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Secretariat, ISO/IEC JTC 1, American National Standards Institute, 25 West 43rd Street, New York, NY 10036; Telephone: 1 212 642 4932; Facsimile: 1 212 840 2298; Email: lrajchel@ansi.org

Telecommunications and Information Exchange Between Systems

ISO/IEC JTC 1/SC 6

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ISO/IEC JTC1/SC6 Secretariat Ms. Jooran Lee, KSA (on behalf of KATS)

Korea Technology Center #701-7 Yeoksam-dong, Gangnam-gu, Seoul, 135-513, Republic of Korea ;

Telephone: +82 2 6009 4808 ; Facsimile: +82 2 6009 4819 ; Email : jooran@kisi.or.kr

PROPOSAL FOR A NEW WORK ITEM

Date of presentation of proposal: 2008-07-18	Proposer: National Body of Korea
Secretariat: KATS National Body Korea	**ISO/IEC JTC 1** ISO/IEC JTC 1/SC 06 N13660

A proposal for a new work item shall be submitted to the secretariat of the ISO/IEC joint technical committee concerned with a copy to the ISO Central Secretariat.

Presentation of the proposal - to be completed by the proposer. .

Title (subject to be covered and type of standard, e.g. terminology, method of test, performance requirements, etc.) Specification of Data Value Domain

Future Network : Problem Statement and Requirements

Scope (and field of application)

This work introduces the description, rationale and general concepts of Future Network to understand the reason why the concept of Future Network is proposed at this moment and what's the scope of standardization work on Future Network.

Recently, as many problems and limitations on the current network have been reported and figured out, the Future Network research based on "Clean Slate design" method is actively progressed. In the work, problems statement and new requirements on Future Network are summarized. Also, there exists other similar approaches and designs for future networking technologies such as ITU-T NGN (Next Generation Network), and IETF IPv6 (Internet Protocol version 6). This work describes the gap between Future Network and other future technologies.

Finally, it discuss milestone on how to move forward. It is intended to deliver a Technical Report on Future Network: Problem Statement and Requirements.

Purpose and justification - attach a separate page as annex, if necessary

The networks are a social trend that has changed, and continue to change how humans communicate for society, economy, cultural and business work. Without question, almost all industrial sectors take advantage of the IP-based network, and all the networking services and technologies will be converged into all-IP networking technologies, according to these trends of emerging all-IP based global networking.

At this phase, current various IP-based networks including the Internet have significant deficiencies that need to be solved before it can become a unified global communication infrastructure. Further, concerns are drastically increasing now that shortcomings would not be resolved by the conventional incremental and 'backward-compatible' style of current research and standardization efforts. That is why the Future Network research effort takes the approach of "*Clean-Slate Design* for the Future Network architecture".

The Future Network, which provides functionalities well beyond the limitations of the current networks including the Internet, is becoming a serious topic in the field of communication network and services. Furthermore, the exponential growth of bandwidth and computing power shall enable new paradigm of networking. We see a growing demand for following features: scalability, security, mobility, Quality of Service (QoS), heterogeneity, robustness, customizability, economic incentives, etc. It is assumed that these new requirement can not be resolved under the restriction of current IP-based design approach.

During the SC 6/WG 7 meeting in April 2008, several contributions regarding problem statement, design goals, general requirements, and gap analysis for future network had been reviewed and discussed. The necessity of initiation of new standardization work on Future Network got a consensus at the meeting. Based on the meeting results of Ad hoc meeting on future network in September 2007 and SC 6 meeting in April 2008, SC 6/WG 7 had decided to propose new work on developing technical report of problem statement and requirements for future network.

Programme of work

If the proposed new work item is approved, which of the following document(s) is (are) expected to be developed?

____ a single International Standard

___ more than one International Standard (expected number: ....)

____ a multi-part International Standard consisting of .... parts

____ an amendment or amendments to the following International Standard(s)

__X_ a technical report, type 3

And which standard development track is recommended for the approved new work item?

