

Research on Constructing Security and Reliable IPv6 Network

Zhihu JIN^{1,2, a}, Yuxi GAN^{3, b}, Yi JIN^{4, c}, Yujun HE^{3, d}, Longbin HU^{3, e}, Jianrong PAN^{2, f}, Minggui WANG^{2, g}, Gui WANG^{2, h}

¹Department of Computer Science and Technology, Tsinghua University, Beijing 100084, China

²Shenzhen Gongjin Electronics Co., Ltd, Shenzhen, 518052, China

³ZTE Corporation, Shenzhen, 518057, China

⁴Shenzhen Institute for Drug Control, Shenzhen, 518057, China

^aemail:597885359@qq.com, ^bemail: gan.yuxi@zte.com.cn, ^cemail:dingxiangshu2010@163.com,

^demail:he.yujun1@zte.com.cn, ^eemail:hu.longbin@zte.com.cn, ^femail:pangjianrong@twosz.com,

^gemail:wangminggui@twosz.com, ^hemail:wanggui@twosz.com

Keywords: IPv6; CNGI; Network Security

Abstract. IPv6 backbone Network has been deployed in 2004 in China, such as CNGI, but the main IPv6 network equipment was provided by foreign supplies. Although we are facing the danger of IPv4 addresses exhaustion, but IPv6 Customer Premise Network was not deployed widely, and the applications based on IPv6 Network were very few. Besides the international influence, the main factors are that IPv6 sample applications with commercial value were few and there are not stimulus-encouraged policies of IPv6 CPN deployment. It is lack of cooperation and integration between the profession and the needs of the industry, and lack of participation and competition for the relevant international standards because there is lack of consideration of long-term interests and enterprises concern about short-term benefits. It has affected that we grabbed the commanding height of the next generation network in a certain degree, and there are some security risks. This paper briefly introduces the construction of IPv6 network with safe, reliable and cost-effective, some suggestions are shown for the accelerating deployment and sample applications of IPv6 networks. Hopefully it gives some reference to accelerate the construction of IPv6 network and enhance network security, especially the IPv6 Customer Premise Network.

Introduction

China is the largest Internet user country based on the IPv4 Protocol. When the quantity of Chinese Internet users reached 253 million, China had the most internet users greatly exceeding the United States. Till June 2014, the quantity of Chinese Internet users reached 632 million. But some of the core technologies was controlled by the United States, such as the top-level root Domain Name Servers, so there is a security risk [1][2].

IPv6 technology can provide a total of 128 power of 2 mass addresses, and is more secure than IPv4. China can break the limits of abroad and protect the safety of Chinese network by constructing IPv6 next-generation Internet in a new round of competitions fundamentally [2].

In early 2002, 57 academicians including Yang Jiachi sent a letter to the State Council which suggested constructing the Chinese Second-Generation academic high-speed Internet backbone. It was caused the attention of the leaders of the State Council [3]. IPv6 backbone network began construction in 2004. In March 2012, the file about the opinions of the next generation Internet development and construction in the 12th Five-Year Plan was jointly issued by seven ministries including the National Development and Reform Commission, in the file a scheme was developed which was large-scale IPv4 network to IPv6 smoothly evolution transition in 2013 and in 2015 realized inter-connect and inter-communicate between IPv4 and IPv6.

One of the built IPv6 backbone network China Next Generation Internet (hereafter referred to as a CNGI) is the network of CN2 (China telecom Next Carrier Network). The equipment came from

Cisco, Juniper, Alcatel Shanghai Bell and Huawei [4]. Although we are facing the danger of IPv4 addresses exhaustion [5], IPv6 Customer Premise Network (hereafter referred to as a CPN) was not constructed widely, and the applications based on IPv6 Network were very few. The IPv6 network cases reported were Shanghai World Expo IPv6 campus network and private competition network for the 26th Universiade Games which enabled IPv4/v6 dual stack, IPv4/v6 access and bearing capacity. In spite of the international factors, but the main factor was that IPv6 sample applications with commercial value were few and a stimulus-encouraged policies of IPv6 CPN deployment was a few. This paper briefly introduces the construction of IPv6 network with safe, reliable and cost-effective, some suggestions are shown for the accelerating deployment and sample applications of IPv6 networks. It gives some reference to accelerate the construction of IPv6 network and enhance network security, especially the IPv6 Customer Premise Network.

Analyze the Reasons of Influencing the IPv6 CPN Deployments

The strength of the policy guiding force is the main factor.

