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Review Article

A Review Paper on IPv4 and IPv6: A Comprehensive Survey

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Abstract

Even though more customers are regularly coming to the Internet, IPv4 addresses have been reduced by the Internet Assigned Numbers Authority (IANA) and have been deactivated in domain name registries (RIRs). IPv6, being the sole important next-generation Internet protocol, has yet to be fully developed and deployed, owing to the lack of a scheme that might address the transfer of IPv4 resources to IPv6 networks as well as collective communication between the two incompatible protocols. The Transmission Control Protocol/Internet protocol version 4 (TCP/IPv4) addresses have been reported as being on the verge of collapsing, while the next generation Internet Protocol version 6 (IPv6) is being identified on a regular basis. Among other advantages, IPv6 provides a significantly wider address space, better address design, and more security. IPv6 distribution necessitates a thorough and meticulous setup in order to avoid network disturbance and reap the benefits of IPv6. Because of the problems with IPv4, IPv6 is currently becoming increasingly popular among organizations, businesses, and Internet Service Providers (ISP). This paper we will explores the evolution of Internet Protocol version 4 (IPv4), its key features, challenges, and limitations, and examines how Internet Protocol version 6 (IPv6) addresses these issues. Additionally, we will highlight the key differences between the two protocols and discuss the transition process from IPv4 to IPv6.

Keywords

IPv4, IPv6, Internet, Networks, Server

1. Introduction

In the early days of computers, a network was defined as a collection of interconnected hosts connected by common media, which could be wired or wireless. A computer network allows its users to communicate and exchange data and information through a network. A network can be a local area network (LAN) that connects several offices, a greater metropolitan area network (MAN) that connects multiple cities, or a wide area network (WAN) that connects multiple cities and colonies [5]. The Internet Protocol (IP) is a collection of technological rules that govern how computers communicate over the internet. The two most recent versions are Transmission Control Protocol/Internet Protocol Version 4 (IPv4) and Internet Protocol Version 6 (IPv6) [6]. In 1991, the Internet Engineering Task Force (IETF) initiated the development of a new Internet Protocol, IPv6, to replace the aging IPv4, with the formal effort beginning in 1994. The

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rapid growth of internet-connected devices led to the exhaustion of IPv4 addresses, which was a primary motivation for creating IPv6. However, the vast number of IPv4 users and the sheer size of the internet make an immediate transition to IPv6 unfeasible. Fortunately, IPv6's auto-configuration feature allows it to coexist with IPv4, enabling users to benefit from IPv6 features while maintaining compatibility with IPv4 devices. This paper will discuss techniques employed by IPv4 to extend its address lifespan and examine key methods and challenges involved in the migration to IPv6. [15].

2. Networking's Challenges

The key idea of the Internet Protocol is to allow logical participation in the establishment of support for the routing of Internet Protocol nodes using something like IPv4 or IPv6. As a recent search on the IETF website shows, numerous surveys and research have been conducted and are still being conducted in this sector. Researchers are also working on a platform called obilenet that will connect entire subnets with the help of Mobile IPv6. [12] Because of the behavior of internet protocol address (IPV4) addresses, route devices could not connect after 255 routers in the previous method, and secondly, IPV4 addresses are 4.3 billion, and when all of these addresses have been used in the future, it will be impossible to use IPv4 due to limited numbers, so there is a solution in IPv6, but this methodology can't change the entire world network. Intra-Domain Movement is a problem in IPv4; frequent intra-domain movement of the MH within a short area will result in continual handoff. As a result, a large number of communication activities have been registered. [11]

The network develops 210 worldwide journals of computer science and technology, and the system capacity is drastically altered.

3. Networking Architecture

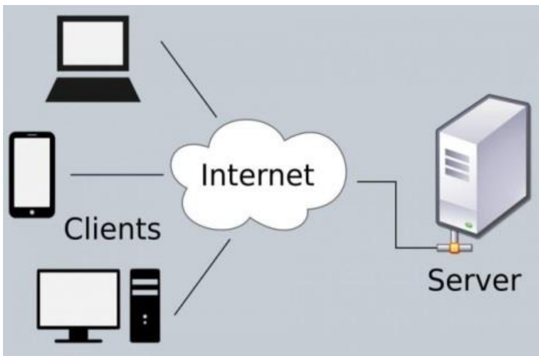

Figure 1. *Network Architecture.*

Various individual computers are connected to each other across a communication network in networking. Out of all the hosts, one acts as a master or server node, allocating tasks to the information systems fields that are applicable or capable of doing the task.