__X_a. Default Timeframe

___b. Accelerated Timeframe

___c. Extended Timeframe

Relevant documents to be considered

See attachment which provide initial work on problem statement, design goals, general requirements, and gap analysis for future network

Co-operation and liaison

Collaborative work with ITU-T SG13

Preparatory work offered with target date(s)

It is expected that JTC1/SC6 WG7 will produce draft text shortly after close of a successful NP ballot.

Signature: Jooran Lee

Will the service of a maintenance agency or registration authority be required? ..No....................

- If yes, have you identified a potential candidate? ....No.........
- If yes, indicate name ....

Are there any known requirements for coding? ...No –

-If yes, please specify on a separate page

Does the proposed standard concern known patented items? ...No..............

- If yes, please provide full information in an annex

Comments and recommendations of the JTC 1 or SC XXSecretariat - attach a separate page as an annex, if necessary

Comments with respect to the proposal in general, and recommendations thereon:

It is proposed to assign this new item to JTC 1/SC 06 WG7

Voting on the proposal - Each P-member of the ISO/IEC joint technical committee has an obligation to vote within the time limits laid down (normally three months after the date of circulation).

Date of circulation:	Closing date for voting:	Signature of Secretary:
2008-07-18	2008-10-18	Jooran Lee

NEW WORK ITEM PROPOSAL - PROJECT ACCEPTANCE CRITERIA		
Criterion	**Validity**	**Explanation**
A. Business Requirement		
A.1 Market Requirement	Essential ___ Desirable _X__ Supportive ___	ITU-T SG13 already initiated similar work on Future Network as one of the new Question for the next study period (2009-2012). Also, there are a couple of similar research works on the Future Network (e.g., GENI/FIN D in US, FP7, FIRE project in EU, AKARI, FIF, CERNET-2 in Asia nations).
A.2 Regulatory Context	Essential ___ Desirable ___ Supportive ___ Not Relevant _X__	
B. Related Work		
B.1 Completion/Maintenance of current standards	Yes _ __ No__ X _	
B.2 Commitment to other organisation	Yes _X__ No___	ITU-T SG13 is trying to initiate new Questions for developing the work on Future Network.
B.3 Other Source of standards	Yes ___ No_X__	
C. Technical Status		
C.1 Mature Technology	Yes _ __ No__ X _	.

C.2 Prospective Technology	Yes __X _ No__ _	It is expected that Future Network can be made on clean slate design and long-term revolutionary approach.
C.3 Models/Tools	Yes _ __ No__ X _	
D. Conformity Assessment and Interoperability		
D.1 Conformity Assessment	Yes ___ No_X__	
D.2 Interoperability	Yes _ __ No__ X _	It is assumed that Future Network can be made on clean slate design.
E. Adaptability to Culture, Language, Human Functioning and Context of Use		
E.1 Cultural and Linguistic Adaptability	**Yes______** **No___X____**	
E.2 Adaptability to Human Functioning and Context of Use	**Yes______** **No___X____**	
F. Other Justification		

Notes to Proforma

A. Business Relevance. That which identifies market place relevance in terms of what problem is being solved and or need being addressed.

A.1 Market Requirement. When submitting a NP, the proposer shall identify the nature of the Market Requirement, assessing the extent to which it is essential, desirable or merely supportive of some other project.

A.2 Technical Regulation. If a Regulatory requirement is deemed to exist - e.g. for an area of public concern e.g. Information Security, Data protection, potentially leading to regulatory/public interest action based on the use of this voluntary international standard - the proposer shall identify this here.

B. Related Work. Aspects of the relationship of this NP to other areas of standardisation work shall be identified in this section.

B.1 Competition/Maintenance. If this NP is concerned with completing or maintaining existing standards, those concerned shall be identified here.

B.2 External Commitment. Groups, bodies, or for external to JTC 1 to which a commitment has been made by JTC for Co-operation and or collaboration on this NP shall be identified here.

B.3 External Std/Specification. If other activities creating standards or specifications in this topic area are known to exist or be planned, and which might be available to JTC 1 as PAS, they shall be identified here.

C. Technical Status. The proposer shall indicate here an assessment of the extent to which the proposed standard is supported by current technology.

C.1 Mature Technology. Indicate here the extent to which the technology is reasonably stable and ripe for standardisation.