National Core Interests. The key core technology of the IPv4 network was controlled by the US. In addition, the United States and other western countries have more assigned class A IPv4 address. The redundant address can be still used, so there is no positive need to promote the deployment of IPv6. Eg. the United States has occupied 74% of 4 billion IPv4 addresses in the world. Based on the national strategy, the other countries were assigned few IPv4 addresses by USA, and the total of Chinese IPv4 addresses are equivalent to the University of California [2].

Actively promoting the IPv6 network construction and technology development will shake the American leadership, even to seize the opportunities of innovation-oriented countries, which USA is reluctant to see the outcome.

Dr. Robert Kahn who was TCP/IP protocol co-inventor and system designer of the ARPANET in the eve of CERNET2 (the Second Generation of China Education and Research Network) launched said: "The US is not active on the development of the next generation of the Internet. The US needs to catch up with China as soon as possible due to development situation." [2].

Native Enterprises Mastered Researching Network Equipment and IP Core Technologies. After fierce competition and accumulation of innovation more than ten years, ZTE Corporation (hereinafter referred to as ZTE), Shenzhen Gongjin Electronics Co., Ltd. (hereinafter referred to as Gongjin) and other native enterprises have completely command the IPv4/v6 network equipments and IP core technologies, successfully developed a whole series of leading global IPv4/v6 equipments, obtained IPv6 Ready Gold Certification.

Large-scale network equipments from China have been applied in dozens of countries, the foreign anti-China forces wouldn't like to see. For example, in 2012 the US Congress hearings was opened for the Chinese telecom equipment companies threatening US network infrastructure security, the United States International Trade Commission launched a large-scale "337" for a number of electronic devices Enterprise including ZTE [6].

Safety Technology of IPv6. IPv6 has technical advantages in address space, address auto configuration, security, QoS and mobility, etc. IPSec of IPv6 security protocol can provide security services for the network layer and the upper protocol, such as connectionless integrity, data source authentication, replay attacks and data confidentiality, etc.

IPSec is optional in IPv4, it is mandatory in IPv6. So IPv6 network more secure.

Encrypted transmission will inevitably increase the crack technical difficulty and cost.

Policy Guidance and Business Model. Although the national level policies were issued, our efforts to promote IPv6 ISP and ICP application is insufficient.

On the business model, the commercial discount suite businesses based on IPv6 is not delivered which attracted attention, very impressed, and cost-effective, such as 20m broadband use IPv4 access fee is RMB1,200, but adopting IPv6 only pays RMB 600 per year, 50% of preferential price, the nation gives some subsidy to ISP, like Shenzhen Municipal Government incentives for eliminating consists of policy, so IPv6 Internet users can't be leaded to IPv6 access.

Industry Promotion and Sampling of IPv6 Sample Project. The existing IPv6 testing systems and sample projects weren't enough to lead industrial development and sample effect, not reverberate and resonate throughout the Internet users, no format new strategic pillar industries.

Investment and Maintenance Complex for IPv6 transition. At present the IPv6 network is isolated from the huge IPv4 network, and the transition from IPv4 technology to IPv6 will increase the investment, maintenance workload and technical complexity of ISP/ICP.

Construct a Safe and Cost-effective IPv6 Network

Although the network equipments of CNGI backbone were made by foreign manufacturers mostly. However, the IPv6 CPN can be constructed safe, reliable, technological advanced, cheap using the domestic IPv4/v6 dual stack core devices and access devices. Because domestic manufacturers have mastered the core technology and were a global leaders, their IPv4/v6 devices obtain large-scale applications local and abroad, accumulated rich experience in engineering. Won the IPv6 Ready Golden certification.

On Nov. 12 to 14, 2012, the world's biggest IPv6 transition technology test conference was organized by the expert committee of CNGI IPv6, 61 devices of total 39 units of at home and abroad took this test. Results show that the number of enterprises focusing on the transition technology is creating in at home and abroad, the degree of industrialization transition equipment has improved significantly, equipment manufacturers supporting for transition technologies began to focus on [7].

Deficiencies of existing IPv4 Metropolitan Area Network.

In 2005, the domestic operators began to optimize the IP metropolitan area network (hereafter referred to as a MAN), as shown in Figure 1. Limited to the technical and industrial capacity at that time, in the distribution layer sets convergence router, in the service access control layer sets SR (Service Router) and BRAS (Broad Remote Access Server) in the same site, this architecture wasn't reasonable and economy now.

