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Future Network Naming and Addressing Schemes: Problem Statement and Design Goals

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1. Summary

This technical report is prepared by Chinese experts in May 2009 for ISO/IEC JTC1 SC6's Future Network meeting in Tokyo, Japan, June 2009. It reviews the structural limitations of existing network in the area of addressing and naming schemes, discusses how these limitations cause inconveniences and inefficiencies in network communications. In light of the design goals of Future Networks, the report discusses why new naming and addressing schemes are needed and what kind of functionalities are required. The report also provides suggestions on the next step.

2. Background

In the Xi'an meeting in April 2007, ISO/IEC JTC1 SC6 decided to initiate work on Future Network, a clean slate design of a new network to face the need beyond 2020.

In October 2007, the first Future Network meeting was held in Paris. Among the 9 presentations submitted to the meeting, only one report covers the issue of a new naming and addressing architecture for the new networks. ¹

During the comment period after the Paris meeting, China National Body submitted comments which pointed out that naming and addressing are the core research areas for the new network and works on these issues should start earlier than other non-core areas. The document also indicated that China's IPV9 project had done extensive research in this area. ²

During the Geneva meeting in April 2008, the National Body of Korea submitted a contribution entitled "A Position-based geographical addressing scheme". ³This is the second document in SC6 regarding addressing and naming after China's IPV9 presentation.

SC6 recognized the importance of naming and addressing issue and encouraged Chinese experts to prepare a detailed report on the concept of a new naming and addressing scheme for Future Network in future meeting. ⁴

3. Objectives of This Study

This report has two objectives: to discuss the importance of a new address and naming scheme for future network and to point out the directions of future research in this area.

This report is more like a feasibility study, rather than presentation of a specific technology. We will focus on the general issues surrounding naming and addressing, such as problems, goals, gaps etc. At this early stage, we will avoid focusing on any specific technology. Nevertheless, some advanced research projects such as China's IPV9 may provide valuable insights or experiences which may inevitably be referred to when we come into specific technical analysis. Without those experiences, we may not be able to find out fully the deficiencies of old naming and addressing schemes and may not be confident about whether Future Network design goals can be met.

4. The Importance of Naming and Addressing Scheme in New Network Designs

Naming and addressing are two closely related core schemes in any network designs.

Naming is a scheme which gives identity to every computer or object connected with the network or the party who is going to send or receive information from the network.

Addressing is a scheme which provides information on the point where the sender or receiver is located in the networks.

Just like the post systems, networks are designed to deliver information from one point to another remote point or from one person to another person. In order to conduct the delivery, the sender must first know the other party's name and secondly he must know where the other party is located. Therefore, a network system must contain the naming and addressing schemes as the most fundamental protocols so that the machines know whom and where to send the information to.

In network designs, naming and addressing are not only essential and indispensable, but also occupy top priority in design time-tables. Only after naming and addressing schemes are set, the whole architecture and other subsystems such as router designs and application services can have a base to start work on.

5. Problems in Existing Naming and Addressing Schemes

In Future Network research, naming and addressing schemes are also essential and indispensable. It is not because the simple fact that a new network needs new scheme, but also because the old naming and addressing schemes have structural limitations and are not fit for future network environment.

5.1 Old Domain name and IP Address Schemes

Current internet networks rely on TCP/IP version 4 and 6 (IPV4 and IPV6) to conduct communication and connection. Every machine has a unique identity-bound IP address, so to distinguish the millions of users and computers from each other on the networks. The network adopted a unique and standard address format, giving a unique IP address to every network connected sub-network or machine, so that it can recognize and distinguish them.

In order to ensure the uniqueness of IP addresses of every computer on the

network, a registration scheme is adopted in older network designs. User has to apply for registration from designated central registry administration agency. The agency considers the applicants size and future development outlook and allocates IP addresses.

IPV4 and IPV6 utilize separate schemes for naming and addressing. IP addresses are designed for machines to find destinations of information delivery. Domain names are mainly composed of characters whose combination can help people to identify and memorize names of the location. Every domain name has one dedicated IP address to match. Domain names make it easier for people to visit locations on the network. The combination of IP addresses, domain names, allocation, registration and management systems forms the core mechanism of current communication networks.

5.2 Historical limitations of old naming and addressing system

When evaluate the current IP naming and addressing schemes, we have to take two perspectives: one is historical and the other futuristic.

In historical perspective, we have to give current IP naming and addressing schemes the credit for what they have achieved. They become the base for world-wide networks that connect billions of people across the world.