C.2 Prospective Technology. If the NP is anticipatory in nature based on expected or forecasted need, this shall be indicated here.

C.3 Models/Tools. If the NP relates to the creation of supportive reference models or tools, this shall be indicated here.

D. Conformity Assessment and Interoperability Any other aspects of background information justifying this NP shall be indicated here.

D.1 Indicate here if Conformity Assessment is relevant to your project. If so, indicate how it is addressed in your project plan.

D.2 Indicate here if Interoperability is relevant to your project. If so, indicate how it is addressed in your project plan

E. **Adaptability to Culture, Language, Human Functioning and Context of Use**

NOTE: The following criteria do not mandate any feature for adaptability to culture, language, human functioning or context of use. The following criteria require that if any features are provided for adapting to culture,

language, human functioning or context of use by the new Work Item proposal, then the proposer is required to identify these features.

E.1 Cultural and Linguistic Adaptability. Indicate here if cultural and natural language adaptability is applicable to your project. If so, indicate how it is addressed in your project plan.

ISO/IEC TR 19764 (Guidelines, methodology, and reference criteria for cultural and linguistic adaptability in information technology products) now defines it in a simplified way:

"ability for a product, while keeping its portability and interoperability properties, to:

- be internationalized, that is, be adapted to the special characteristics of natural languages and the commonly accepted rules for their se, or of cultures in a given geographical region;

- take into account the usual needs of any category of users, with the exception of specific needs related to physical constraints"

Examples of characteristics of natural languages are: national characters and associated elements (such as hyphens, dashes, and punctuation marks), writing systems, correct transformation of characters, dates and measures, sorting and searching rules, coding of national entities (such as country and currency codes), presentation of telephone numbers and keyboard layouts. Related terms are localization, jurisdiction and multilingualism.

E.2 Adaptability to Human Functioning and Context of Use. Indicate here whether the proposed standard takes into account diverse human functioning and diverse contexts of use. If so, indicate how it is addressed in your project plan.

NOTE:

1. **Human functioning is defined by the World Health Organization at http://www3.who.int/icf/beginners/bg.pdf as:**
   <<In ICF (*International Classification of Functioning, Disability and Health), the term functioning refers to all body functions, activities and participation.>>*
2. **Content of use is defined in ISO 9241-11:1998 (*Ergonomic requirements for office work with visual display terminals (VDTs) – Part 11: Guidance on usability) as:***
   <<Users, tasks, equipment (hardware, software and materials), and the physical and societal environments in which a product is used.>>
3. **Guidance for Standard Developers to address the needs of older persons and persons with disabilities).**

F. Other Justification Any other aspects of background information justifying this NP shall be indicated here.

<Attachment> Initial considerations on Future Network at SC 6/WG 7 meeting

This document describes initial considerations about problem statement, design goals, general requirements and gap analysis on future network, which were reviewed and discussed at the SC 6/WG 7 meeting in April 2008. This document will provide some useful informative materials to think of the necessity of new standardization work on future network in JTC 1/SC 6.

Section 1: Problem Statement for Future Network

1. Introduction

The Future Network, which is anticipated to provide futuristic functionalities beyond the limitations of the current network including Internet, is getting a global attention in the field of communication network and services. We see that there are many concerns on the following aspects on current network, including IP based networks: scalability, ubiquity, security, robustness, mobility, heterogeneity, Quality of Service (QoS), re-configurability, context-awareness, manageability, data-centric, economics, etc.

This document describes the overview, assumptions, and problem statement. This document gives an overview of history of current IP technology's success and original design goals and design principles. It spells out the underlying assumptions of changes of networking environments and design choice for Future Network. Finally, it describes problems associated with current IP technology for Future Network.

2. Overview

The Internet is a social trend that has changed, and continue to change how humans communicate, business work. Without question, almost all industrial sectors take advantage of the Internet, and all the networking services and technologies will be converged into all-IP networking technologies, according to these trends of emerging all-IP based global networking.