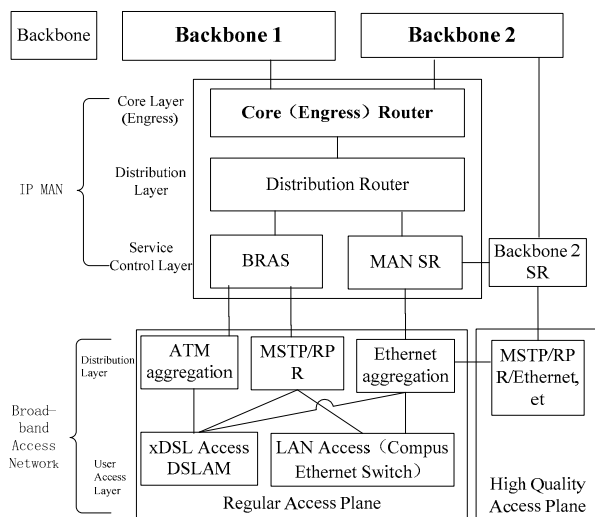


Fig.1: 2005 IP MAN Optimization diagram

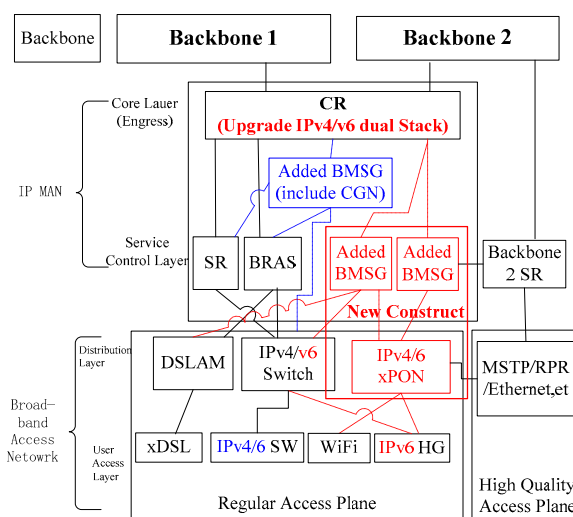


Figure 2 Optimized IP MAN use Broadband Multi-Service Gateway

After more than 10 years of accumulation of technology and innovation, equipment performance is enhanced greatly, IPv6 has the industrialization, high-end routers, SR/BRAS, access Ethernet switches, xPON, home gateway HG and WiFi wireless access routers already had IPv6 commercial capabilities.

IPv4 network can be optimized, the new IPv6 network with high-performance, security and reliability can be constructed also.

Optimization Scheme of IPv6 CPN. The transition technology of IPv6 network has NAT64, NAT444+DS, DS-Lite, 6RD. See Table 1.

Table 1 IPv6 transition technology comparison table

Items	DS-Lite	6RD	NAT444+DS	NAT64
Maturity	Standard. Many Supplies support	Standard. Some Supplies support	Standard. Many Supplies support	Standard. Supplies less support
Initial Construction Cost	Access network and BRAS to rebuild or upgrade. High cost	BRAS upgrade, deploy BR. Low cost	Access network and BRAS to be rebuild or upgrade. High cost	Access network and BRAS upgrade, deploy NAT64 and DNS64. High cost
Equipment Capacity	BRAS and Access Device deploy IPv6 single stack	BRAS and Access device deploy IPv4 single stack	BRAS and access network deploy IPv4/v6 dual stack	BRAS and Access device deploy IPv6 single stack
Feature	single-layer NAT, resolve addresses shortage. poor scalability	Not resolve addresses shortage unless overlapping NAT4. Scalability limited	Resolve addresses shortage, double stack NAT. Poor scalability	single NAT, translation techniques, different from others. Poor scalability
Application Scenarios	Early and scale stage. IPv4 users through IPv6 access to IPv4 services	Early stage. IPv6 users through IPv4 access to IPv6 services	Early and scale stage	Early and scale stage. IPv6 users access to IPv4 services

Comprehensive comparison, consider the future, learning from experience in engineering, we recommend DS-Lite + NAT64 combination IPv6 migration scenarios, it can integrated solute the needs which IPv4 bearer services and IPv6 users access IPv4 services under IPv6.

ZXR10 M6000/M6000-S series are Broadband Multi-Service Gateway with large capacity and high performance, covering SR/BRAS/CGN(Carrier Grade NAT) product features. Focusing on service controller layer, M6000/M6000-S provide abundant service features and full service uniform bearing. It is the optimal choice for constructing IP MAN powerful products [8].

