytes up to 100MB with an inter-request time of 2000 seconds. We have a small difference in throughput of an IPv4 and IPv6 network when the FTP traffic is low, and as FTP data traffic volume crosses 500Bytes with an inter-request time of 2000 seconds, the IPv6 network throughput increases in comparison to the IPv4 network.

Regarding packet throughput for both IPv4 and IPv6, their simulation result is similar for both protocols when FTP data is sent between 50bytes through 500bytes with an inter-request time of 2000 seconds. Though the difference is very low but as the FTP traffic crosses 100KB with an inter-request time of 2000 seconds, IPv6 packet throughput almost doubles in comparing it with that of IPv4 packet throughput after 10MB payload. As it gets to the limit of link bandwidth, the packet throughput remains constant.
The increase in the FTP traffic increases the number of packets thereby increasing delay of the network. Delay in IPv4 network is 0.19ms compared to that of IPv6 network which is 0.16ms respectively. This is to say that when FTP data volume increases, the number of packets in IPv4 increases thereby causing delay in the IPv4 network. Therefore the delay in IPv6 network is less than IPv4 regarding the lesser number of packets in the network.

This analysis gives a clear picture of the response time of both IPv4 and IPv6 as it is measured from the time a client application sends a request to the server to the time it receives a response packet. Analyzing the graph, when the FTP traffic sent is between 50bytes to 10KB with an inter-request time of 500 seconds, the response time is low for the both protocols. As data traffic increases, the response time for IPv4 network increases also. The effect of the response time in both IPv4 and IPv6 network is small.
Both graphs illustrate how packets are dropped by queue in both IPv4 and IPv6 based on LAN. My findings from the chart shows that in IPv6 there was no packet loss but in the case of IPv4 there was some loss of packets by queue which are represented by purple and highlighted using the yellow color. At some point there was no loss of packet, but as the load on network exceeds, packet loss increases.

4. Results and Discussion

The result of the research study through the literature review and experimental analysis proved that the co-existence of both Internet Protocol version 4 (IPv4) and the Internet Protocol version 6 (IPv6) should be considered. After proper understanding of the purpose of this paper and understanding that it is to assess basic throughput, packet loss, delay in networks, etc; in considering performance with regards to evaluation and of both IPv4 and IPv6, the comparisons have been made in factual areas after simulation and seen reliable for co-existence.

Results show that the introduction of the IPv6 did not solve the problem statement of IPv4 in general. Thus, IPv4 and IPv6 co-exist. Therefore, in the opinion of this research, network administrators should either DUAL-STACK or TUNNEL as the scenario may call for.

4.1 Dual Stack

Dual-stack migration strategy is to make the transition from the core to the edge. This involves enabling two TCP/IP protocol stacks on the WAN core routers, then perimeter routers and firewalls, then the server-farm routers and finally the desktop access routers. After the network supports IPv6 and IPv4 protocols, the process will enable dual protocol stacks on the servers and then the edge computer systems.

4.2 Tunneling

Tunneling introduces carrying one protocol inside another. These tunnels take IPv6 packets and encapsulate them in IPv4 packets to be sent across portions of the network that haven’t yet been upgraded to IPv6. Tunnels can be created where there are IPv6 islands separated by an IPv4 ocean, which will be the norm during the early stages of the transition to IPv6. Later there will be IPv4 islands that will need to be bridged across an IPv6 ocean.
5. Conclusion

The selected topic was based on the evaluation of the Internet Protocol version 4 (IPv4) and the Internet Protocol version 6 (IPv6) in close comparison. Some issues were addressed regarding the problem facing IPv4. The researcher’s knowledge in Internet Protocol Addressing introduced the work and review on some journals to address some issues on TCP/IP. Some justifications have been made condemning the IPv4 and IPv6 on several review journals, but the obvious reasons for coexistence are rising. Most users are discovering the resources they need along with good information, though bad information and are causing unwarranted concern. Now the fact that performance is one great reason for this study, the analysis of IPv4 and IPv6 networks illustrated with their performance showed that the performance of IPv6 seems better than the IPv4 with no much difference but yet did not shown 100 % absolute performance over IPv4. This analysis includes their throughputs, delays, packets throughputs and response time.

Through this paper, the researcher concluded that though IPv6 deployment is a necessity, it is still a gradual transition in spite of the various advantages associated with the new version. IPv4 and IPv6 will coexist for a long time hence the need for methods of communication between the new and old versions will arise. Having gathered and reviewed this fact, the researcher is of opinion that there is immediate need for adoption of either of the practices; DUAL-STACKING or TUNNELING as quickly as possible, so as to avoid future problems in the internet networks since the related issues/challenges addresses spaces in the numbering system of the Internet Protocol version 4 (IPv4).

Reference


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