At this phase, current various IP based networks including Internet have significant deficiencies that need to be solved before it can become a unified global communication infrastructure. Further, concerns are drastically increasing now that shortcomings would not be resolved by the conventional incremental and 'backward-compatible' style of current research and standardization efforts. That is why the Future Network research effort is called as "*Clean-Slate Design* for the New Internet's Architecture" [1].

Before we can discuss the current problems on the Internet, we need to briefly review the current IP-based technology [2].

The design goal of current Internet was :

- To connect existing networks
- Survivability
- To support multiple types of services
- To accommodates a variety of physical networks
- To allow distribute network management
- To be cost effective
- To allow host attachment with a low level of effort
- To allow resource accountability

To achieve this goals, the following design principles have been invented and used :

- Layering
- Packet Switching
- A network of collaborating networks
- Intelligent end-system / end-to-end arguments

The design principle could simplify network architecture and protocols. Particularly, a layering, the packet switching, and intelligent end-system / end-to-end arguments principles were the first core philosophy for the current IP technology's success. But the current Internet environment was considerably changed as follows [3]:

- Environment : Trusted => Un-trusted
- Users : Researchers => Customers
- Operators : Nonprofits => Commercial
- Usages : Host-oriented => Data-centric
- Connectivity : End-to-end always-on IP connectivity => Intermittent any network (IP or non-IP) connectivity

The current IP technologies have significant deficiency that need to be solved before it can be become a unified global communication infrastructure. Particularly, there are problems with a large number of hosts, such as sensors, the various wireless and mobile nodes, multiple interface and multi-homed nodes, the support of the fast mobile hosts, the safe e-transaction, the quality of service guarantee at a network, the business aspect complementary, and etc., on current IP network, so various researches had been being in progress to solve these problems.

3. Assumption – Clean Slate Designs

There are two choices to evolve or change the current IP-based network architecture [1].

- Incremental Design
  - A system is moved from one state to another with incremental patches
  - *How should the Internet look tomorrow ?*
  - Conventional, backward-compatible and short/mid-term research
- Clean-Slate Design
  - The system is re-designed from scratch
  - *How should the Internet look in 15 year ?*
  - Unconventional, bold, and long-term research

It is assumed that the current IP's shortcomings will not be resolved by conventional incremental and "backward-compatible" style designs. So, the Future Network designs must be discussed based on clean-slate approach.

4. Problem Statement for the Future Network

Based on the characteristics of current IP technologies defined in the overview and assumptions section, the following sections elaborate on the main problems with current IP-based technology for Future Network.

The problems for the Future Network could be classified into *i) basic problems* and *ii) problems with original design principles* as follows :

4.1 Basic Problems

4.1.1 Routing Failures and scalability

The current Internet is facing challenges in scalability issues on routing and addressing architecture. The problems have been examined as being caused by mobility, multi-homing, renumbering, provider independence (PI routing), IPv6 impact, etc. on the current Internet architecture. The problem is known to be caused by current ID-Locator Integration within IP address scheme. As the Internet continues to evolve, the challenges in providing a scalable and robust global routing system will also change over time.

4.1.2 Insecurity

One of the main problems on the current Internet is not to provide secure communication. As current communication is not trusted, problems are self-evident, such as the plague of security breaches, spread of worms, and denial of service attacks. Even without attacks, service is often not available due to failures in equipment of fragile IP routing protocols.

4.1.3 Mobility

Current IP technologies are designed for hosts in fixed locations, and ill-suited to support mobile hosts. Mobile IP was designed to support host mobility, but Mobile IP has problems on update latency, signaling overhead, location privacy. Also the current Mobile IP architecture is facing challenges in fast and vertical handover.

4.1.4 Quality of Service

Internet architecture is not enough to support quality of service from user or application perspective. It is still unclear how and where to integrate different levels of quality of service in the architecture.

4.1.5 Heterogeneous Physical Layers and Applications

Recently, IP architecture is known as a "*narrow waist* or *thin waist*". Today's IP enables a broad range of physical layers and applications. But, this physical layers and applications heterogeneity poses tremendous challenges for network architecture, resource allocation, reliable transport, context-awareness, re-configurability, and security.