Construct network scheme, see the blue part of Figure 2:

- Upgrade CR and campus Ethernet switch dual stack;
- The original SR and BRAS remain unchanged;
- New added IPv4/v6 BMSG (including CGN function) connected to the CR, SR, BRAS and Campus Ethernet Switches respectively;
- Upgrading HG and User-end Access Ethernet Switches are main, replacement is supplement;
- New added IPv6 PON directly uplink Campus IPv4/v6 Ethernet switches.

Services opened:

- Dual stack BMSG enables PPPoEv6 and IPoEv6 functions to accesses pure IPv6 users;
- IPv6 dial-up users use PPPoEv6+NDRA mode accessing internet;
- The double-stack BMSG enables Single PPP for both IPv4/v6 functionality, the dual stack mode end-users can get IPv4/v6 two addresses by once PPPoE dial;
- The dual stack BMSG enables NAT64/DNS64 functions, IPv4 visits IPv6 each other, IPv6 users can access IPv4 resources.

Scheme of IPv6 CPN new constructing

Construct network scheme, see the red part of Figure 2:

- CR and Campus Ethernet Switches upgrade dual-stack;
- 2 new added IPv4/v6 BMSG (including CGN function), new added IPv4/v6 PON, BMSG connected to CR, new PON, Ethernet Switches in existing IPv4 network respectively;
- New added HG and End-user Access Ethernet Switches must be dual-stack;
- New added IP PON directly uplink IPv6 BMSG.

Service opened:

- The dual-stack BMSG enables PPPoEv6 and IPoEv6 functions to access pure IPv6 user;

- Remote IPv6 users access by PPPv4/v6 over L2TP;
- IPv6 dial-up users access by PPPoEv6+NDRA mode;
- IPv6 VPN users through 6vPE access internet in dual-stack mode;
- Dual-stack BMSG enables NAT64/DNS64 functions to implement IPv6 users accessing IPv4 services.

IPv6 Access Terminal Equipments with Cost-effective. Gongjin with ZTE and a number of well-known manufacturers in the world has formed a strategic partnership together to enter the IPv6 terminal devices market. Developed a series IPv4/v6 dual-stack access terminal equipments, such as wired Terminal (such as ADSL router of IAD series, xDSL2+ wireless voice gateway, VDSL router, xDSL modem, ADSL2+ wireless gateway, ADSL2+ wireless voice gateway, and VDSL2 wireless gateway,) and Optical Communications Terminal (such as GPON HGU/MDU, GPON SFU, EPON HGU/MDU, and EPON SFU, etc).

Gongjin used open architecture of the software system and independently developed OpenRouter firmware system by the Linux that's open source operating system, OpenRouter can run on mainstream chip vendors including Broadcom, Qualcomm, Realtek, etc, as shown in Figure 3.

Dual-stack IPv4/v6 software is modular in design, fully shielded hardware characteristics by hardware-driven encapsulation, so that the system application layer is irrelevant to hardware of variety of access terminals, and provide a unified, portable, stable and reliable software platform.

Through many years of continuous technology innovation and industrialization of accumulation, Gongjin has become a leading global, China's largest network communication terminal electronics manufacturing supplies, provide cost-effective access equipment around the world.

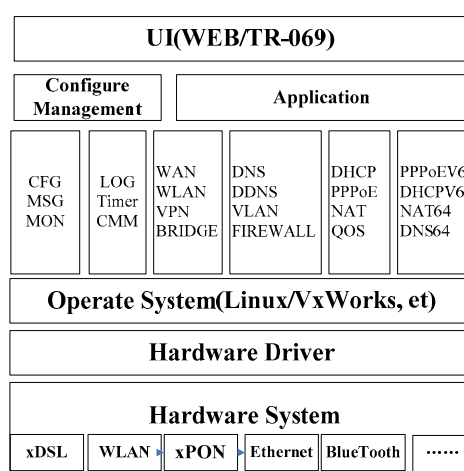


Figure 3 IPV4/v6 software module architecture of dual-stack access terminal devices diagram

Industry Sample and Leading Role of IPv6

Services Provided by the Operator. IPv6 network can replace the IPv4 network completely and bears all current IP broadband services, such as NGN and 3G services [9].

The key is to reduce the network rent and increases the user experience of IPv6.