In futuristic perspective, we have to realistically acknowledge that current IP naming and addressing schemes, because of their inherent weaknesses, is incapable of doing what we would ask them to do. We have to search for alternatives.

Current IP naming and addressing schemes rely on a design concept which was formed about 40 years ago and is therefore outdated.

IPV4 naming and addressing schemes were originated in the 1960s and 70s. At that time, computer communications has limited usage. The designers never envisioned how fast and how broadly the networks have developed and expanded worldwide. There are millions of computers and billions of users on the network everyday. There is a conflict between the limited usage design and unlimited actual usage request. This creates many problems. The shortage of IP addresses was one example of the problems.

Although IPV6 adopted a new addressing scheme, it does not deal with all the problems. The advantage of IPV6 is its expansion of available IP addresses. However, because IPV6 continued an “evolutionary” approach and never intended to do complete structural reshaping, it left many problems untouched.

5.3 Technical limitations of old naming and addressing system

Current naming and addressing schemes have the following major limitations:

- 5.1 The Old schemes require the Central registration authority, which maintains the control of the key facilities of the Internet. This causes widely concerns of information security among the international community.
- 5.2 The centralized domain name registration schemes create economic burdens for heavy IP address users or nations.
- 5.3 IPV4 address resources have limited supplies. By 2010, IPV4 addresses are forecast to be exhausted.

- 5.4 Routing tables are becoming more and more bulky. It causes problems for management and maintenance and increases router work load.
- 5.5 Centralized domain name system forms a vertical structure, with multiple bottlenecks which generate or increase heavy network congestion.
- 5.6 The separation of domain names and IP addresses requires a Domain name to IP Address conversion process. It reduces information delivery speed and causes many burdens.
- 5.7 IPV4 can only utilize data encryption (IPV6-IPSec), but its addresses cannot be encrypted. It cannot provide address confidentiality.
- 5.8 IPV4 addresses can only provide “type” addresses, but can not provide “leveled” addresses which are essential for high quality communication applications such as multi-media and real time information transmissions.
- 5.9 Existing naming and addressing schemes lacks consideration or respect for geographical or national considerations. It creates problems for national government in network management and information security.
- 5.10 IPV4 name and address schemes do not provide language (such as Chinese, Korean, Japanese, Russian, French, German, etc.) direct routing function, and have to rely on domain name conversion schemes.
- 5.11 However, current domain name conversion systems do not provide language supports other than English, therefore, it cannot create allow or convert domain names based on other languages such as Chinese, Korean, Japanese, Russian, French, German, Arabian, etc.
- 5.12 Current domain name conversion system cannot provide all decimal name systems such as telephone number, OID coding, mobile phone number, merchandise code, etc. Those numbers have to be inserted into English domain names for conversion. This complicates a simple process. It reduces data security and wastes network resources.

5.4 The Limitations of IPV6

The major improvements from IPV6 are that it increases the length of IP addresses and expands address resources. However, IPV6 does not make significant changes to other aspects of the IPV4 naming and addressing structure. Therefore, IPV6 carries most of the IPV4 deficiencies in naming and addressing. Furthermore, IPV6 eliminates the geographical concept in addressing scheme. This is not good for management, security and economic efficiency.

6 Gap Analysis

6.1 The need for a Clean Slate Design

From above analysis of the limitations of current IP-based network technologies, we can derive the following views:

- Current IP-based networks have many deficiencies.
- Those deficiencies result from structural designs.
- Problems in current IP-based networks were largely related to flaws in

naming and addressing schemes.

- It is impossible to overcome those problems without structural overhaul.
- The evolutionary approaches such as IPV6 are inadequate to fix the problems.
- Future Network's clean slate design principle is justified.
- A clean-slate design must include redesigning the naming and addressing schemes.
- In order to achieve the design goals of Future Network, we have to find out what kind of gaps are there between the goals and current systems.

6.2 Future Network Design Goals

In document 6N13490, SC6 described the design goals of Future Network as including eight aspects: ⁵

- ◆ Scalability
- ◆ Security
- ◆ Mobility
- ◆ Robustness
- ◆ Heterogeneity
- ◆ Quality of Service
- ◆ Customizability
- ◆ Economic incentive

6.3 The Gaps

If we compare section 5 of this document which analyze the technical strengths and weaknesses of current IP naming and address schemes with the design goals of Future network described in Section 6.2, we can clearly see the gaps between the two.

The design goals describe idealistic objectives that Future Network is intended to achieve or perform. They are based on the overall observation or evaluation of the existing IP-based networks. Using the design goals as a base for evaluation, we will find that current IP-based network naming and addressing schemes cannot satisfy the needs of Future Network.

