Comparison Research on Future Network Between IPv4, IPv6 and IPV9

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***Abstract*—IPv4 is the most widely used protocol on the Internet, and its address space is 232. In the early stage of the Internet, due to the underestimation of the development of Internet, IP resources were very limited. By 2010, there was no address that could be allocated. In order to solve the problem of insufficient addresses, the IETF designed the next generation IPv6 protocol to replace IPv4, IPv6 has 2128 addresses in theory, and however, only one-eighth of the addresses can actually be allocated to end users. At present, 128 barcodes are already having 128 bits, and it cannot be covered, so IPv6 have some considerable limitations. In 1998, Chinese researcher proposed IPV9. In order to distinguish from IPv4 and IPv6, the V in IPV9 is uppercase, not lowercase. The IPV9 includes three technologies: a new address coding design, a new addressing mechanism and a new address architecture design. These technologies constitute the core technology system at the bottom of the new generation IP network. The new network framework designed on this basis can form a network system that is connected and compatible with existing networks. IPV9 is not a simple upgrade of IPv4 or IPv6 and its address space is 10256 by default. The massive address can meet the needs of human activities about 750 years, this paper will introduce the characteristics of the future network, and comparison the system between the IPv4, IPv6 and IPV9, and lay a solid foundation for the subsequent development.**

Keywords-IPv4; IPv6; IPV9; Future Network

With the rapid development of science and technology, the world has entered an information age of data communication. The most famous of the data networks is Internet, a packet-switched network developed by the U.S. department of defense called the ARPANET, which is considered the precursor to the information superhighway. Now almost all countries and regions have joined the Internet.

In order for information to be transmitted correctly over the Internet to its destination, each computer connected to the Internet must have a unique address. At present, there are three kinds of address compilation methods: one is "IP address", which consists of four digits divided by the dot; the other is "domain name", a series of strings split by dots, and the third is "Chinese domain name system", which consists of a three-level domain name split by a decimal and an oblique line. These three address structures have become the current network system; bringing great convenience to people's

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access to the Internet, the network has completely changed people's lives.

I. PROBLEMS WITH IPV4 AND IPV6

A. Problems with IPv4

1) Insufficient address

Internet uses IPv4 protocol address scheme, the address number up to 232, due to the early development of the Internet to estimate the development trend of Internet, the IP allocation is not reasonable, address resources are exhausted, although no classification of addressing CIDR technology, network address translation NAT technology to alleviate the crisis, but still can't solve the problem. And address will be more and more widely used in e-commerce logistics code, space code, identity code, digital currency, three-dimensional geographical code and other intelligent terminals, the original address allocation technology cannot meet the needs of social development.

2) Route table expansion

The topology of address space directly results in the form of address allocation independent of the network topology. With the increase of the number of networks and routers, the excessively expanded routing table increases the search and storage overhead and becomes the bottleneck of the Internet. At the same time, the length of packet head is not fixed, and it is very inconvenient to extract, analyze and select routes by hardware, so it is difficult to improve the throughput of routing data. Then there is the uneven distribution of IP addresses. Due to its origin in the United States, more than half of all addresses are owned by the United States, resulting in a serious imbalance in the distribution of IP addresses.

3) Lack of quality of service (QoS)

IPv4 was originally designed for military use, and was not intended to be open to the outside world. As a result, QoS of quality of service and security were very poor, and it was difficult to provide rich QoS functions for real-time multimedia, mobile IP and other commercial services. Although the later developed protocols such as RSVP provided QoS support, the cost of planning and constructing IP network was relatively high.

Despite of its shortcomings, IPv4 was the first network all over the world, and people had got to used it, so it will going forever.

B. Problems with IPv6

The length of IPv6 is 128 bits, or 2128 addresses. The address space is much larger than the 32-bit address space. Moreover, the principle of Aggregation is adopted, which enables the router to represent a subnet with an Entry in the routing table, it greatly reducing the length of routing table in the router and improving the speed of forwarding packets. The addition of Multicast support and Flow Control over IPv6 has led to significant advances in multimedia applications, providing a good network platform for, Quality of Service Control (QoS). Despite its obvious advantages, IPv6 has a big flaw in the design of its address structure. The shortcomings are as follows.

1) Structural hierarchy disorder

IPv6 confuses the network hierarchy in the design, and the interface ID inserts the physical address into the logical address layer, which on the one hand results in the physical address space forming a limitation on the empty IP address, the security does not belong to the content of the IP layer, it is not necessary to design security technology in the IP layer. Because with the development of security technology, security methods and key length will change constantly, so the development of security technology will eventually lead to the need for IP address redesign.