Industries Market Applications in Government and Enterprises. Demonstration and leading, the key is the industry market including government, enterprises and the other. Regarding field and type of application, the government is the core of the key promoter. For example, the Shenzhen municipal government proposed to hold "the most exciting, the most successful and influential" World University Games, the mayor personally push down, IPv6 network at the 26th Universiade was commercial test using IPv6 technology, and built a competition events network and administration network, Chinese first IPv6 video surveillance system application was deployed.

Another example is the pharmaceutical industry and drug testing, preclinical drug safety assessment, they require fast and effective computerized system validation CSV (Computerized System Validation). Constructing a safety, stable, reliable and efficient IPv6 bearer network can

break the foreign monopoly in this area and be geared to international standards [10].

Conclusion

China pays the attention to the construction of IPv6 backbone network. China Education and Research Network and each operator have built their IPv6 backbone. Home-grown communication supplies accumulated more than ten years, mastered the core technology, developed a whole series of IPv6 network devices covering at all levels including core, convergence and access layer, walked in the forefront of the world. So we can construct a safe, reliable and technologically advanced IPv6 network, but we did not meet expectations. For example, as of 2014, the most criticized of CN2 is the low utilization rate, the whole network utilization rate is only 30%, its utilization rate is about 50% in the eastern developed regions [11].

Therefore, IPv6 network construction and applications is recommended:

1. All levels of government to promote the IPv6 commercial was regarded performance of government departments as Key Performance Indicator, and indeed implement the national strategy to the commanding height of the technology;
2. Develop a roadmap and timetable for forcing operators to IPv6 migrate, such as the policy of consists car the eliminated;
3. Operators develop real premium discount package for the IPv6 broadband access users;
4. In the case of minimal impact to the existing network, ensure the transparency of the end user and crossing IPv6/v4 applications, smoothly migrate for the end user no sense, real provide a good user experience;
5. Equipment suppliers provide more cost-effective devices, greatly reduce cost of constructing IPv6 network, promote the IPv6 industry development;
6. Emphasis the IPv6 network is more secure than the IPv4 network, and the future Internet can take on the security responsibility;
7. ICP actively provides rich contents;
- 8 Develop emerging operators to deploy IPv6 network, encourage private capital to participate in IPv6 network construction and operation, etc.

Acknowledgement

In this paper, the research was sponsored by National Development and Reform Commission on 2012 next generation Internet technology research and development, industrialization and commercial scale commercial special (Next generation IPv6 multifunction terminal equipment).

References

- [1] Yi Li. Beijing Times: Chinese Internet Please Keep the Root[EB/OL]. <http://opinion.people.com.cn/BIG5/n/2014/0122/c1003-24190918.html>, 2014-01-24
- [2] CERNET2: Open the Dream of Next Generation Internet with Innovation[EB/OL]. http://news.tsinghua.edu.cn/publish/news/4205/2011/20110225231713656681194/20110225231713656681194_.html, 2011-02-25.
- [3] Ke Xu, Mingwei Xu, Wenlong Chen, ET al. Advanced Computer Network[M]. Beijing: Tsinghua University press, 2012: 458-463.
- [4] Jia Yin. Who will be the Supplies of CN2 China Telecom CN2 Facing Transition Test[EB/OL]. http://news.ccidnet.com/art/1032/20060911/896983_1.html, 2006-09-11.
- [5] Longbin Hu, Li Wang. Research on IPv6 transition technology[J]. Guangdong Communication Technology, 2014, 6: 69-70.
- [6] Xiaoyu Gu. ZTE will participate in the U.S. congressional hearings to respond to the U.S. challenge [EB/OL]. <http://tech.163.com/12/0901/02/8A9KHQ3P00094MOK.html>, 2012-09-01.

- [7] Test the organizing committee. The world's largest IPv6 transition technology testing conference closing[EB/OL]. <http://www.ipv6enabled.cn>, 2013-09-25.
- [8] Long Hu. Research on Key Technologies of Next Generation High End Router. *GuangDong Science & Technology*[J], 2014, 8(16): 188-189
- [9] Yuxi Gan, Zhihu Jin, Jin Yang. Testing on the Capacity of IPv6 Network Bear NGN and 3G Services. *ZTE Technology Journal* [J], 2013, 19(4): 49-53.
- [10] Zhihu Jin, Yuxi Gan, Yi Jin, ET al. Study on the IP bear network construction for GAMP 5. *GuangDong Science & Technology*[J], 2012, 22(6): 117-118+86.
- [11] Jianfeng Xu. China Telecom CN2 built 10 Years of Age [EB/OL]. <http://www.ccidcom.com/html/yunyingshang/201406/30-229794.html>, 2014-06-30.