4.1.6 Network Management

The original Internet lacks in management plane. Instant and easy management for users is highly required, as the Future Network can be composed of new emerging heterogeneous wireless, mobile and ad-hoc architectures. For example, the following autonomic management should be provided to future mobile networks: self-protecting, self-healing, self-configuring, self-optimizing, etc.

4.1.7 Congestive Collapse

Current TCP is showing its limits in insufficient dynamic range to handle high-speed wide-area networks, poor performance over links with unpredictable characteristics, such as some forms of wireless link, poor latency characteristics for competing real-time flows, etc.

4.1.8 Opportunistic and Fast Long-Distance Communications

Original Internet was designed to support always-on connectivity, short delay, symmetric data rate and low error rate communications, but many evolving and challenged networks (e.g., intermittent connectivity, long or variable delay, asymmetric data rates, high error rates, fast long-distance communications, etc.) do not confirm to this design philosophy.

4.1.9 Economy and Policy

There is also a question of how network provider and ISP continue to make profit. Some of the economic travails of the current Internet can be traced to a failure of engineering. The current Internet lacks explicit economic primitives.

4.2 Problems with Original Design Principles

4.2.1 Packet Switching

Current IP technologies use packet switching making it hard to take advantage of improvements in optical. Packet switching is also known to be inappropriate for the core of networks and high capacity switching techniques (e.g., Terabit). Instead, we need to re-design dynamic circuit switching or hybrid (packet –circuit) switching for the core of networks.

4.2.2 Models of the End-to-End Principle

The models of the end-to-end principle has been progressively eroded, most notably by the use of NATs, which modify addresses, and firewalls and other middle boxes, which expect to understand the semantics behind any given port number (for instance to block or differentially handle a flow). As a result, end hosts are often not able to connect even when security policies would otherwise allow such connections. This problem will only be exacerbated with the emerging need for IPv4-IPv6 translation. Beyond this, other changes in the way the Internet is used has stressed the original unique-address:port model of transport connections.

4.2.3 Layering

Layering was one of important characteristics of current IP technologies, but at this phase, it has inevitable inefficiencies. One of challenging issues is how to support fast mobility in heterogeneous layered architecture. We should explore where interfaces belong, and what services each layer must provide.

References

[1] Stanford Univ., Clean-Slate Design for the Internet, http://cleanslate.stanford.edu/

[2] Anja Feldmann, "Internet Clean-Slate Design: What and Why?", ACM SIGCOMM CCR, Vol. 37, No. 3, July 2007, pp59-64

[3] Internet Innovation Workshop, Presentation Slides, June 19-20, 2007, http://cfit.ucdavis.edu/ internet_futures/

[4] IRTF, Internet Research Task Force, http://www.irtf.org

Section 2: Design Goals and General Requirements for Future Network

1. Introduction

The Future Network, which provides functionalities well beyond the limitations of the current networks including Internet, is becoming a serious topic in the field of communication network and services. Furthermore, the exponential growth of bandwidth and computing power shall enable new paradigm of networking. We see a growing demand for following features: scalability, security, mobility, Quality of Service (QoS), heterogeneity, robustness, customizability, economic incentives, etc. These features are desired for clean-slate design of future network.

2. Design Goals and General Requirements for Future Network

2.1 Scalability

Scalability issue is emerging as continuous growth of cultural demands for networking in the future. During the next 10-15 years, it is envisioned that the telecommunication networks including internet will undergo several major transitions with respect to technologies, services, size, and so on. For example, machine-to-machine communication might be pervasive in addition to the current way of communication that human-beings are involved.

Scalability consideration shall include following aspects:

- Routing and addressing architecture
- Multi-homing and provider independence (PI routing)

2.2 Security

The Future Network should be built on the premise that security must be protected from the plague of security breaches, spread of worms and spam, and denial of service attacks, and so on.

2.3 Mobility

The Future Network should support mobility of devices, services, users and/or groups of those seamlessly. For example, Mobile computing is one of the important service requirements of the evolving network. Following features can be considered under the context of mobility in the future network.

2.3.1 Supporting New Devices/Networks

Mobility in the future network should support new devices such as sensors, RFIDs, etc. It is also expected to support new networks that are emerging.