4. IPv4

IPv4, introduced in the 1980's, is a crucial part of the TCP/IP suite, identifying hosts using logical addresses. It functions at the OSI model's network layer for data routing. ARPANET researchers debated IP address content and 128-bit length before implementing IPv4. In 1977, Vint Cerf decided 32-bit IPv4 addresses. IPv4 has five classes: A, B, C, D, and E, with different bit lengths for each class. Class E addresses are reserved for future use. IPv4 uses a 32-bit addressing which amounts to 4,294,967,296 unique addresses [1]. An example of an IPv4 address is "159.85.167.5", it involves four octets of 8 bits each all resulting to a 32-bit address [5]. In binary form, it would look like 10011111.01010101.10100111.00000101 for the four octets.

The table shows of IPv4 address classes, including the number of hosts in each class.

Table 1. *Summary of IPv4 Classes.*

Network Class	Number of Networks	Hosts per Network
A	126	16,777,214
B	16,382	65,534
C	2,097,150	254

Summary of IPv4 Classes

The IP addressing system has a subnet mask that lets us clarify a network address from a host. For instance, if we have an IP address of 192.168.0.3 and a subnet mask of 255.255.255.0, the network, or class C address, is identified by "192.168.0," and the host is identified by the last octet in decimal, "3". [6]

Now, we are running out of IPv4 addresses because its system can only support about 4.3 billion addresses, which isn't enough for all the devices connected to the internet today, like smartphones and smart devices. The problem has been made worse by the way addresses were handed out in the past, and the huge increase in connected devices. IPv6 is designed to fix this with a much larger address space, but the switch to it has been slow.

5. IPv6

IPv6 (Internet Protocol Version 6) is the sixth iteration of the basic internet protocol. The Internet Protocol (IP) is the common language of the Internet, and every device on the network must be able to communicate in it. The current version of Internet Protocol version 4 (IPv4) contains a number of flaws that are inescapable and compound issues such as address space exhaustion, security issues, and the lack of auto-configuration, and, in some circumstances, create a barrier to the Internet's continued expansion. [10] While that is a large number of IP addresses, it is insufficient to last indefinitely. IPv6 is the Internet Protocol's sixth iteration and the successor to IPv4. It works in the same way as IPv4 in that it assigns unique numerical IP addresses to devices that can interact over the Internet. It does, however, have one significant difference: it uses 128-bit addresses. In a moment, we'll explain why this is significant. The number of IP addresses is the primary distinction between IPv4 and IPv6. IPv4 address numbers are 192.116.0.4; 197.45.0.8; 168.122.0.6; IPv6 address numbers are 2001:0db8:85a3:0000:0000:8a2e:0370:7334, fe80:1fff:fe23:4567:890f;2607:f8b0:4005.

Components in IPv6 Address Format

a. There are 8 groups and each group represents 2 Bytes (16-bits).
b. Each Hex-Digit is of 4 bits (1 nibble) Delimiter used – colon (:)

Both versions of the Internet function in the same way technically, and both versions are expected to continue to run on networks independently in the future. Currently, most IPv6 networks accept both IPv4 and IPv6 addresses on their networks [2].

6. Transition from IPv4 to IPv6

The transition from IPv4 to IPv6 is an important process that helps fix the problems of the older protocol and supports the growing number of devices connected to the internet. Here explain about three transition strategic:

a. Dual Stack
b. Tunneling
c. Header translation

Dual stack:

This strategy enables simultaneous use of IPv4 and IPv6 on network devices, ensuring compatibility and connectivity during transition periods, allowing gradual transition to IPv6 services. [7]

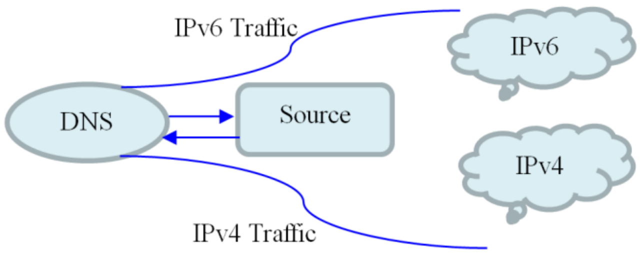

Figure 2. *Dual stack Transition.*

Tunneling:

Tunneling wraps IPv6 traffic inside IPv4 packets, allowing different networks and users to communicate. Techniques like 6to4 and Teredo help connect IPv6 and IPv4 networks until we can fully switch to IPv6. [8]

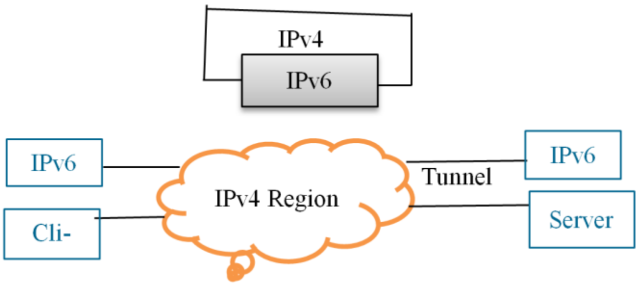

Figure 3. *Tunneling Transition.*

IPv6 packet is encapsulated in an IPv4 packet when it enters IPv4 Region

Header Translation:

Header translation from IPv4 to IPv6 involves converting 32-bit IPv4 addresses to 128-bit IPv6 addresses, creating a new IPv6 header. This process can cause compatibility and performance issues in the network. [7]

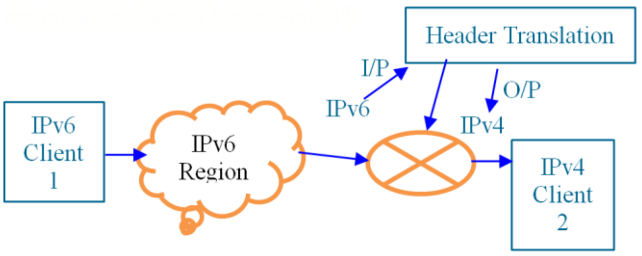

Figure 4. *Header Translation.*

When most of system are on IPv6 but some still uses IPv4.

7. Comparison of IPv4 and IPv6

IPv4's Network Address Translation (NAT) reduces public IP addresses but has security and performance issues. IPv6 offers direct end-to-end connections, auto-configuration, and IPsec for secure communication. IPv6 reduces the need for proxies and IPsec, enhancing network security. NAT works well for client-server communications but can cause issues for peer-to-peer connections like VoIP. [9, 13, 14]

Shows some of the key differences between IPv4 and IPv6:

Table 2. Differences between IPv4 and IPv6.

Differences between IPv4 and IPv6	
IPv4	**IPv6**
Uses 32 bits.	Uses 128 bit.
Decimal notation.	Hexadecimal notation.
Total number of addresses 2^{32}	Total number of addresses 2^{128}
Each number in the set range from 0 to 255.	Each number in the set range 0 to f.
IP addressing range: 0.0.0.0 to 255.255.255.255	IP addressing range: 0000:0000:0000:0000: 0000:0000:0000:0000 to ffff:ffff:ffff:ffff:ffff:ffff:ffff:ffff.
IPsec is not compulsory.	IPsec is compulsory.
Broadcasts sends traffic to all hosts on a subnet.	There are no broadcasts instead multicasts are used thereby reducing broadcast floods found in IPv4
Separated by dot/period.	Separated by colons.

8. Review of Literature

Dipti Chauhan and Sanjay Sharma's study, "A Survey on Next Generation Internet Protocol: IPv6", proposes that as the Internet evolves, the transition from Internet Protocol Version 4 to Internet Protocol Version 6 has become unavoidable and rather immediate. The Internet Assigned Numbers Authority (IANA) has finally used up all of the worldwide IPv4 address space, leaving the community with little alternative but to accelerate the IPv6 transition. Given that IANA has run out of IPv4 address space, the Internet will inevitably transition to IPv6. Despite this, IPv4 and IPv6 networks will coexist for a long time during the transition. The move to IPv6 should be gradual and painless. As a result, IPv4 and IPv6 coexisting networks should maintain both IPv4 and IPv6 availability, as well as support IPv4-IPv6 connectivity [1].