2) Ambiguous address space

In the unicast address with more IPv6 applications, the structure of "network ID+ host ID" similar to IPv4 is adopted from a large point of view, and the network

ID of IPv6 is changed into a three-layer more structure with a fixed length of subnet prefix: "top-level aggregation ID+ secondary aggregation ID+ site-level aggregation ID". IPv6 is a kind of patchwork addressing. So its address space is not pure 128 bits.

IPv6 address space is not the 128-bit address space that people think of. Due to the special address structure design, IPv6 itself has to go through three significantly different version transitions if it wants to truly implement the 128-bit address space, the IPv16 for 64-bit effective address space; IPv26 for 128-bit valid address space. The transition between the three versions is like to upgrade the three different protocols.

3) Incompatible with IPv4

IP address is the basic protocol of the Internet, and it is very difficult to solve it through complete replacement. Initially, without further study, the designers of IPv6 decided that the 32-address space problem of IPv4 could not be solved by a smooth upgrade, so they simply redesigned it entirely from scratch. IPv6 requires all nodes of the entire network to support the new IP protocol, and all terminal operating systems and applications to support upgrades, making the problem extremely difficult.

These shortcomings are also the main reason why IPv6 has not been widely used since its emergence.

II. FUTURE NETWORK IPV9

A. Process of IPV9

In December 1998, Xie Jianping, a scholar from Shanghai, China and the inventor of the Future Network, applied to the National Intellectual Property Administration (NIPA), PRC (formerly the Patent Office of China) for the invention patent of "the method of assigning addresses to computers connected to the network with full digital codes", which was officially authorized by the NIPA on November 7, 2001.

In December 1998, Mr. Xie jianping registered the copyright in the national copyright administration of China in “the method of unified compilation and distribution of addresses of networked computers and intelligent terminals”, “the overall distribution method of computer addresses allocated by full decimal algorithm for networked computers”, and “the gateway of decimal number”.

In October 2001, the “copyright of IPV9 protocol and application” was registered.

In 2001, the former Science and Technology Department of the Ministry of Industry and Information Technology of China established the China Decimal Network Standards Working Group (IPV9 Working Group) with enterprises as the main body and industry, university and research institute as a combination.

In 2002, the “code for digital domain names” was published, defining the "decimal network, IPV9 resource record and management organization".

In 2007, the former Ministry of Industry and Information Technology of China formally defined IPV9 as the "future network" to distinguish the next generation of the Internet for IPv6.

In 2011, the authoritative professional institutions of the US government have confirmed legally and technically that China has the core technology of sovereign network with independent intellectual property rights under the IP framework. This is the patented technology of IPV9 which is different from the existing technology of the US Internet. The official patent name is "Method of using whole digital code to assign address for computer".

In December 2011, the U.S. federal patent and trademark office issued a patent certificate numbered US 8,082,365, stating in its notice of approval that the applicant's identification report was "very convincing".

On May 21, 2013 and March 11, 2014, the United States twice voted in favor of the China-led "naming and addressing" and "security" of the future network.

On February 23, 2013, the State Council issued the national science and technology infrastructure construction medium and long term plan (2012-2030), in order to break through the future network basic theory and support the new generation of Internet experiments, the construction of future network test facilities.

On June 1, 2016, the Ministry of Industry and Information Technology of China released relevant industry standards for IPV9 implemented nationwide: Including SJ/T11605 "for products and services based on the technology of radio frequency domain rules", "SJ/T11604 decimal network based RFID tag information orientation, query and service discovery technology standard", SJ/T11603 "used Digital ID format in information processing products and services", SJ/T11606 "the network architecture of RFID tags information query service specification", SJ/T11682 "based on the electronic tag information of decimal network location, query and service discovery and application".

B. About IPV9

IPV9 is completely independent intellectual property rights on the basis of full decimal digit code, it has 2^{256} of cyberspace sovereignty, including from mother root, master root, 13 root name servers, using zero trust security communication mechanism after verification first, compatible with the current Internet system, with overlapping geographical position and the IP address space for the future network architecture.

On the basis of compatibility with all the functions of the Internet at present, IPV9 adopts the TCP/IP/M three-layer and four-layer hybrid architecture, with mixed virtual and real circuits, to complete the video data transmission of large code stream.