6.3.1. On scalability, the rigid structure of centralized domain registration and hierarchical routing systems in IPV4-IPV6 prevent scalable networks from emerging.

6.3.2. On security, the centralized domain name conversion and exposed IP addresses cause wide security concerns.

6.3.3. On mobility, current domain names and address protocols does not fit well into the future network environment which will have more and more new communication devices or services such as mobile phones, RFID, sensors, etc.

6.3.4. On Quality of Service, the future network should support quality of service (QoS) from user and/or application perspectives. The current IP-based network naming and addressing schemes needs to give more freedom to users and more rooms of expansion for applications.

- 6.3.5. On Heterogeneity, current domain names and address is incapable of providing name and address structural support for accommodating the integrated networks.
- 6.3.6. On Robustness, the centralized domain name conversion and hierarchical network routing structures in current IP-based networks is one of the causes for network congestion.
- 6.3.7. On Customizability, current naming and addressing schemes has too rigid policies and does not provide flexibility for customized network communications.
- 6.3.8. On economic incentives, current IP names and address fee systems are too expensive for users. Better designed naming and addressing structures also may produce economic incentives resulting from more security and network efficiency.

7 Design goal for Future Network naming and address scheme

Above discussions not only demonstrate the need for a new naming and addressing scheme for Future Network, but also provide valuable information on what kind of goals we should have when considering and evaluating possible candidates of new naming and addressing schemes.

We believe, an ideal Future Network naming and addressing scheme should strive to achieve the following objectives:

- 7.1 Clean slate design: the naming and addressing must show a clean slate design. Modifications to the current naming and addressing structures are insufficient to fulfill the ambitious goals of Future Network.
- 7.2 Horizontal structure. The new naming and addressing scheme must have horizontal structures so that it can provide services that the old vertical structures are unable to do.
- 7.3 Geographical boundaries in Digital World. The new naming and addressing must consider and respect geographic boundaries, especially the national sovereignty in digital world.
- 7.4 Address confidentiality. The new naming and addressing schemes should provide room for installing mechanisms aimed at improving address confidentiality.
- 7.5 Flexibility in domain name management. Users (individuals, institutions or public authorities) should have more freedom and flexibility to create, register and manage domain names.
- 7.6 Enhanced security. The new naming and addressing schemes should provide better security for information exchange through the networks, but also take into consideration of wider security issues, such as the need to maintain rule and order, public facility, personal safety and national security.
- 7.7 PTP connections. The new naming and addressing schemes should provide a base for Point to Point (PTP) connections which would bring better services, more efficiency and more security.

- 7.8 Cultural awareness. The new naming and addressing schemes should take consideration of the special needs of different cultures and provide technical support for multi-cultural network environment.
- 7.9 Information transmission speed: The new naming and addressing schemes should be able to increase the speed of information distribution in Future Network. They may take new naming mechanisms and new address architectures. They should be able to support ideas such as direct routing (without the need for name-address conversion) or character routing.
- 7.10 Multi-dimensional structure. FNNAS should consider the concept of multi-dimensional network so that the limitations of current hierarchical structure are resolved. Multi-dimensional structure may include concepts such as grid computing, position based addressing schemes, layered addressing schemes, etc.
- 7.11 Address availability: FU-NAS should design a new address architecture that would offer truly unlimited resources of addresses to whoever wants them and at an affordable cost.
- 7.12 Address allocation: FN-NAS should reduce the inequality in current address allocation systems. For example, China which possesses 20 percent of world population should be able to have enough addresses to satisfy the need of its huge population.
- 7.13 Reduce Network Congestion. FN-NUS must aim at using the new schemes to help reduce network congestion. There should be clear response to bottlenecks exist in current networks.
- 7.14 Intelligent networks. FNNAS must have a scheme to support the intelligent networks. The issues of mobility, scalability and reprogramming should be considered.
- 7.15 Economic benefits. The new naming and addressing schemes should increase efficiency so that users would have less economic burden.
- 7.16 Integration and harmonization. FNNAS must provide mechanisms to support the integration and harmonization of various kinds of services, applications and networks, so that a network platform is established to support the concept of all-service network.
- 7.17 Pure decimal world. FN-NAS must have designs for pure decimal network communications so that the new network can provide support to some special applications such as mobile phones, RFID, etc.
- 7.18 Name and Address integration. Looking into the future, there will for sure be a demand from special applications for integration of name and addresses into one entity, but current IP-based networks always separate the two. FN-NAS must find a way to bridge the gap.
- 7.19 Room for new applications. FN-NAS must have forward looking mentality and leave rooms for providing naming and addressing support to new applications that would emerge in many years to come.
- 7.20 Consistency. Although there will be too many aspects to consider, FNNAS must maintain consistency. It must have thorough theoretic research

and engineering proof of soundness in concepts. Position based addressing scheme.