The document "A Review of Implementation Issues in IPv6 Network Technology" is a review of implementation issues in IPv6 network technology. According to Ramesh Chand Meena and Mahesh Bundele, IPv4 addresses are already depleted in the Internet Assigned Numbers Authority (IANA) and have run out in regional Internet registries (RIRs), despite the fact that more clients are joining the Internet every day. Because a system to address the transfer of IPv4 resources to IPv6 networks, as well as mutual communication between the two incompatible protocols, has not been fully developed and deployed, IPv6, as the only accessible next peer group Internet protocol, is still not commercially successful. Security, address, error detection, and wireless sensor network difficulties were the four main issues that were encountered in the technology. Researchers have proposed a number of remedies to the problems that have arisen during the adoption of IPv6 [2].

Srinidhi K. S., Smt. R. Anitha, and A. V. Srikantan presented "Tunnel-based IPv6 Transition with automatic bandwidth control."

Because the present IPv4 allocation is likely to run out, the Internet will soon be sailing in very stormy waters. Because IPv4 and IPv6 are incompatible protocols, switching from IPv4 to IPv6 is not easy. The IETF has recommended a number of transition strategies to make the shift from IPv4 to IPv6 as painless as possible. Since the depletion of IPV4 addresses, it has become imperative (rapid) for all internet service providers to move to a new addressing technique, IPv6, which may assign IP addresses to up to 2^{128} devices [3].

In comparison to 4.3 billion (2^{32}) IPv4 addresses, it was designed to accommodate +340 undecillion (2^{128}) Internet Protocol addresses. If every person on the planet (6.77 billion) needs three IP addresses, then calculate the total number of IP addresses required for everyone on the planet (6.77 billion x 3 = 20.31 billion IP addresses [4].

9. Conclusion

Switching the entire global network from IPv4 to IPv6 is challenging. The future of the internet is definitely with IPv6, but moving from IPv4 to IPv6 will take time and might take several years to complete. Luckily, there are ways to make sure both protocols can work together smoothly during this transition. These methods will help keep devices connected as businesses switch to the new system, allowing them to take their time without causing major problems. As more companies adopt IPv6, we'll be able to enjoy its benefits while still using IPv4.

Abbreviations

Md	Mohammad
IETF	Internet Engineering Task Force
IPv4	Internet Protocol Version 4
IPv6	Internet Protocol Version 6
RIRs	Regional Internet Registries
IANA	Internet Assigned Numbers Authority
TCP	Transmission Control Protocol
ISP	Internet Service Providers
LAN	Local Area Network
MAN	Metropolitan Area Network
WAN	Wide Area Network
MH	Multihomed Mobile Host
IP	Internet Protocol

Author Contributions

Md. Turab Hossain: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing

Jesmin Zaman Binti: Conceptualization, Formal Analysis, Investigation, Methodology, Resources, Supervision, Visualization, Writing – review & editing

Md. Rayhan Uddin: Formal Analysis, Investigation, Resources, Visualization, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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Biography

Md Turab Hossain is serving as a Researcher in the "Embracing diversity in Asia through the adoption of inclusive practices" Project at DiversAsia and Inter-university education programs among universities throughout Asia, with the purpose of establishing a wide area Internet education platform utilizing satellite technologies Project at SoiAsia (IICT, BUET). He has completed an act as a Graduate Research Intern (remotely) at Keio University, Japan, Information and Computer Science Department (Internet Engineering). He obtained his Bachelor degree and M. Engg. degree in the Institute of Information and Communication Technology (IICT) from the Bangladesh University of Engineering and Technology (BUET).

Jesmin Zaman Binti is a dedicated Lecturer in the Department of Computer Science and Engineering at the University of Development Alternative. With a passion for teaching and research, Jesmin has distinguished herself in academia. She earned both her Bachelor's and Master's degrees in CSE from the same institution, showcasing her deep-rooted commitment to the university. Jesmin's excellence was further recognized through the prestigious "Dean Award" for her MSc degree, reflecting her outstanding academic achievements and contributions to the field.

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Md. Turab Hossain: Networking, Microprocessor, Microcontroller, Bioinformatics, Embedded System, Optics.

Jesmin Zaman Binti: Computer Networks & Communication, Data Science & Big Data, Quantum Computing, Embedded Systems & Hardware Design, Bio-informatics, Cloud Computing & Distributed Systems.

Md. Rayhan Uddin: Machine learning based on coal evacuation and detection of carbon emission, Bioinformatics, Environment Safety and sustainable economy and reuse waste carbon particle.