IPV9 obtained Chinese patent in 2001 (CN98 1 22785), and has obtained authorized patents successively in more than ten countries and regions, including South Africa, Turkey, Kazakhstan, Russia, South Korea, North Korea, Hong Kong, Canada, Singapore, Australia, Mexico and Norway. IPV9 applied for US patent in 2004. It was issued seven times of "non-final rejection opinion" and six final rejections by the US Patent Office. During this period, it was repeatedly criticized by senior members of the US IETF and famous American IT companies. In December 2011, the US Patent and Trademark Office officially issued a patent certificate numbered US 8,082,365, and clearly stated in its approval notice that the appraisal report provided by the applicant was “very convincing”. In December 2011, the US Patent and Trademark Office officially issued a patent certificate numbered US 8,082,365, and clearly stated in its approval notice that the appraisal report provided by the applicant was "very convincing".

III. SPECIAL CHARACTERISTICS OF IPV9

1) Address space is huge

IPV9 has a larger address space than IPv4/IPv6. IPv4 defines the bit length of IP address is 32, that is, there are 232-1 addresses; While the length of IPv6 is 128, that is, 2128-1 addresses, the standard length of an IPV9 address is 2256-1, with 42 layers address structure design will be 10256-1 (21024-1). To put it mildly, if IPv6 were widely used, every grain of sand in the world would have an IP address. Then after IPV9 is widely used, the smallest molecule of bright matter in the whole universe will have a corresponding address. It is no exaggeration to say that if IPV9 is fully applied, every cell and living gene in the world can be assigned to an IPV9 address. Layer 42 is the asset management address (including legal digital currency space) compatible with ean-ucc128 barcode length.

2) Route tables are smaller

IPv6 has a smaller routing table than IPv4. The address allocation of IPv6 follows the principle of Aggregation at the beginning, which enables the router to represent a subnet with an Entry in the table, this greatly reducing the length of routing table in the router, and improving the speed of forwarding packets in the routing table.

The routing table of IPV9 is very small, and the address allocation of IPV9 follows the principle of Geo-spatial clustering from the beginning, which enables IPV9 router to represent a country subnet and an application subnet with a single record, it greatly reducing the length and cleanliness of routing table in the router, and improving the speed of forwarding packets by routing table. At the same time, this subnet can express a specific geographical location, for example, we assign the IPV9 address segment of Shanghai as 86[21[5]/96, then in other routers of the same level, only one route pointing to the address segment of 86[21[5]/96 can realize the IPv9 address routing of Shanghai. According to this logic, only one route is needed from country to country. For example, the route to China is 86/64. The IPv4 routing table is large and irregular, and the IPv6 routing table is smaller than IPv4, but the IPv6 routing table contains no geographic information and the routing is messy.

3) Automatic configuration support

IPV9 adds support for automatic configuration of variable length addresses, which is an improvement and extension of DHCP protocol of IPV9, making network management more convenient. IPV9 supports multicast, and supports the ISO/IEC C6 future network << naming and addressing >>TCP/IP/M model, and supports long packet code streams for virtual and real circuits. This allows multimedia applications on the web to ensure video quality and reduce overhead, provide faster and faster applications such as industrial controls and unmanned vehicles, and provide better and cheaper service over the Internet than IPv6.

4) Address length could be select

IPV9 address length has a variety of options, which can realize the change of 16, 32, 64, 128, 256, 512 and 1024 bit address length, and select the most appropriate address length according to different usage scenarios to reduce the routing overhead.

5) Dual encryption

The address length of IPv9 is long enough to realize dual encryption from the transmission of source and target addresses, which plays an important role in some specific network transmission fields.

6) Add location information to the address

IPV9 addresses can be embedded with geo-location information, as well as personal and industry ID information, this making IP addresses uniquely tied to personal information.

7) Compatible with previous addresses

IPV9 address is backward compatible with IPv4/IPv6 address. In order to absorb the upgrade difficulty of IPv6 incompatibility with IPv4, IPV9 protocol remains and unchanged, so that IPv4/IPv6 upgrade to the new version of IPV9, the upgrade cost is very low.

8) Sovereignty is different

IPv4/IPv6 addresses Spaces and copyright ownership: United States.

IPV9 address space and copyright ownership: China.

IV. FEATURE OF IPV9

IPV9 technology has many features; a comparison of IPV9 and IPv4, IPv6 features is listed below.