7.21 Compatibility and interoperability. Clean slate design does not mean elimination of old facilities. FNNAS will not be bound by old naming and addressing rules, however, we should not mislead to believe that the new future network would have conflict with networks build on old naming and addressing schemes. FNNAS should take into consideration of compatibility and interoperability between old and new future network and show a way how it can be achieved (probably it can be done through engineering works).

7.22 Environment protection. FNNAS should find ways to contribute to the protection of environment. Possible options are NAS designs that could reduce the use of energy in network operation and information processing and transmission.

8 Feasibility

Above requirements are essential to achieve the lofty design goals of Future network. They can be met by one NAS design or by a combination of multiple designs. However, no matter how many designs are offered, a coherent relationship must be established among them. Ideally, one proposal is offered that would be able to address all the issues and provide solutions in a systematic way.

Although the requirements look idealistic, they are not impractical illusions. Chinese experts has conducted research on new naming and addressing schemes for many years and from experiences of projects such as IPV9, we are confident that the requirements can be met. (At this early stage, we are not going to discuss detailed technical information of IPV9 here).

There will be an issue regarding whether SC6 is the proper organization to work on a new naming and addressing scheme. There will be a possible argument that traditionally IP naming and addressing schemes are done in IETF. However, we believe that it is must and proper for SC6 to work on the FNNAS project. Our reasons are:

8.1 SC6 Future Network is a project to redesign a new network that would satisfy the needs of the future. Naming and addressing schemes are essential elements of network design. So the FNNAS is within the scope of SC6.

8.2 Future network is a clean slate design, which requires completely new naming and addressing schemes.

8.3 IETF's mission is to maintain current internet and take an evolutionary approach to improve the current IP-based networks. ⁶ A new clean slate design of the network is not intended or interested IETF. It is also questionable whether IETF is capable of doing such a very complicated and demanding work Furthermore, IETF has not shown no indication that it will start a project similar to SC6 Future Network and the FN-NAS discussed in this document.

8.4 Although other new generation of internet research projects such as

U.S. GENI and FIND also recognize the need for new naming and addressing schemes, they have not produced significant progresses in this area. This makes the FN-NAS project look like an exploratory effort in an open frontier.

8.5 The Chinese IPV9 naming and addressing schemes are more like a complementary rather than competitive effort as Chinese experts have been actively involved in Future Network project and are leading the work on FNNAS research.

9 Next Step

We hope that after the November meeting, SC6 will recognize the importance of a new naming and addressing scheme for Future Network research and take the following immediate steps to move forward on this subject.

9.1. After the meeting, SC6 Secretariat will send this document to SC6 national bodies and relevant organizations for comment and review (or as a NP ballot?) The authors are requested to consider the comments received and provide a comment disposal report to the next SC6 meeting.

9.2. In this meeting, SC6 adopt a resolution to formally start a study period on Future Network Naming and addressing schemes (project code name FN-NAS).

9.3. Chinese experts are encouraged to draft a document on Technical guidelines for Future Network Naming and Addressing Schemes. This document may serve as a directional guidance for FN-NAS research and/or as a base for evaluating technical proposal contributions on NAS. A preliminary report should be presented to the next SC6 work group meeting.

9.4. A call for contribution will be sent to National Bodies and relevant organizations to outline a mid-term road map on FN-NAS.

¹ ISO/IEC JTC1 SC6 document, 6N13376, “IPV9: The Common Ideal for Human Being”, by Xie Jianping, Shanghai Decimal System Network Information Technology Ltd”.

² ISO/IEC JTC1 SC6 document, 6N13488, “National Body of China’s Comments on 6N13422 on Future Network”, Jan 31, 2008.

³ ISO/IEC JTC1 SC6 document, 6N13495, “National Body of Korea’s contribution to Future Network: A position-based Geographical Addressing Scheme”, 2008-02-04.

⁴ ISO/IEC JTC1 SC6 document, 6N13618, “Meeting Report of ISO/IEC JTC 1/SC 6/WG 7 on Future Network,” 2008-04-06.

⁵ ISO/IEC JTC1 SC6 document, 6N13490, Design Goals and General Requirements for Future Network.

⁶ RFC3935, IETF Mission Statement.