2.3.2 Context-awareness

Context-awareness is applied to mobility, it refers to a general class of mobile systems that can sense their physical environment, i.e., their context of use, and adapt their behaviour accordingly. Three important aspects of context are: where you are; who you are with; and what resources are nearby. Although location is a primary capability, location-aware does not necessarily capture things of interest that are mobile or changing.

2.3.3 Multi-homing and Seamless Switching

Mobility in the future network should support multi-homing, i.e., multiple access paths to heterogeneous /homogeneous networks. It is also expected to support seamless switching between those multiple access paths.

2.4 Quality of Service

The future network should support quality of service (QoS) from user and/or application perspectives.

2.5 Heterogeneity

The Future Network should provide much better support for a broad range of applications/services and enable new applications/services. In addition, it should accommodate heterogeneous physical environments.

2.5.1 Application/Service Heterogeneity

The Future Network should be designed to support new services and/or applications, e.g., data-centric services. Original Internet was designed to support host-centric, which means users tell client to contact to another host (e.g., telnet, ftp). However, new emerging services are more likely data-centric. Users want to access particular data or service (e.g., P2P) and do not care where the data or service is located.

2.5.2 Physical Media Heterogeneity

The Future Network should accommodate heterogeneous physical media, such as Optical fiber, Wireless access (e.g., IEEE 802.11/16/15.4 …), etc. This physical media heterogeneity poses tremendous challenges to Future Network architecture.

2.5.3 Architecture Heterogeneity

The Future Network should accommodate heterogeneous network architecture. For example, heterogeneous wireless, mobile, and ad-hoc architectures would be deployed.

2.6 Robustness

The future network should be robust, fault-tolerant and available as the wire-line telephone network is today. Robustness shall be considered from the following aspects.

2.6.1 Re-configurability

The Future Network shall import and configure new invented technologies into its architecture. Therefore, programmable and/or re-configurable networking and computing methods need to be adopted. One of the good examples would be programmable and/or re-configurable routers/switches.

2.6.2 Manageability

The future network will become more and more complex with emerging services and architectural diversity. Therefore, Instant and easy management is desired in the future network. For example, the following autonomic management might be provided to future mobile networks: self-protecting, self-healing, self-configuring, self-optimizing, etc.

2.7 Customizability

The Future Network should be customizable along with various user requirements.

2.7.1 Context-Aware Numbering and Content-Centric Service

The Future Network shall be aware of context. For example, numbering shall be supported in a content-centric manner.

2.7.2 Service-Specific Overlay Control and Service Discovery

The Future Network shall discover a service based on service-specific overlay control.

2.8 Economic Incentives

The future network shall provide economic incentives to the components/participants that contribute to the networking. For example, network providers and/or ISPs contribute to construct the infrastructure of network. The users of GRID computing contribute to provide resources. Therefore it is desired that the future network provides with explicit economic primitives.

Section 3: Gap Analysis for Future Network

1. Introduction

The Future Network, which is anticipated to provide futuristic functionalities beyond the limitations of the current network including Internet, is getting a global attention in the field of communication network and services. For the design of Future Network, the design goals and requirements are discussed and described in other companion contribution in the title of "Design Goals and General Requirements for Future Network". At the same time, there exists other similar approaches and designs for next generation network or future networking technologies such as ITU-T NGN (Next Generation Network), and IETF IPv6 (Internet Protocol version 6). This document describes the gap between design goals and general requirements for Future Network and NGN and IPv6.

This is a newly-defined design goal list for the Future Network.

- *Scalability*
- *Security*
- *Mobility*
- *Quality of Service*
- *Heterogeneity*
- *Robustness*
- *Customizability*
- *Economic Incentives*

2. Gap Analysis

This section discusses a gap between design goals and main characteristics for existing standards and/or proposals for next-generation or new generation and the Future Network listed in section 1.

Corresponding technologies and architecture for gap analysis :

- ITU-T NGN (Next Generation Network)
- IETF IPv6 (Internet Protocol version 6, Next generation Internet)

2.1 NGN vs. Future Network (FN)

As universal high speed Internet access has spurred the growth of e-life applications, it has raised the necessary of NGN (Next Generation Network) which will lead the world all-IP based.