TABLE I. COMPARISON BETWEEN IPV4 AND IPV9

Item	IPv4	IPV9
Bit length	32	256
Address format	Dot decimal, uncompressible	[ ] Bracket decimal notation, with zero compression, can be compressed on both sides
Network express	Mask or length prefix representation	Length prefix express that supports public geographic space clustering
Loop Address	127.0.0.1	[7]1
Public address	Common public IP address	Aggregate global address location unicast addresses
Automatic configuration	Automatically configured address（169.254.0.0/16）	Link-Local Address:4269801472[0/64
Broadcast address	Contains broadcast address	No broadcast address, transitional support broadcast address
Unspecified address	0.0.0.0	[8]
Domain name resolution	IPv4 Host address(A) resource record	IPv9 host address (AAAAAAAA) resource record
Mother root server space	32bits (232-1 addresses)	Realized 256bits (2256-1 addresses) design objective 2048bits
Root domain server name	13 letters from A to M	13 letters from N to Z
China top-level domain	.CN	.CHN
Inverse Resolution	IN-ADDR.APRA Domain	IN-ADDR.APRA9 Domain
Compatibility 1	Incompatible with IPv6 addresses	Compatible IPv6 address：y]y]y]x:x:x:x:x:x:d.d.d.d
Compatibility 2	Incompatible with IPV9 addresses	Compatible IPv4 address：y]y]y]y]y]y]d.d.d.d
Transition address	No	Transition address IPv4：[7]d.d.d.d 简写 J.J.J.J
Encryption	No IP address encryption	Dual encrypted of the source address and the destination address
Address length	Fixed 32 bits	Not fixed，canbe16、32、64、128、256、512、1024bits
Geographic information	No geographic location information	Geographic location information Can be embedded
DHCP	Nonsupport DHCP	Added support for automatic configuration of variable - length addresses
ISO/IEC C6 & TCP/IP/M model	Not supported	Supported
Communication rules	Communicate first, then verify	Verify before communication
Network model	TCP/IP	TCP/IP/M
Sovereign	America	China

TABLE II. COMPARISONS BETWEEN IPV6 AND IPV9

Item	IPv6	IPV9
Bit length	128	256
Address format	Colon-separated hexadecimal with zero compression, single compression	[ ] [ ] Bracket decimal notation, with zero compression, can be compressed on both sides
Network express	Mask or length prefix representation	Length prefix express that supports public geographic space clustering
Loop Address	：：1	[7]1
Public address	Can aggregate the global single point transmission address	Aggregate global address location unicast addresses
Link-Local Address	FE80：：/64	4269801472[0/64
Broadcast address	No	No broadcast address, transitional support broadcast address
Unspecified address	0: 0: 0: 0: 0: 0: 0: 0	[8]
Domain name resolution	IPv6 Host address(AAAA) resource record	IPv9 host address (AAAAAAAA) resource record
Mother root server space	128bits (2128-1 addresses)	Realized 256bits (2256-1 addresses) design objective 2048 bits
Root domain server name	13 letters from A to M	13 letters from N to Z
China top-level domain	.CN	.CHN
Inverse Resolution	IP6.INT Domain	IN-ADDR.APRA9 Domain
Compatibility 1	Incompatible with IPv9 addresses	Compatible IPv6 address：y]y]y]x:x:x:x:x:x:d.d.d.d
Compatibility 2	Incompatible with IPv4 addresses	Compatible IPv4 address：y]y]y]y]y]y]d.d.d.d
Transition address	No	Transition address IPv4：[7]d.d.d.d 简写 J.J.J.J
Encryption	No IP address encryption	Dual encrypted of the source address and the destination address
Address length	Fixed 128 bits	Not fixed，canbe16、32、64、128、256、512、1024bits
Geographic information	No geographic location information	Geographic location information Can be embedded
DHCP	Support DHCP, no automatic configuration for variable-length addresses	Added support for automatic configuration of variable - length addresses
Network model	TCP/IP	TCP/IP/M
ISO/IEC C6 & TCP/IP/M mode	Not supported	Supported
Communication rule	Communicate first, then verify	Verify before communication
Network model	TCP/IP	TCP/IP/M
Sovereign	America	China

V. CONCLUSIONS

The IPV9 protocol uses 0-9 Arabic digital network as the virtual IP address and uses decimal as the text representation method, which is a convenient way to find online users. IPV9 has a large number of assignable IP addresses, and the maximum number of address bits is 2×1048 In order to improve efficiency and facilitate end users, some addresses can be used directly as domain names, which is the cornerstone of the future digital world. At the same time, IPV9 is also called "New Generation Security and Reliable Information Integrated Network Protocol" because it uses the classification and coding of the original computer network, cable broadcast television network and telecommunication network.

IPV9 technology and the whole network architecture make China to be the second country in the world with complete future network architecture. This paper introduces the generation process and characteristics of IPV9, and compared with the existing Internet, with the continuous optimization and improvement of IPV9 Future Network, it will be applied in many other countries.

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