The concept of an NGN has been introduced to take into consideration the new realities in the telecommunications industry, characterized by factors such as: competition among operators due to ongoing deregulation of markets, explosion of digital traffic, e.g., increasing use of "the Internet", increasing demand for new multimedia services, increasing demand for a general mobility, convergence of networks and services, etc.

ITU-T has been making effort to develop NGN, and it published quite important deliverables on NGN which describe requirements and necessary functions. NGN Release 1 and the ongoing Release 2 work cover broad area of technologies including inter-network, inter-operate with non-NGN networks, transport connectivity, media resource management, Quality of Service, security, network management, open service environment, multimedia subsystem, account and billing, etc. It will be provided to connect all legacy networks into NGN and support seamless services for e-life applications.

The NGN can be further defined by the following fundamental characteristics. The characteristics could be compared to design goals of Future Network.

- Packet-based transfer
- Separation of control functions among bearer capabilities, call/session, and application/ service;
- Decoupling of service provision from transport, and provision of open interfaces;
- Support for a wide range of services, applications and mechanisms based on service building blocks (including real time/ streaming/ non-real time and multimedia services)
- Broadband capabilities with end-to-end QoS (Quality of Service)
- Inter-working with legacy networks via open interfaces
- Generalized mobility
- Unrestricted access by users to different service providers
- A variety of identification schemes
- Unified service characteristics for the same service as perceived by the user;
- Converged services between fixed/mobile
- Independence of service-related functions from underlying transport technologies;
- Support of multiple last mile technologies;
- Compliant with all regulatory requirements, for example concerning emergency communications, security, privacy, lawful interception, etc.

If we compare the list of Future Network design goals (and general requirements) with NGN characteristics, we note that these are very similar with each other, and these can be considered as those of major futuristic challenges on the network of the future.

The major differences are that any IP-based network architecture or packet switching technology is not assumed for Future Network, whereas NGN is based on all-IP networks and packet-based transfer. Also, NGN research is based on short/mid term evolutionary approach, so NGN technologies could be evolved from the current IP-based network. But Future Network is based on clean-slate designs and long-term revolutionary approach.

A major goal of the NGN is to facilitate convergence of networks and convergence of services. Thus, NGN is not totally a new network, but all-IP converged networks. Instead, Future Network researchers believe that it is impossible to resolve the new characteristics (or requirements) facing today’s IP technology without re-design the fundamental assumptions.

Table 1 shows the review results on gap analysis of NGN and Future Network from perspective on design method, fundamental characteristics, and deployment aspect.

Table 1. NGN vs. Future Network

		NGN	FN (research candidates)
Design Methods		**Incremental (backward-compatible) design**	**Clean-slate design**
Fundamental Characteristics	**Transport Method**	**Packet-based transfer**	**Not assume any packet or circuit transfer**
	Layering and API	**Concrete layered architecture and open interface**	**Cross-layered architecture**
	Control Plane	**Separation of control functions**	**New control plane** **(separated from data)**
	End-to-end principle	**Not strict**	**New principle required** **e.g., End-Middle-End principle**
	Scalability	**A variety of ID schemes support including IPv4 and IPv6**	**New ID,** **ID/locator split and multi-level locator**
	Security	**Layered security** **(e.g., L2 security, L3-IPsec, etc.)**	**Not clear yet**
	Mobility	**Generalized mobility** **(e.g., MIP)**	**Cross-layer design based mobility**
	QoS	**Broadband capabilities with end-to-end QoS**	**Not clear yet**
	Heterogeneity	**Support for a wide range of medium, and services**	**Application/Service Heterogeneity** **Physical Media Heterogeneity**
	Robustness	**Management plane**	**Manageability,** **Autonomic management**
	Network **Virtualization**	**None**	**Re-configurability** **Programmable Network**
	New Services and technologies Support	**Support of multiple last mile technologies**	**Easy support of new service** **e.g., Data-centric** **Context-awareness**
	Economics	**None**	**New parameters**
Deployment Aspect		**Incremental migration,** **Integration**	**New testbed and infrastructure required**

In the meantime, some questions about the current network have been issued. It has started from the agony of today’s Internet, which shows some of unintended consequences;

- Is it right way to keep the current role of Internet address which delivers who you are, where you are, and how the packets should be delivered?;
- Is the current address mechanism bringing the big challenge of mobility support?
- Is spam a necessary outcome of the Internet mail delivery?;
- Why the identification and trust of end peers become a challenge?
- Why has Quality of Service proved to be a commercial failure?;
- Is the host-oriented internet able to smoothly cover data-oriented usage of current Internet?;
- etc.

It is believed that the NGN is being designed to support seamless mobility, strong security, QoS, etc., which includes those issues. It is, however, not clear yet if they were unavoidable, and if NGN do not hand over the problems. Thus, it is necessary to study to find the answers and gives the input to design beyond NGN or other futures.

At this phase, current various IP based networks including Internet have significant deficiencies that need to be solved before it can become a unified global communication infrastructure. Further, concerns are drastically increasing now that shortcomings would not be resolved by the conventional incremental and 'backward-compatible' style of current research and standardization efforts. That is why the Future Network research effort is called as “*Clean-Slate Design* for the Internet’s Architecture”.

2.2 IPv6 (Next generation Internet) vs. Future Network

IPv6 is the next generation Internet Protocol (IP) proposed as a successor of current IPv4. One important key to a successful IPv6 transition is the compatibility with the large installed base of IPv4 hosts and routers.

The requirements and design goals for IPv6 was as follows

- Number of addresses
- Efficiency in routers low and very high bandwidth (100G/bytes++)
- Security
- Mobility
- Auto-configuration
- Seamless transition
    - Don’t require a day X for switching to IPv6
    - No need to change hardware

As seen above, IPv6 was designed to supplement the current IP, IPv4, so, main goal of IPv4 was to inherit the current IP characteristics. Thus, when we consider deployment and migration from current IPv4, IPv6 might be better approach for the network of the future. Some researcher is considering IPv6 as one of proposed solutions for the Future Network. However, IPv6 has the same limitation like IPv4, IPv6 can not fulfil all the requirements for the Future Network.

If we compare the list of Future Network design goals (and general requirements) with IPv6 characteristics, we note that these are very similar in some point, but many other new requirements are still missed in IPv6, for examples, Heterogeneity, Re-configurability, Context-awareness, Data-centric, Virtualization, Economics. Actually, these kinds of new requirement can not be resolved without any new trial of re-design.

Table 2 shows the review on gap analysis of IPv6 (Next generation Internet) and Future Network from perspective on design method, Fundamental Characteristics, and deployment aspect.

Table 2. IPv6 vs. Future Network

		IPv6	FN (research candidates)
Design Methods		**Incremental (backward-compatible) design**	**Clean-slate design**
Fundamental Characteristics	**Transport Method**	**Packet-based transfer**	**Not assume any packet or circuit transfer**
	Layering and API	**Concrete layered architecture and open interface**	**Cross-layered architecture**
	Control Plane	**Not separated from data**	**New control plane** **(separated from data)**
	End-to-end principle	**Strict principle**	**New principle required** **e.g., End-Middle-End principle**
	Scalability	**Problems with scalable routing and addressing**	**New ID,** **ID/locator split and multi-level locator**
	Security	**IPsec for IPv6**	**Not clear yet**
	Mobility	**MIPv6**	**Cross-layer design based mobility approach**
	QoS	**Not support within IP**	**Not clear yet**
	Heterogeneity	**Problems with support for a wide range of medium, and services**	**Application/Service Heterogeneity** **Physical Media Heterogeneity**
	Robustness	**Fault-tolerant**	**Manageability,** **Autonomic management**
	Network **Virtualization**	**None**	**Re-configurability** **Programmable Network**
	New Services and technologies Support	**Not easy support of new service**	**Easy support of new service** **e.g., Data-centric** **Context-awareness**

	Economics	**None**	**New parameters**
Deployment Aspect		**Incremental migration,** **Integration**	**New testbed and infrastructure required**

References

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